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Assessment of changes in households food availability, access, utilization and stability using farm stratification associated with the introduction of legume technology in Salima district, Malawi

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Disclaimer

The research for this Master thesis is part of an Erasmus exchange programme between Wageningen University and University of Hohenheim. The field research has been conducted in Malawi within the Wageningen University led programme N2Africa, and as such was largely supervised by Wageningen University. Therefore, part of the material has been used in the form of an unpublished report for Wageningen University.

N2Africa

Putting nitrogen fixation to work for smallholder farmers in Africa

Table of contents

0. Summary

N2Africa is a 2 phase project that focuses on agricultural intervention of legume technology targeting the small scale farmers in sub-Saharan Africa. Through multi-purpose grain legumes which can fix atmospheric nitrogen into soils resulting in higher crop yields, N2Africa aims to improve crop and livestock productivity, human nutrition and farm income as well as enhancing soil fertility for the small scale African farmers' needs. The N2Africa project is currently in its second phase which focuses on the dissemination and institutionalization of the legume technology. One of the goals of N2Africa is to provide opportunities for small holder farmers and enhance their food and nutritional security by the year 2019. However, food security should be targeted comprehensively with a multi-dimensional approach to capture all relevant outcomes of N2Africa. In previous research, the adoption rate of N2Africa proved to be limited for poorer farmers due to the features of low resource endowed farmers, which are risk averse and have few resources to invest. This casts a doubt on the possibility of achieving the goal. Therefore, an assessment of the changes in households' food availability, access, utilization and stability in relation to the N2Africa project activities was carried out taking in consideration that different impacts can be realized in socio-economically different farm types (low and high stratum). Sustainable livelihoods framework, women empowerment score and farm stratification are used as tools for the comprehensive food security assessment.

N2Africa contributes mainly to the availability of legumes. Economic access in terms of income from legumes is not significantly increased by N2Africa. Women's access to input and size of land for legumes is significantly increased by N2Africa. Increased women's access to size of legume field is only valid when women own the land. Enhanced health status of household members, higher cooperation with other households, increased size of legume field, household income and access to inputs for farming are additional improvements regarding the access domain of food security. N2Africa does not contribute to utilization. This result is assumed to be due to the narrow definition of utilization in this research mainly concerned on quality of diet, and to the traditional culture of legume consumption in Salim district, Malawi. N2Africa contributes to the stability of crop availability by reducing crop damages regardless of weather conditions and pest/diseases, but does not affect the stability of daily calorie intake from legumes. Household income is recognized as stable by participating in N2Africa when crop and input prices fluctuate, and when there is a decline of employment. N2Africa does not contribute to stability of utilization. However, regarding access and stability, the benefits of N2Africa are often not delivered to low stratum. This is due to the fact that those pillars are highly associated with resource endowment. Nevertheless, there are positive potentials of N2Africa to deliver its benefits to low stratum in three ways; some impacts occurred in both farm types, the role of social groups sharing seeds, labor and food, and low dependency on fertilizer of legume cultivation.

1. Introduction

1.1 N2Africa project: Legume, biological nitrogen fixation

The N2Africa project aims to make the previously inaccessible atmospheric nitrogen available to small holder African farmers' needs of protein and nitrogen through increasing the yield of grain legumes which can fix the atmospheric nitrogen into soils (Brand, 2011). With the potential of biological nitrogen fixation of grain legumes, N2Africa aims to improve crop and livestock productivity, human nutrition and farm income as well as enhancing soil fertility (Woomer et al., 2014). The project starts from identifying the niches for targeting nitrogen fixing legumes and testing varieties of multi-purpose legumes to adoption and dissemination of the legume technology to each household ("N2Africa Putting nitrogen fixation to work for smallholder farmers in Africa," 2013). It also introduces inoculant technologies to increase biological nitrogen fixation (BNF). The first stage of the project consisted of identifying varieties of multi-purpose legumes and selecting superior rhizobia strains for enhanced BNF and developing inoculum production capacity (Chataika et al., 2013). They also mention that the researchers in N2Africa also deliver the technologies to male and female farmers through partnership and campaigns, and capacity building for BNF research, technology development and application. In the first phase (2009-2013), N2Africa reached more than the expected numbers of households who expanded the grain legume production through adoption of best management practices and expansion of their land areas (Woomer et al., 2014). The second stage of the project started this year 2014, and it will be mainly focusing on the dissemination and institutionalization of this legume technology ("N2Africa Putting nitrogen fixation to work for smallholder farmers in Africa," 2013). One of the N2Africa's goals is that N2Africa will have provided opportunities for small holder farmers and enhanced their food and nutritional security by the year 2019. At the beginning of the second phase and in light of the goal, it is worthwhile to have a closer view of on the food security implications of N2Africa interventions.

1.2 Theoretical framework

1.2.1 Farm typology

Tittonell et al (2010) claim that smallholder farming systems in southern Africa are very heterogeneous depending on the socio-economic environments and biophysical conditions. They also state that understanding the diversity across the smallholder farming systems is an important step to improve the agricultural production by connecting the biophysical and socio-economic variables and their interactions. The small holder farming systems are stratified into five farm types by resource endowment, production orientation and main source of income (Tittonell et al., 2010). Understanding the heterogeneity of smallholder farms by farm typology provides opportunities for better targeting agricultural technologies resulting in high adoption rates. Based on this farm typology adjusted from Tittonell et al (2005) and Brand (2011), we investigated the smallholder farms in Salima and Mchinij districts in Malawi. Farm types in the districts are determined by the main criteria in Table 1. Brand (2011) explains the five farm types as follows. Households of farm type 1 usually depend on income from working for other farmers casually. Farms of

type 2 have small temporary business such as trading vegetables or repairing bicycles, and earn sometimes a little income from a farm produce. Farms of type 3 earn income from farm surpluses and small enterprises such as carpenter. Sometimes house roofs with iron sheets are found in this type. Farms of type 4 and 5 own larger land holdings and numbers of livestock. Houses are larger with iron sheets roofs, and sometimes cement is used. They produce for markets mainly with hired labor. The typical feature of farms of type 5 is that one of the household members earns a fixed monthly salary outside the farm.

Table 1 Description of the farm types based on the main criteria considered for their categorization

farm type	resource endowment*	production orientation	main source of income
1	LRE	Self-subsistence	Casual labor
2	LRE	Self-subsistence	Little farm produce and/or small services
3	MRE	Self-subsistence, market-oriented	Little farm produce and/or other small enterprises
4	HRE	Market-oriented	Cash crop and other farm produce
5	Mainly HRE, some MRE	Self-subsistence, market oriented	Salary from a job, farm surpluses and sometimes cash crops

*L,M,HRE=Low, Medium, High Resource Endowment
Source: Brand (2011)

1.2.2 Sustainable livelihoods framework

A livelihood comprises the capabilities, comprised of assets (including both material and social resources) and activities used by a household for means of living (DFDI, 1999). A household's livelihood is secure when it can cope with and recover from stresses and shocks, and maintain or enhance its capabilities and productive asset base (Chambers and Conway, 1992). This is the most often used definition of livelihood. In simple words, livelihoods are 'means of making a living' (DFDI, 1999).

The sustainable livelihoods framework (SLF) shown in Figure 1, is adjusted by Adato and Meinzen-Dick, (2002) to claim that such a framework can be used for assessing and prioritizing agricultural interventions. Originally the sustainable livelihood framework was developed by the Sustainable Rural Livelihoods Advisory Committee, building on earlier work by the Institute of Development Studies in the United Kingdom. It aims to help understand and analyze the livelihood of the poor (DFDI, 1999). The SLF can be used to assess the contribution to livelihood sustainability made by existing activities and also as a practical tool that outlines a holistic approach to the design and monitoring of food security and livelihood interventions" (ACF International, 2010). This approach provides a broader view of food security as food security is one outcome of a successful livelihood strategy.

Adato and Meinzen-Dick (2002) tested and adapted the SLF for use in agricultural research. The position of agricultural technologies is visualized in Figure 1. Agricultural technology can affect vulnerability context, the asset base and/or be part of policies,

institutions, and processes. The advantage of this method is enabling researchers to understand the big pictures, and then to narrow down to what can have the highest impacts or what is more relevant to the target groups since it is a holistic and synthetic framework (Adato & Meinzen-Dick, 2002).

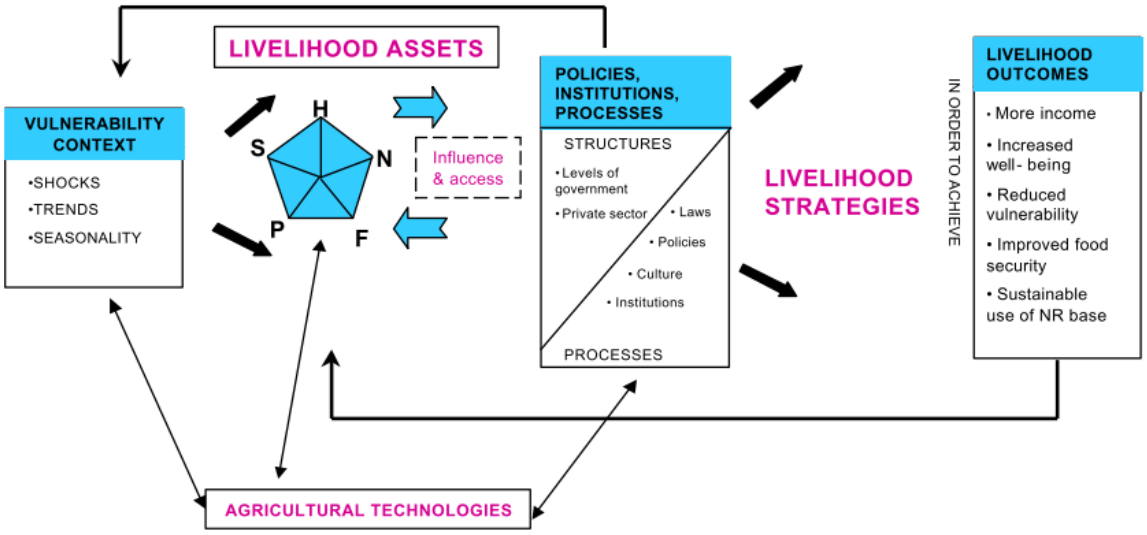

Figure 1. The sustainable livelihood conceptual framework with agricultural technologies

Source: Adato & Meinzen-Dick (2002)
Agricultural technology interacts with vulnerability context, livelihood assets and policies, institutions, and processes.

1.2.3 Food security

Food security is defined as follows by the 2009 Declaration of the World Summit on Food Security: "Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food, which meets their dietary needs and food preferences for an active and healthy life." Although there have been changes in the definition of food security, to date, there are 4 main pillars in food security which are 'availability', 'access', 'utilization' and 'stability' as declared by the World Food Summit in 2002. By measuring food security according to these 4 pillars, it is expected to capture all aspects of food security.

There are several levels of food security: global, national, household and individual and they are closely linked together (Smith et al., 2000). At national level, food availability is a rather dominant concept using food balance sheets to assess national food security. However, more attention is required in other pillars when it comes to household food security. For instance, there is a shift at household level food security toward a more complex system of "food access", rather than food availability (FAO, 1997). Therefore, special attention to household food security should be given using the 4 pillars mentioned above.

1.2.3.1 Availability

Availability is defined by The World Food Programme as "The amount of food that is

present in a country or area through all forms of domestic production, imports, food stocks and food aid" (WFP, 2009).

1.2.3.2 Access

Access is defined by The World Food Programme as "A household's ability to acquire adequate amount of food regularly through a combination of purchases, barter, borrowings, food assistance or gifts" (WFP, 2009). Although many people tend to consider access within an economic context, food access is approached by three ways, which are physical, economic and socio-cultural.

Napoli et al (2011) explain the three context of access as follows. The physical dimension is to ensure food access by having efficient and existent transport infrastructure including ports, roads, railways, communication and food storage facilities to make delivery possible to another part of a country or region suffering from a lack of food. Other institutions that facilitate the functioning of markets are included. The economic dimension means that people can afford to buy sufficient food and the importance of market systems to ensure access to food. The social-cultural dimensions is of importance as food insecurity may occur when people are not able to have access to food due to being a member of a particular social group or even gender, so-called social conflict.

There are two ways to access to food according to FAO (1997): First is the ability to produce which is a direct access to food. Another is people's ability to exchange their assets for food such as barter, purchase and food-for-work. Their income; their access to, use of and/or ownership of land; their livestock; their labor and the products of their labor; their inheritance; and gifts and transfers are some examples of people's assets (FAO, 1997). But both ways depend on the access to resources (land, labor, tools, seeds, drought power, credit, agricultural services, knowledge to grow crop) to some extent.

1.2.3.3 Utilization

This dimension can be defined from the part of the definition of food security that states "safe and nutritious food which meets their dietary needs". Napoli et al (2011) mention that the food consumed has to provide sufficient energy for routine physical activities. Safe drinking water, adequate sanitary facilities, awareness of food preparation and storage procedures are within the element of utilization (Napoli et al., 2011). Quantitatively mainly expressed in terms of calories and qualitatively considering diets including protein, micronutrients, safety and cultural acceptability are both of importance in nutritious food. As for grain legumes, they provide protein, a variety and different concentrations of micronutrients (vitamin B, iron, calcium, zinc) and fat which is usually deficient in African diets (Jager, 2013). Besides the nutrients that grain legumes have, Jager (2013) points out the importance to consider bio-availability particularly for grain legumes which contain high amounts of anti-nutritional components. It is said to be nutritious food when there are good quantity and quality of nutrients and high bio-availability which is affected by anti-nutritional factors, preparation method and a good combination with other food that does not decrease the absorption of nutrients (Jager, 2013). It is notable than within a household, what is adequate for one member is not adequate for another as a requirement for persons' nutrients differ depending on many

factors such as age, sex, level of activity and physiological status (FAO, 1997).

1.2.3.4 Stability

Stability means food must be present "at all times" in terms of availability, access and utilization for food security to exist. It is temporal determinant and this can affect any or all of the other 3 dimensions of food security (Napoli et al., 2011). In terms of households, it is the ability of a household to procure food on a continuing basis through income or production in any situation such as crop failure, market fluctuations, decline of employment and loss of productive capacity because of sudden illness (FAO, 1997). Maxwell and Frankenberger (1992) distinguish between chronic food insecurity and transitory food insecurity. Besides this distinction, there is seasonal food insecurity which falls between chronic and transitory food insecurity. Seasonal food insecurity occurs when there is a cyclical pattern of inadequate availability and access to food, which is caused by, such as, seasonal fluctuations in weather conditions, cropping patterns, labor demand and disease (FAO, 2008). It also includes that procuring foods from a market is more difficult the longer after the harvesting season, owing to the increasing price.

In the long-term, stability is also understood as maintenance of resources. If the use of resource is not sustainable, people cannot have food security at all times. In this regard, the role of legume fixing nitrogen biologically resulting in high soil fertility in the long-term is important.

In addition, the threat of climate change is likely to disrupt the four dimensions of food security. The risk to food insecurity brought about by climate change is expected to be higher for the poor and other vulnerable such as small-holders who are geographically located in sub-Saharan Africa and South Asia (HLPE, 2012). The role of legumes in mitigation of climate change is worth notice. Jensen et al (2011) explain that cultivating legumes for soil fertility reasons results in lower green-house gas missions compared to the system that is fertilized with industrial nitrogen, and legumes also play a role in soil carbon sequestration.

1.2.4 Women empowerment

Legume is generally regarded as woman's crop in sub-Saharan Africa (Kanesathasan, 2012; Mapfumo et al., 2001). Processing of legumes is also a responsibility of women. The use of legume stalks for fuel wood made great relief on rural women allocating their labor more efficiently to others because women spend most of their energy on load-carrying activities involving transport of fuel wood, water, and grain for grinding (*Gender in Agriculture; Source book*, 2009). And when this feature of legume is combined with the N2Africa legume technology targeting specifically women participants, it is expected that the legume production especially for those households which adopted the N2Africa legume technology will play a role for women empowerment. CGIAR (2013) illustrates that their grain legume programme increases women's employment opportunities and enables smallholder women farmers to participate equally in decision making process.

The improved access of women is measured by Women's Empowerment in Agriculture Index (WEAI). WEAI is a survey-based index comprised of two sub-indices : Five

domains of empowerment in agriculture (5DE) and Gender parity index (GPI) to track the change in women empowerment as a result of a food security interventions (IFPRI, 2012). Instead of calculating the WEAI index, 5DE is referred to developing the questionnaire. The five domains are production, resources, income, leadership and time related to agriculture. There are several indicators within each domain and each domain is equally weighted, and within each domain the indicators receive equal weight. Sraboni et al. (2013) explain the 5 domains as follows. 'Production' domain indicates the decisions over agricultural production, and indicating the sole or joint decision-making over food and cash-crop farming and livestock and also the autonomy in agricultural production of women. 'Resource' refers to ownership, access to and decision-making power over productive resources such as land, livestock, agricultural equipment, consumer durables, and credit. 'Income' concerns the control over the use of income and expenditures. 'Leadership' domain measures the women's social involvement as a group member and whether she feels comfortable speaking in public. 'Time', concerns the allocation of time to productive and domestic tasks, and to leisure activities. 5DE is elaborated in the Table 2. Among the five domains, only production, resource and income domains are referred in the questionnaire since these are considered to be the most relevant to be affected by agricultural technology of N2Africa.

Table 2 The five domains of empowerment in the WEAI

Domain	Indicator	Definition of indicator	Weight
Production	Input in productive decisions	Sole or joint decision making over food and cash-crop farming, livestock, and fisheris	1/10
	Autonomy in production	Autonomy in agricultural production. Reflects the extent to which the respondent's motivation for decision making reflects his/her values rather than a desire to please others or avoid harm	1/10
Resources	Ownership of assets	Sole or joint ownership of major household assets	1/15
	Purchase, sale, or transfer of assets	Whether respondent participates in decision to buy, sell, or transfer her owned assets	1/15
	Access to and decisions on credit	Access to and participation in decision making concerning credit	1/15
Income	Control over use of income	Sole or joint control over income and expenditures	1/5
Leadership	Group member	Whether respondent is an active member in at least one economic or social group	1/10
	Speaking in public	Whether the respondent is comfortable speaking in public concerning various issues, such as intervening in a family dispute, ensure proper payment of wages for public work programs, etc.	1/10
Time	Workload	Allocation of time to productive and domestic tasks	1/10
	Leisure	Satisfaction with the available time for leisure activities	1/10

Source: Alkire et al (2012)

Women's access to resources, appropriate farming practices, infrastructure and knowledge and education is important for household food security (FAO, 1997). Based on the definition of domains in Table 2, in this research, women empowerment is categorized to the access pillar of food security. In addition to this, women empowerment is seen to indirectly improve the utilization domain, since high decision making power of women will improve access to nutritious food as well as the investment in health and education considering that malnutrition is aggravated by disease and lack of health care, not only due to the poor quantity and quality of foods (Jager, 2013). This will be tested in this research whether women prioritize their household expenditure on food, food-related items, health and education than men do. The linkage between women empowerment and improvement in nutrition security is already found in McDermott et al (2013). Women, more than men, spend their incomes on food resulting in improved household food security and nutritional security as well as the development of children (*Gender in Agriculture; Source book*, 2009). This is also demonstrated that gender empowerment is necessary to achieve household nutrition security (FAO, 2011; Gillespie et al, 2012). Hyder, et al (2005), Ibnouf (2009) and Maxwell (1999) reveal that women enhance their households nutrition status by food preparation, processing of food products, and daily determining of quantity and quality of food provisions that are all carried out by women. Therefore in this regard when the legume production with N2Africa technology contributes to women empowerment, it reaches to the utilization pillar of food security. This change in gender roles by N2Africa which may affect how household income is spent is also expected in Jager (2013) with the potential pathways described by Hoddinott (2011) through which improved agricultural interventions may improve nutritional status.

1.3 Problem definition

1.3.1 Comprehensive approach to household food security needed

There have been revisions of the food security definition, from the focus on food availability until the current multidimensional approach. Food security cannot be discussed only in terms of a single dimension of the food security definition. Considering the context where food insecurity occurs, it is natural to conclude that the four dimensions should be taken into account at the same time. It is asserted in FAO (2008) that all four dimensions must be fulfilled simultaneously to realize the objective of food security. Within the N2Africa research, the role of legume on food security has been investigated mainly in terms of food availability and protein in diet and livelihood is mainly determined in terms of income. This ignored important aspects such as access and stability, women empowerment and different livelihood capitals and outcomes.

Although there are assessments relevant to access and availability within the N2Africa research, the data that deal with the 4 sets of food security dimensions at the same time in the same region still lack. To evaluate the achievement of the N2Africa in terms of food and nutrition security by 2019, assessing only one aspect of food security is not enough to lead to the complete conclusion. To take India for example, India moved from food deficit to food surpluses and reduced poverty significantly. Yet 210 million people are undernourished and there exist 39% of the world's underweight children (The World Bank, 2008). It illustrates the misleading food security assessment when including only a single

dimension, and the gap between national and household food security. Assessment only with availability dimension more detrimental when it comes to household food security in which the access is of particular importance. The research focuses on household food security as measuring household food security allows precise targeting of vulnerable households who are most likely to be affected by interventions, in particular when the purpose of food security research is to inform actions diagnostically (Barrett, 2010). Thus, systematic food security assessment covering all dimensions is required. It is in line with the food security approach of the FAO and World Food Programme (WFP). In 2013, FAO developed a suite of indicators of 4 dimensions of food security. This results in the comprehensive assessment in 'the State of Food Insecurity in the world' by FAO (2014), in which the conclusion is categorized by the 4 pillars of food security. WFP also takes 'Comprehensive Food Security and Vulnerability Analysis (CFSVA)' to have a deep picture of the food security situation and the vulnerability of households.

With respect to women related activities of N2Africa, it merely considered the involvement of women in the activities under the objective 4:'Develop strategies for empowering women to benefit from the project products' of the Activity 5 (de Wolf, 2014). It is limited to judge women empowerment only through the participation rate of the activities. Involving women into the N2Africa would be the first step for empowering women, while the linkage between the women participation and the women empowerment of their decision making power in various domains is still missing. Proving the linkage would finally lead to benefit women from the project products. Having achieved women participation of more than 50% in the N2Africa activities in Malawi in the first phase, it is necessary to measure women empowerment taking into account their actual decision making power from various angles.

Although livelihood can be simply understood as a means of living of a household, it is not enough to understand the whole picture of livelihood given that the means of living is determined by capabilities and assets of a household. Although agriculture is only one part of people's livelihood, understanding the other factors is essential to improving the ultimate impact of agricultural research (Adato and Meinzen-Dick, 2002). In Malawi where most of the people are involved in agriculture, it is critical for agricultural research to consider many intervening factors at multiple levels through livelihood approach. To investigate the role of legumes for people's livelihood with special focus on food security will be of main importance to capture the role of legume on food security comprehensively. It is expected from this thesis research to have a broader view on the role of legumes on food security and livelihood by approaching the issue through the sustainable livelihood framework and thoroughly looking into the four pillars of food security.

1.3.2 Potential of low adoption of agriculture technology by low resource endowed farmers

In the previous research by Brand (2011), small-farms in Malawi districts of Salima and Mchinij are stratified into five different farm types in the light of better adoption of legume technologies. Franke et al (2014) conclude that the grain legumes have excellent potential as food and cash crops particularly for medium and high resource endowed

farmers, while for low resource endowed farmers legumes can improve food self-sufficiency of household only if legumes are managed with P fertilizer and inoculation for soybean. And they point out that the adoption of legume technologies by poorer farmers could be limited due to the features of low resource endowed farmers, which are risk averse and have few resources to invest. This is in accordance with Adato & Meinzen-Dick (2002) who claim that often the adoption of agricultural technologies depends on the assets required to realize it. For example, large holdings (natural capital) and agricultural credit (financial capital) and roads or transportation (physical capital) are required to permit 'Green Revolution' agricultural technologies. Likewise to a lesser extent the legume technology of N2Africa is likely to be less attractive to the household with low-resource endowment among small holdings, which may result in inequality.

The conclusion of Franke et al (2014) might imply that targeting mainly the high-resource endowed households would be efficient to disseminate the N2Africa technology, which aggravates the inequality issue. This is also found in the conclusion of Tittonell et al (2010) stating that farmers in the poorer categories, who lacks access to resources leading to pursuit of non-farm livelihood strategies, should be the major beneficiaries of social promotion intervention, while those "that exhibit a more agriculture-based livelihood strategy are more likely to implement and eventually adopt proposed technologies for agricultural intensification". The importance of delivering benefits equally to the heterogeneous smallholders is pointed out in the report of The World Bank (2008), which clearly asserts "the heterogeneity of smallholders calls for differentiated agricultural policies that do not favor one group over the other, but that serve the unique needs of all households". This is of importance for N2Africa given that it targets smallholder farmers, particularly when it comes to Malawi where the rural inequality is increasing (FAO, 2014). At this point, there is need for a further N2Africa research to improve adoption rates among low resource endowed farmers rather than merely stating the high adoption rate realized by high resource endowed. It is recognized that social capital can facilitate the adoption of technologies for the worse-off farmers, usually in a form of collective action to coordinate the action of individuals for common investment. The contribution of N2Africa to creating social capital should therefore be part of the investigation. This is critical in food security research since the ability to ensure adequate food security depends on the ability to identify vulnerable households (FAO, 2003). This also supports the need of using farm stratification in food security and livelihood assessment for N2Africa. Furthermore, although adoption rate for legume technology is likely to be lower for low resource endowed households, the impacts of N2Africa might be different between the farm types depending on the types of impact. And its impacts might be higher for low resource endowed household than high-resource endowed households in terms of food security and better livelihood. Based on Figure 1, the agricultural technology, N2Africa can be likely to work as an asset of low-resource endowed easily whose assets are small in number. And, N2Africa can increase the access of the resource poor households whose constrain is mainly the limited access to resources, showing that the agricultural technology can be considered as a component of policies, institutions and process (PIP) (Figure 1) to which access dimension is mostly related. This aspect of appreciation needs to be further investigated.

Without consideration of the four pillars of food security at the same time, misleading food security assessment could be made. It is important for N2Africa of which one of objectives is to achieve food and nutritional security by 2019, while there has not been the comprehensive food security approach at the same time for the same region. Comprehensive food security assessment also started to be carried out by international organizations such as FAO and WFP. Having achieved more than 50% of women participation for N2Africa activities in Malawi, it requires to prove the linkage whether the high participation of women leads to women empowerment in their decision making power. Livelihood is not a simple concept which cannot be just captured through income. By broad understanding of livelihood through SLF, it helps to improving the ultimate impact of agricultural research as well as the comprehensive view on food security. The possible inequality implication of N2Africa favoring high resource endowed household should be complemented by exploring the ways to improve adoption rate by low resource endowed household. And besides the research on adoption rate of N2Africa, the impacts of N2Africa by different farm types should be investigated. Therefore, the roles of legumes in household food security will be investigated using the four pillars of the food security definition with the sustainable livelihood framework and the women empowerment index. Furthermore, the impact of legume technology of N2Africa on different farm types will be investigated as well as the social capital as one of ways to improve adoption rate.

1.4 Research questions and their operationalization in the context of the project

1.4.1 Seven roles of legumes

To begin with, 7 roles of legumes are identified and they are distributed over the 4 pillars of food security.

1. Availability: Is maize yield increased by using legume in rotation or intercropping?

   It is hypothesized that maize yield will be higher at the same plot of land when legume is intercropped or rotated due to the role of the latter of nitrogen fixation, weed control and cutting off pest and disease cycles, compared to continuous maize cultivation on that plot.

2. Availability: Do legumes substantially contribute to calorie provision of household?

   In terms of calorie intake, it is hypothesized that the relatively high energetic value of legume will substantially contribute to daily calorie intake of household members.

3. Access: Do legumes substantially contribute to the household income?

   It is hypothesized that legumes will have a substantial contribution to the household income as it has a higher price in the market than the surplus of maize, and processed legume such as oil and milk may be sold even at higher prices.

4. Access: Do legumes decrease the dependency of inputs?

Rising fertilizer costs made fertilizers unaffordable to small-holders. It is hypothesized that they are less dependent on fertilizer inputs as legumes can be used as an alternative fertilizer (Kerr et al. 2007). Using legume can also make them less dependent on food from other sources.

5. Utilization: Do legumes increase the quality of diet?

   Within household, it is hypothesized that protein, fat and micronutrients intake from legume will enhance the quality of diet.

6. Utilization: Do legumes enhance women empowerment?

   It is hypothesized that legume contributes to women empowerment.

7. Stability: Do legumes contribute to stability of food security?

   Stability dimension is specified as follows; a. Legumes may reduce the seasonal hunger. b. Legumes provide more diverse diet assuring the long term health of household members. c. Fertilization effects of legume will contribute to maintaining the resource base for food production.

1.4.2 Research questions and sub-questions

The 7 questions can now be grouped under three main research questions (RQ1, 2 and 3) and operationalized in sub-questions in relation to N2Africa interventions.

RQ1. Did households which adopted legume technology of N2Africa improve the household food security, taking into account the multidimensional definition of food security?

1.1 Was the maize yield of the households which adopted legume technology of N2Africa increased by using legume in rotation or intercropping?

1.2 Did legumes contribute to daily calorie intake of the households which adopted legume technology of N2Africa and increase stability by contributing to daily calorie intake during the hunger season (1.7a)?

1.3 Did legumes substantially contribute to the household income of the households which adopted legume technology of N2Africa?

1.4 Did legumes decrease the dependency on inputs of the households which adopted legume technology of N2Africa and potentially improve the long term stability of the resource base (1.7c)?

1.5 Did legume increase the quality of diet of the households which adopted legume technology of N2Africa thereby potentially increase household stability in terms of human health (1.7b)?

1.6 Did legume enhance the women empowerment of the households which adopted legume technology of N2Africa?

RQ2. Did the households which adopted legume technology of N2Africa improve their livelihood?

The 7 roles of legumes are tested in the section of vulnerability context, assets base and change in policies, institutions and process.

RQ3. Does the impact of the legume technology of N2Africa on food security and people's livelihood differ between farm types?

For each sub question of RQ1 the impact per farm type is investigated. For instance sub-question 3.3 "Did the contribution of legume to the household income differ between the farm types of the households which adopted legume technology of N2Africa?".

2. Research site and background

Figure 2. Map of Malawi districts

Source: Adapted from National Statistical Office, 2011

2.1 Geography, topography and climate

The research was conducted in Salima district situated in the central region of Malawi. It is about 103 kilometers away from the capital of Malawi, Lilongwe. Sample villages are located along the road from Salima to Lilongwe. Villages about 20 kilometers away from the Salima center are reached. Lilongwe river flows from Salima to Lilongwe, thus some villages about 6 kilometers away from the Salima center have rather easy access to river, cultivating their crops along the river.

The altitude of the district varies from the rift valley floor ranging from 200 to 500m above sea level along the lake, to hilly places, upland area with an altitude ranging from 500 to 1000m above the sea level (*Salima District Socio Economic Profile*, 2006). The lakeshore where Salima is located is described to have calcimorphic soil dominantly in the valleys (Reynolds, 2000), but in general, soil in Salima varies from clay-loam, alluvial deposits, deep dark clay and black to red shallow stony solids (*Salima District Socio Economic Profile*, 2006).

There are three short seasons which are, hot wet season from November to April, hot dry season from August to October and cool dry season from May to July (*Salima District Socio Economic Profile*, 2006). Hot wet season is when usually main crops are being cultivated. Salima district experiences higher temperature than Lilongwe as it is located in lower altitude. According to the statistical year book by National Statistical Office (2012), the annual average rainfall between 2002 and 2011 is 1285mm in the district, which is estimated as the 4^{th} highest rainfall among the total of 18 districts in Malawi. They measured the average monthly temperature between 2002 and 2011 in Salima is 25 ^{0}C (degree celcius), the average monthly maximum temperature is 29.5 ^{0}C the minimum temperature 20.5 ^{0}C. This is the 5^{th} highest temperature among the total of 18 districts in Malawi (National Statistical Office, 2011). The growing season in Salima varies from 120 to 150 days (Reynolds, 2000).

2.2 Land tenure system

This section mainly refers to the chapter 3 Land Use of *Salima District Socio Economic Profile* (2006). There are three land tenure systems, that is; customary, private and public land.

Customary land system is that the land is administered by chiefs on behalf of the government. The chiefs have been delegated the role of distributing land and cultivation rights to their subjects and report to the government. Most of the arable land is under the customary land system. In Salima, about 78% of the land is under customary land system, and this land is usually used for subsistence farming. Private land is the land owned by individuals, companies and other institutions except government, which accounts for about 18% of the land in Salima. This land is mainly used for extensive farming, hotels or houses etc. Public land is the land owned by the government, and is used for government institutions. About 4% (9.025 hectares) in Salima is within this system.

In the sample, only households under customary land system are included. Therefore it implies that it is important to have a good relationship with the village headman. Kaspin (1996) also states that village headmen and their close kin have the best land for their own uses while the marginal land is distributed to more distant relatives and strangers. Chieftainship is a dominant tradition in Chewa communities.

2.3 People: Ethnic group and marriages

In central region of Malawi, Chewa tribe is predominant, and in Salima, one of the central districts, Chewa and Yao are major tribes in the district (*Salima District Socio Economic Profile*, 2006). Yao tribe is dominant close to the lake, while Chewa is dominant on the

opposite to the direction of the lake. Yao tribe usually believes in Islam. One of the distinct differences observed was that Chewa tribe tends to educate their children even girls at school, whereas the children of Yao tribe start working instead of going to school.

Christianity and Islam are the two major religions. Over 60% of the people in Salima are Christians, followed by Islam with 30%, and the rest are considered to be cult or to believe in animism (*Salima District Socio Economic Profile*, 2006).

In Malawi, matrilineage is common in the center, including Salima district, and the South (Reynolds, 2000). In the patrilineal marriage, the woman moves to the man's home and the man pays bridal fees to the parents of the bride for thanking (*Salima District Socio Economic Profile*, 2006). In the matrilineal system, the man settles at the woman's home and cultivation rights are inherited by the wife (Reynolds, 2000). Gough (2004) claims that traditionally Chewa was a matrilineal society, however today, they allow influences of both matrilineal and patrilineal leadership, which is confirmed by one of the extension workers in Salima. Likewise, these two types of marriage coexist in the samples which all belong to Chewa tribe. It was observed that when it is matrilineal marriage, the cultivated land was usually "owned (the cultivation right)" by the wife, as for patrilineal marriage, they utilize both land of wife and husband. Depending on the type of the marriage relevant to the different land "ownership of the cultivation right", the status in the household could differ as "landowners" (who owns the cultivation right) are considered to have higher status (Gough, 2004).

2.4 Food

The Chewa diet is comprised mainly of *Nsima*, a thick porridge made from maize flour and *Ndiwo* which is a relish usually prepared with leafy vegetables, bean and other ingredients ("Chewa and other Maravi Groups," n.d.). Morris (1998) states that Chewa prefers meat, however there tended to be a scarcity of meat of livestock and lack of purchasing power to buy meat in the market. Therefore, they often enjoy other forms of meat including fish, insects, locusts, bats, chickens, mice, antelope and any other mammals (Morris, 1998).

2.5 Agriculture

This section mainly refers to the chapter 5 Economy of *Salima District Socio Economic Profile* (2006). The economy of Salima district depends much on agriculture. They reports that about 93% farm families get their income from agriculture and 80% of people are employed in this sector. Food crops in this district are maize, rice, cassava, sweet potatoes, millet, sorghum and groundnuts. Comparing root vegetables of cassava and sweet potatoes, the production of sweet potatoes is higher than cassava. Thus sweet potatoes are more important as food security crop than cassava in Salima district. Tobacco, cotton, grain legumes, sweet pepper, fruits and vegetables are the main cash crops. Area cultivated with tobacco has decreased recently unlike that of cotton. This can be explained by the high input costs incurred in tobacco production, and at the same time the governments cotton up-scaling program subsidizing cotton seeds and pesticides.

More than 75% of land in Salima is used for production of maize, pulses, ground nuts,

cotton, cassava, sorghum, sweet potatoes, mangoes and bananas. Table 3 shows the dominant cultivated crops in Salima. Maize constitutes the largest area cultivated as it is a staple crop, followed by cotton and groundnuts. This shows that among the grain legume, groundnuts cultivation widely spreads out in Salima. In general, legumes, common beans, pigeon pea and groundnuts are traditionally grown by smallholders in Malawi (Reynolds, 2000). However, common beans are not often cultivated in Salima due to the high temperatures in the district.

Table 3. Crop area cultivated by smallholders in Salima district

Crop	2004-2005(ha)
maize	39335
cotton	10922
groundnuts	5294
sweet potato	2618
cassava	1364
rice	1298
burley	762

Source: Adapted from Salima District Agricultural Office, 2006

2.6 Farm input subsidy program

Farm input subsidy program (FISP) was launched in 2005/2006 to increase the agricultural production, and is by far the largest agriculture support program (*Republic of Malawi, Sustainable agricultural production programme (SAPP) Programme design report*, 2011). FISP is administered through coupons that allow beneficiary to purchase fertilizer and seeds at significantly reduced prices (Schutter, 2014). The full package includes 5-10kg of maize and legume seeds respectively and 100kg of fertilizer (Pauw and Thurlow, 2014). They state that FISP is primarily a maize production subsidy, although it currently includes a legume component, the seeds. The program put emphasis towards providing hybrid maize seed rather than seed of both hybrid and open-pollinated varieties, and planned fertilizer distribution has varied between 150,000–170,000 metric tons per year (Pauw and Thurlow, 2014). It targets 1.5 million beneficiaries, who each receive inputs sufficient for approximately 0.33 hectares of land if the inputs are applied as recommended (Schutter, 2014). However, not all beneficiary households receive the full subsidy package due to sharing of seed or fertilizer coupons. The beneficiaries are selected by village headmen, and there are a fixed number of coupons assigned to each village. Schutter (2014) points out that targeting beneficiaries is one of problems of FISP. Although FISP officially targets vulnerable resource-poor Malawians who own a piece of land and can make effective use of the subsidized inputs, the allocation of the coupons is revealed to be unequal requiring more transparency in the allocation process according to the assessment of Schutter (2014).

3. Materials and methods

Semi-structured interviews with translators were conducted with questionnaire for the 50 households in Salima district from April to June in 2014. The questionnaire includes quantitative and qualitative data (Appendix 5). Quantitative data is analyzed by SPSS statistical package, and qualitative data is mainly presented as percentage. Casual observation and informal conversation with extension workers were used to complement the information acquired.

Samples were selected by extension workers who also performed as translators. Respondents for interview were either a wife or a husband of the households depending on the questions and availability of them. All households in the sample are cultivating at least one of any grain legumes in 2013/2014. They consisted of 25 households participating in N2Africa, which were provided with one of the seeds of grain legumes by N2Africa, and 25 households of those not participating in N2Africa (Non-N2Africa). It is assumed that there is no difference in the samples inherited from ethnic group as all samples except one household in which the wife is half Chewa mixed with Yao, are Chewa tribe. Convenience sampling was used with several criteria to balance the socio-economic state of N2Africa and Non-N2Africa samples. In the text, N2Africa household is abbreviated to N2 and Non-N2Africa household is to Non-N2 or Non. 'Stratum' is often omitted, hence 'Low' indicates low stratum and 'High' for high stratum. Every sampled household is visited twice before and after the maize harvest. It is mainly to repeat the interview to investigate the differences in quality of diets and calorie intake of households between maize harvest seasons.

3.1 Sampling methods

Three extension workers worked as translators. Four interviews for two N2 household and two Non-N2 households were planned in a day. First interview of each day usually started with a lead farmer of the village or a village headman. Lead farmer is a leader of the N2Africa group in the village who delivers the knowledge acquired in the N2Africa training. And then the rest of the households were chosen neighboring the first household. When selecting the households, there were three criteria: i) households who had not harvested maize yet for the first interview, ii) households without polygamy but comprised of a wife and a husband and iii) households which did not participate in other projects when possible.

The first criterion is to see whether there are seasonal differences to compare before and after the maize harvest in quality of diets and calorie intake of the households. The second one is due to the women empowerment question comparing a wife and a husband in the same household. The household samples mainly comprised parents and children. Female-headed, or orphan-headed households were excluded for sample selection. One household was a family consisting of a brother and a sister with their grandchildren. Among the household, only two households were under polygamy. The data of household comprised of a brother and a sister is excluded for the women empowerment questions. The last criterion is to minimize the effects of other projects in order to compare the sheer effects of N2Africa. Households which have not participated in any projects except N2Africa

project were preferentially selected for Non-N2z samples and N2 samples. Yet, 34 out of 50 samples have participated in other projects initiated by other organizations. Within the total number of 25 of N2 sample, 19 households have participated in other projects, while within the total number of 25 of Non-N2 sample, 15 household have participated in other projects. There were no other projects which directly intervene with the grain legumes.

After the first 10 interviews, socio-economic status of the household was taken into account when selecting the next households to be interviewed. Since the first several samples are mostly distinguished as low stratum by some of the wealth endowment indicators which are calculation of assets, livestock ownership and housing type, the next households are selected from those, whose roof is made of iron or who own cows to balance the sample composition of N2 and Non-N2 groups for socio-economic factor. This procedure was made on a daily basis.

With the first translator, within N2 households only those were interviewed that continued with N2Africa variety and those who were provided with groundnuts. With the second and third translator, households were preferentially chosen who were provided with cowpea or soybean. And once the N2 household interviewed appeared to keep using the same variety of N2Africa cowpea or soybean another N2 household which dropped out in the same village was interviewed. However, since the first criterion of households 'before maize harvest' was the first priority which must be fulfilled, and this was difficult due to the time of interviewing close to the maize harvest, the rest of the criteria were not strictly observed.

As a result, 50 households (25 of N2 household, 25 of Non-N2 household) were selected by extension workers using the pre-set criteria. 9 out of 25 N2 households are those who dropped out of N2Africa activity. In the population, there are two types of households participating N2Africa, one is those who keep using the same variety of grain legume which was provided by N2Africa marked as 'continuing', and others named as 'drop-out' are those who stop using the same variety of grain legume introduced by N2Africa. More information about continuing (drop-out) is elaborated in Appendix 1. The results can be influenced by the ratio of continuing and drop-out households in N2Africa samples. In the sample, more continuing households (56%) are included than the village level ratio (46%) shown in Table 4. It may be possible that the results for the N2Africa impact are more positively judged than the real. Furthermore, questions were formulated as 'grain legume' which aggregates groundnut, cowpea and soybean. The numbers of households introduced by the three grain legumes are not equally weighed in the sample. Instead, comparing the households in the villages and in the sample, households given soybean in the sample (5) were less represented than those in the villages (89) compared to other grain legumes (Table 4). However, the continuing ratios by grain legumes are comparable between the households in the village level and in the sample.

Table 4 Average continuing ratio[a] of N2Africa by grain legumes between the households in villages and in the sample

	Average continuing ratio		Groundnut	Cowpea	Soybean
Households in the villages[b]	46%	Number of total households participating in N2Africa	157	60	89
		Number of continuing households	91	27	30
		Continuing ratio	58%	45%	34%
Households in the sample	56%	Number of total household participating in N2Africa	14	6	5
		Number of continuing households	11	3	2
		Continuing ratio	79%	50%	40%

[a]continuing ratio = (number of continuing households) / (number of total households participating in N2africa)
[b]The villages are where the samples are selected.

Table 5 below shows that there is no significant difference between N2 and Non-N2 groups in the size of the arable land, livestock ownership and assets suggesting that the interviewed two groups are comparable in terms of wealth endowment. Mann-Whitney U test is used since the data do not satisfy the normality assumption for comparing the mean values of the groups verified by the Kolmogorov-Smirnov test.

Table 5. Verification of equivalence of samples of N2Africa and Non-N2Africa households in resource endowment indicators

	size of arable land	livestock	assets
Unit[a]	ha	US $	US $
N2 (n=25)	1.70(0.9)	97(180)	98(154)
Non-N2 (n=25)	1.30(1.0)	48(134)	103(103)
Sig.[b]	.116	.095	.793

[a]Values expressed as median(interquartile range)
[b]Mann-Whitney U test at $p<0.05$
*N2=Households participating in N2Africa, Non=Households not participating in N2Africa

3.2 Data collection

Data was collected through semi-structured interview with questionnaires using a translator to overcome the language barrier. Draft questionnaire was revised with the extension workers and the coordinator of Makandi EPA after a trial interview of a N2Africa household. Casual observation and informal conversation with extension workers are also conducted. For the question about their household sources of income respondents were asked to distribute a fixed number of beans proportionally over the

suggested sources, for the ranking of expenditure over different categories, respondents were asked to pick a picture representing the categories one by one in order of importance.

3.2.1 First and second visits

Households were visited twice with a month in between. It is mainly to investigate the differences in quality of diet and the calorie intake in a household before and after the maize harvest. Also the questions are distributed to be asked for the first and second visits to lessen the load for each interview. For the first interview, general information of the household, livelihood questions, calorie intake from legume and maize for the previous month, source of income with a ranking, production costs and market information of each crop, dependency on external input and quality of diet asked to women are asked. If allowed to sit only with the woman, the questions for women empowerment were asked. The second interview was conducted in the same order as the first interview to have the same interval between the households. Calorie intake from legume and maize for the previous month and the quality of diet of women are repeated in the same way. Source of cash income is asked again with proportional piling using same size of the beans. Maize yield affected by legume from rotation and intercropping, processing of legume, household expenditure, desired household expenditure by woman and man are asked for the second interview.

3.2.2 Special method for asking

Household expenditure questions were asked by ranking. The number of items varies with the questions, up to 15. Since this is too many for respondents to memorize and subsequently choose each item by their preferences or household situations an alternative method was used. Pictures were provided with sufficient explanation what they represented. The pictures of each item were drawn by the author, and the same are used for every respondent. Respondents had to pick the picture they rank most important first, followed by the next importance (Figure 3).

Figure 3 Ranking question for household expenditure asked with pictures

Source of cash income at the 2nd interview was asked using a fixed number of beans. Respondents were asked to allocate the number of beans proportionally to their sources of

cash income. 50 beans were used in total, and the quantity of beans on each source of cash income is doubled to sum up 100 for percentile.

Some questions in women empowerment were asked to choose one answer among the 5 quartile proportion 0%, 25%, 50%, 75%, and 100%. As respondents had difficulty understanding the different proportions, they were to choose one answer among the five circles colored with different proportion. Each circle is divided into quarters to represent the quartile (Figure 4).

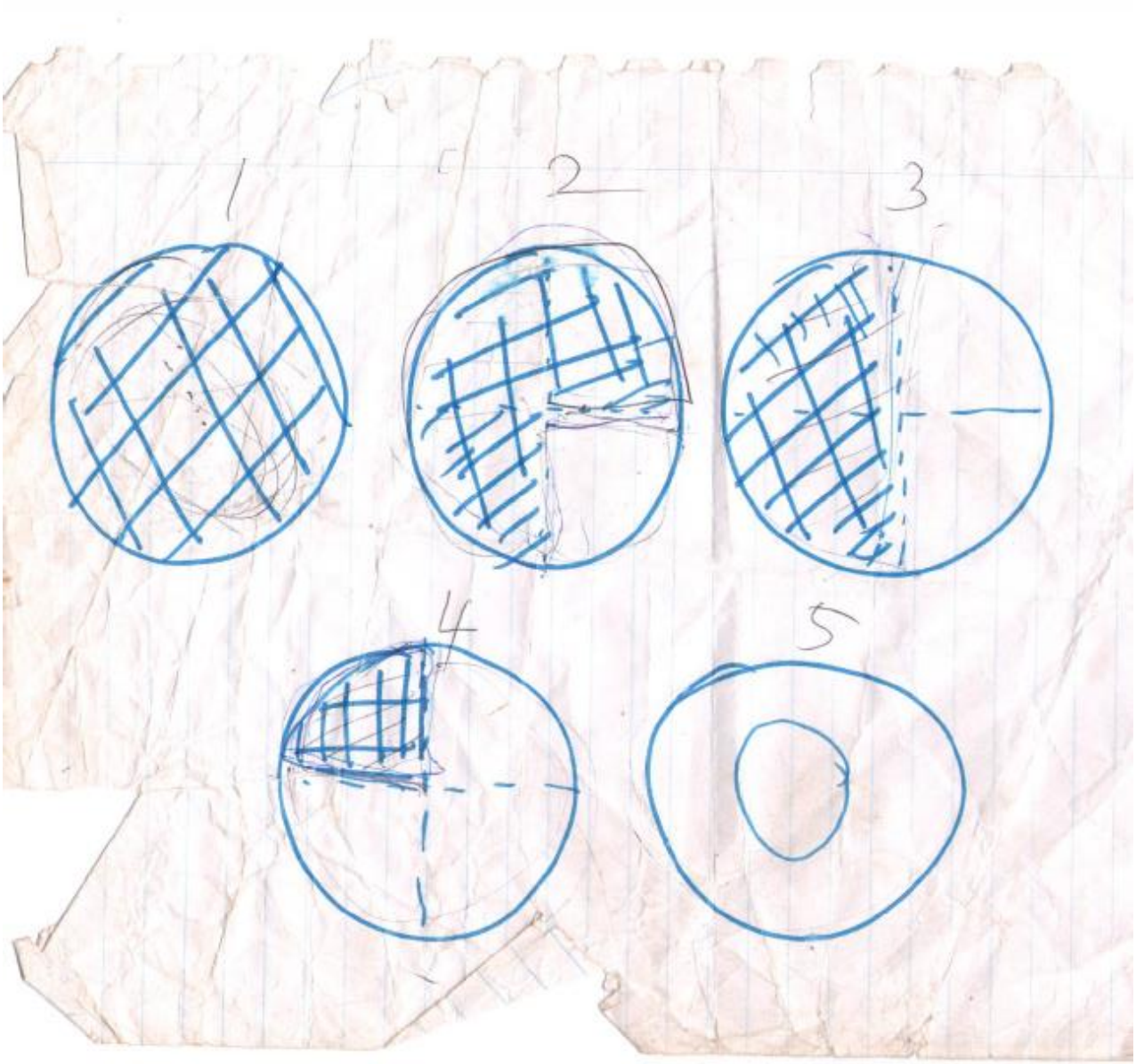

Figure 4 Five quartile proportions used for the RQ1.6 women empowerment question A.1.

3.2.3 Different respondents for each question

Questionnaire is attached in Appendix 5. There are several questions to answer for each research question. Those are categorized by topic with capital letter of alphabet as A, B, C and so on.

Research Question (RQ) 1.5, and from RQ1.6A to RQ1.6C1.1 were asked specifically to the woman respondent in the household. The women respondent was interviewed alone with no presence of her husband for RQ 1.6. If both man and women were available when interviewing, questions were answered by different respondent assuming he or she knows better on the topic of their household. RQ 1.1 were answered by man, RQ 1.2 by woman, RQ 1.3A&B by man, RQ1.3C&D by woman, RQ 1.4 by woman, RQ 1.5 always by woman, RQ 1.6A-C1.1 always by woman, and RQ1.6C1.2 always by man. However, the bias or missing parts of the one respondent answering for his/her household should be considered except for the RQ 1.5 and 1.6. There were no differences in choice of respondents between N2 samples and Non-N2 samples. For the question of livelihood for N2 samples, it was answered by the woman or man who got training from N2Africa project.

3.3 Data handling and analysis

3.3.1 Local unit conversion

Respondents reported the yield in local units as pail, bag or oxcart. The local units are converted into kilogram or ml, confirmed by one of extension who often deals with the local units, Brand (2011), and National Statistical Office (2012). The reported yield of crops only includes grain, without the cob of maize and without the shells of legumes.

Table 6. Local unit conversion into international system of units (SI)

	Maize	Ground-nut	Other grain legumes	Tomato	Fertilizer	Manure	Pesticide
Unit	kg	kg	kg	kg	kg	kg	ml
Oxcart	350					500	
Bag	50	13	50		50	50	
Pail	4.47(5L)	10(20L pail) or 2.5(5L pail)	16(20L pail) or 4(5L pail)			5	
Small plate			0.17*				
Wheelbarrow						150	
Bottle							250
Basin				6.16*			

*National Statistical Office (2012)

3.3.2 Farm typology

Farm stratification is determined by wealth (or resource) endowment, source of income, production orientation. Wealth endowment is comprised of assets, livestock, housing type and arable land. The prices of assets were decided by the average price of the respondents purchasing those and one of extension worker as a key informant. Prevailing exchange rate of 1 US dollar = 400 Malawian kwacha during the data collection period (from April

2014 to June 2014) was applied. Households are divided into Low Resource Endowment (LRE) and High Resource Endowment (HRE) by median of each value, yet they are confirmed by comparing with the division by mean of each value. Households whose values were close to the classification threshold were determined together with the housing type and casual observations. Adapted from the 5 different farm strata Salima by Brand (2011), in this research households were divided only in 2 strata combining strata 1 and 2 from Brand in low stratum , and 3, 4 and 5 from Brand in high stratum.

Sources of income of households were divided into on-farm, mixed with temporary, mixed with enterprise or job, off-farm with temporary, and off-farm with enterprise or job. 'On-farm' households are those who earn over 70% of their annual income from on-farm activities including cropping and livestock keeping. 'Mixed' indicates that households earn between 30 and 70% of their annual from on-farm activities. 'Off-farm' means that households earn less than 30% of their income on-farm.

- with temporary' means the source of income includes temporary business, service or selling labor, while '- with enterprise or job' is when the main source of income is from a small shop or a salary from job. These labels are based on the division from Brand (2011) to distinguish 1,2 strata and 3,4,5 strata. 'On-farm', 'mixed with enterprise or job' and 'off-farm with enterprise or job' are named as High stratum. 'Mixed with temporary' and 'off-farm with temporary' are classified as Low stratum.

Production orientation is determined by the ratio of amount of all crops sold over the total yield of all crops. By quartile, households are classified into 'market-oriented', 'subsistence+high market', 'subsistence+low market', and 'subsistence'. Only Households labeled as 'subsistence' are classified as Low stratum, whereas the rest of them are labeled as High stratum.

The final marking of 'Low' and 'High' is attributed to a household when it is classified into one of these categories in more than two criteria. As a result, 13 households are categorized into 'high stratum' and 12 households into 'low stratum' in the N2Africa group and the Non-N2Africa group respectively with two modifications by the author's observation. The households with iron sheets as roof, and with enterprise or job as source of income are always classified into high stratum

Each stratum is comparable between N2 and Non-N2 samples in the resource endowment since there are no significant differences in all resource endowment indicators between N2-low and Non-N2-low groups, and N2-high and Non-N2-high groups (Table 7).

Table 7 Comparison of resource endowment indicators within each stratum between N2Africa and Non-N2Africa samples

	Low(n=12 for N2 and non-N2)			High (n =13 for N2 and for non-N2)		
	arable land[a]	livestock[b]	assets[b]	arable land[a]	livestock[b]	asset[b]
Unit[a]	ha	US $	US $	ha	US $	US $
N2[c]	1.32(0.42)	38.0(38.6)	53.6(90.0)	2.01(0.85)	207(227)	122(125)
Non-N2	1.09(0.42)	8.55(42.3)	13.5(106)	1.80(1.30)	120(158)	104(238)
Sig.[d]	0.198	0.078	0.319	0.336	0.264	0.650

[a]Value expressed as median(IQR)
[b]Value expressed as mean(s.d)
[c]N2=Households participating in N2Africa, Non=Households not participating in N2Africa
[d]Independent t-test is used for the size of arable land, while Mann-Whitney U test is applied for the other parameters

3.3.3 Casual observation and informal conversation

Before interviews began, open-markets, supermarkets, shops selling farm inputs were observed. When possible, the price and origin of the produce or products of grain legumes were asked to the sellers. By visiting the open-markets during the lunch time and joining the lunch of respondents, common dishes for Malawian people were identified. During the interviews, other trivial wealth indicators were observed, which was briefly noted down for farm typology. The crops in the fields and soil were observed when moving to other households and villages. Numerous pictures were taken.

When there were contradicting answers of respondents while interviewing, it was asked to extension workers after each interview. To have the overview of the N2Africa activities in the first phase, several questions were asked to extension workers about the operations of N2Africa activities at households and village levels. More information about the first phase of N2Africa was acquired by informal conversation with former farm liaison officer of the first phase of N2Africa, important notes were written down.

3.3.4 Qualitative and statistical analysis

Qualitative answers are categorized to present as percentage or as the most frequent answers (mode). Answers for ‘how-?’ or ‘why-?’ questions were mainly used to interpret and support their choice for the given answers. However, only a few of respondents could elaborate those answers.

Statistical analysis is conducted with SPSS and Microsoft Excel. The choice of the statistical tests depends on the type of variables. If the dependent variables are continuous, parametric tests are firstly considered. For the continuous variables, Kolmogorov-Smirnov test is always conducted to verify the normality assumption in order to decide which test to use between parametric tests and non-parametric tests, since parametric tests require normality assumption. For the categorical or ordinal variables, non-parametric tests are performed. Data are described either as mean with standard deviation (s.d) when

parametric test is used, or as median with interquartile range (IQR) when non-parametric test is used. Median is more appropriate than the mean for non-parametric tests (Field, 2013). For nominal variables, Pearson chi-square test is conducted with cross tabulation. When assumptions for Pearson chi-square is not satisfied, the p-value of Fisher's Exact test is alternatively reported since it is an alternative method when Pearson chi-square test is not applicable.

In our data, independent t-test and paired t-test as parametric tests, and Mann-Whitney U test, Wilcoxon Signed Rank test, Friedman's test and Kruskal-Wallis test as non-parametric tests are carried out. The significant p-value is always determined at $p<0.05$. The statistical tests used in each data are always indicated together with tables. It should take notice that Mann-Whitney test, Kruskal-Wallis test, Friedman's test verify the different 'distribution' of each sample (Hart, 2001). Although median is presented for the non-parametric tests, the three tests do not compare the median of each sample, but just a difference between the samples depending on the factors. To explain the mechanism of Mann-Whitney U test, for instance, it takes all of the scores (or data) for the two groups and put them into one column, and rank order them from the lowest to the highest. Then once the ranks are assigned, the scores are split back into the two groups, which is used to decide whether they are significantly different. Technically, Mann-Whitney test, Kruskal-Wallis test, Friedman's test verify the differences in 'mean rank' of each group.

Speaking of sample size for statistical tests, SPSS statistical package (version 20.0) provides the p-value from 'exact test' instead of p-value from 'asymptotic test'. Exact test is automatically performed by SPSS when the sample size is considered to be small usually below 40. Although exact p-value is presented in the results, in our samples where statistical tests are applied, the sample size is even bigger than the threshold values for sample sizes when asymptotic testing is permitted indicated in Siegel and Castellan (1988).

To answer the first research question investigating the role of N2Africa, the results of households participating in N2Africa are compared with those of households belonging to Non-N2Africa as a control group (section 4.1.1 – 4.1.6). Low stratum of N2 and Non-N2, high stratum of N2 and Non-N2 are compared respectively for the different impacts of N2Africa on different farm types for the third research question relevant to the food security (RQ 1). Analysis of the research question for livelihood (RQ 2) is different from RQ 1. The impact of N2Africa is confirmed by two comparisons; before and after participating N2Africa by the Wilcoxon Signed Rank test, Non-N2 Africa and after score of N2Africa by the Mann-Whitney U test. It is attributed to the impacts of N2Africa when the two comparisons both are significantly differently proven. RQ 3 relevant to the livelihood (RQ 2) is made with the comparisons of the low stratum of N2Africa before and after, and high stratum of N2Africa before and after by the Wilcoxon Signed Rank test.

4. Results

4.1 Food security

4.1.1 Maize yield affected by legumes in intercropping and rotation

RQ1.1 Was the maize yield of the households which adopted legume technology of N2Africa increased by using legume in rotation or intercropping?

RQ3.1 Did the impact of legume in rotation or intercropping differ between the farm types of the households adopting legume technology of N2Africa?

Maize field is a field in which the maize is planted in 2014. The number of maize fields is identified together with the maize yield. Only grains of maize are counted as maize yield. Intercropping is counted when there is a different crop between the maize in 2014 even though the intercropped one is not planted in every row in between. Rotational practice is credited when there was at least one crop in the same field other than maize between 2011 and 2014. In both cases, reason for these agricultural practices is reported.

4.1.1.1 Intercropping

There is no significant difference (p=0.501) in maize yield per hectare (ha) between intercropped and not intercropped maize. Median for maize yield when intercropping is 1750kg/ha which is higher than for those not intercropping (1490kg/ha) (Table 8). The number of total sample here is higher than the total number of household (50), since it is based on the number of maize fields (n=70). In the review paper of the cereal-legume intercropping system by Matusso et al (2014), they state that there are several aspects required to be taken into consideration for the success of an intercropping system, such as crop species, density of crops and light interception. This could account for the reason for the insignificant difference when intercropping and not.

Table 8 Maize yield (kg/ha) depending on intercropping in the maize fields

	Group	Number of maize fields	Maize yield[a] (kg/ha)	Sig.[b]
Intercropping	No	4	1490 (1182)	0.501
	Yes	66	1750 (1525)	

[a]Values expressed as Median(IQR)
[b]Mann-Whiteney U test

Since intercropping does not significantly contribute to higher maize yield in the current data, the effect of N2Africa on intercropping is analyzed through the number of households. Shown in Table 9, all N2 households practice intercropping, and 4 households out of 23 Non-N2 households do not practice intercropping. The 4 households not intercropping in Non-N2 are all low stratum households. It is proven by the Pearson chi-square test that N2Africa participation and the households practicing intercropping are significantly related or associated (p=0.046) at a moderate level (Phi Value = 0.341). Since all households of N2Africa irrespective of strata practice intercropping, it seems

there are no different impacts of N2Africa on different strata. The lower ratio of practicing intercropping in Non-N2 households is in line with their perception towards it. Most of the N2 households strongly agree that intercropping helps providing bigger grain of maize and lower pest and disease to maize, whereas most of the Non-N2 households strongly disagree on those. There is no difference in the perceptions between low and high stratum of N2Africa. Both groups respond strongly agree on the inquired two effects of intercropping as the most frequent answers.

Table 9 Number of households practicing intercropping in maize fields

		N2africa	Non-N2Africa[a]
Intercropping	Yes	25	19
	No	0	4
		Value	Sig.
	Pearson Chi Square	4.743	0.046*
	Phi	0.341	0.046*

[a]The information of 2 households in Non-N2Africa is missing
*Significantly correlated at p<0.05

17 respondents reported 'to maximize the land use, double the yield' as the reason for intercropping, followed by soil fertility by 10 respondents. Intercropping to 'get more food', 'because they perform well together either for maize or the crop intercropped and 'by habit or tradition' are next common reasons. When respondents answer with the last two reasons, pumpkin is always intercropped in their field. Other reasons are as follows; as insurance, for testing and for pumpkin to capture the remainder of the fertilizer on maize.

The intercropped crops are all leguminous crops including cowpea, groundnut, soybean and *Tephrosia vogelii* except pumpkin. Many households intercrop several crops on the maize field. A higher proportion of households use legumes as intercrops in the N2 households (18/25=72% versus 11/19=58%) (Table 10). Often the respondents do not use the crop which they think the best due to the non availability of seeds.

Table 10 Number of households with different intercrops of N2Africa and Non-N2Africa

Number of household	Intercropping[a]	Only pumpkin	Only legume	Legume+Pumpkin
N2Africa	Yes=25	6	10	8[a]
	No=0			
Non-N2Africa	Yes=19	8	9	2
	No=4			
Total	Yes=44	14	19	10
	No=4			

[a]One household has pumpkin and cucumber for intercropping

Despite the insignificant effect of intercropping on maize yield, the maize yield when

intercropped with legume and without is tested. Shown in Table 11, there is no significant difference in maize yield whether there is legume in intercropping or not. Breaking down the overall into N2 and Non-N2, neither is there a significant effect of legume in intercropping to maize yield within N2. The significantly higher maize yield of Non-N2 when there is no legume in intercropping (2042kg/ha) than legume in intercropping (963kg/ha) is against expectations of the legume's role increasing maize yield through BNF when intercropping. It suggests that other factors are playing a role. Looking into the strata we can see that among the 19 fields of Non-N2 without intercropping 2 fields of low and 17 fields of high strata are present. Among the 12 fields of Non-N2 with intercropping, 5 fields of low and 7 fields of high strata are present. We can assume that the strata may influence the maize yield given that the high number of field belonging to high stratum in Non-N2 without legume in intercropping, where there is a significantly higher maize yield than with legume in intercropping. The influence of strata on the maize yield could be attributed to the different soil state resulting from the use of mineral fertilizer. When soils are acidic with limited phosphorus availability, it is harmful for BNF process therefore decreasing the N contribution of the legume to the intercropping system (Giller, 2001). The limited use of mineral fertilizer by low stratum due to their financial constraints, could worsen the contribution of legume to increasing maize yield when intercropped (Matusso et al., 2014). Another cause could be that high strata often use hybrid maize seeds that are more responsive to increased N supply.

Table 11 Maize yield depending on the inclusion of legume in intercropping

	Legume in intercropping	Number of fields	Maize yield[a] (kg/ha)	Sig.[b]
Overall	No	28	1750(1422)	0.449
	Yes	38	1750(1458)	
N2	No	9(5;Low, 4;High)	1167(1531)	0.173
	Yes	26 (9;Low, 17; High)	1979(1586)	
Non-N2	No	19 (2;Low, 17;High)	2042(875)	0.005*
	Yes	12 (5;Low, 7;High)	963(1039)	

[a]Value expressed as Median(IQR)
[b]Mann-Whiteney U test
*Significantly different at p<0.01

4.1.1.2 Rotation

There is no significant difference (p=0.751) in maize yield between with rotational practice and without (Table 12). At least one rotational crop was grain legume in every household between 2011 and 2014. Considering the biological nitrogen fixation of the legume benefiting the subsequent crop, another test follows when rotation is credited only when legume is preceding the maize. Yet, there is no significant difference (p=0.538) between with rotation and without consideration of the legume before the maize. Literature shows that grain legumes in rotation with maize play a vital role to increase the maize yield compared to continuous sole maize field (Rao and Mathuva, 2000; Yusuf et al., 2009) However, to be able to realize the potential benefits of the legume-based systems, other farm management practice is required such as integrated pest management

for the case for cowpea and pigeon pea in rotation (Rao and Mathuva, 2000). Adequate nitrogen fertilization also plays a role to acquire high maize yield even with legume-maize rotation (Bonsu and Asibuo, 2013; Yusuf et al., 2009). It indicates that there are other factors contributing to legume-maize rotation system to show higher maize yield than continuous maize system.

Table 12 Maize yield (kg/ha) depending on the rotation in the maize fields

	Group	Number of maize fields	Maize yield[a] (kg/ha)	Sig.[b]
Rotation	No	6	1458(1462)	0.751
	Yes	64	1750(1510)	
Rotation (legume preceding maize)	Yes	33	1750(1371)	0.538
	No	37	1750(1604)	

[a]Value expressed as Median(IQR)
[b]Mann-Whitney U test

Table 13 is generated with the number of households, since legume in rotation for the maize field is proven not to be significant to acquire high maize yield in the current research, in the same manner as the results of the intercropping. Only one household (4%) out of 25 does not practice crop rotation in N2 group, and three households (13%) out of 23 in Non-N2 group. There seems no difference in number of households between low and high strata practicing rotation. It is proven by the Pearson chi-square test that N2Africa participation and households doing rotation are not significantly related or associated (p=0.338).

Table 13 Number of households practicing rotation in the maize field

		N2africa	Non-N2Africa[a]
Rotation	Yes	24	20
	No	1 (Low)	3
		Value	Sig.
	Pearson Chi Square	1.283	0.338
	Phi	0.163	0.338

[a]The information of 2 households in Non-N2Africa is missing

Main reason for crop rotation is for soil fertility, and the availability of seed. Among the 24 households in N2 group who are practicing rotation, 22 households (92%) answered that the yield of maize is particularly high when the legume is in rotation. Among the 20 households in Non-N2 group who are practicing rotation, only 13 households (65%) acknowledge the role of legume in rotation for maize yield. It is both in general a high ratio but still this is a big difference between N2 and Non-N2 households in farmer's attitude towards legume. Among the 22 households which belong to low stratum and practice rotation, 14 households (64%) agree to the contribution of legume to high maize

yield when in rotation, while 21 households (88%) out of total 24 households practicing rotation in high stratum agree on it. N2 households compared to Non-N2, and high stratum compared to low stratum show more positive attitudes to legume for contributing to high maize yield. The higher ratio of N2Africa households practicing rotation than Non-N2 households (Table 13) seem to be associated the positive attitude of N2 households towards legume in rotation with maize.

Besides the effects of rotation and intercropping, we investigated the difference in maize yield per ha compared with the group factor of N2Africa and farm strata regardless of the rotation and intercropping (Table 14). There is no significant difference in maize yield between N2 and Non-N2 groups. However, maize yield is significantly higher in high stratum in comparison to low stratum. It can be interpreted that high stratum households can afford and use more inputs such as high-yielding hybrid maize seeds and fertilizer than low stratum. It is confirmed by Bonsu and Asibuo (2013) stating "application of N fertilizer generally resulted in increase in maize grain yield regardless of the preceding legumes". It supports the result and explanation in Table 11 where fields with no legume in intercropping showed significantly higher maize yield than legume in intercropping within the Non-N2 group. Based on result of Table 14, the composition of the group which is composed of more households of high stratum than low stratum can be put forward to be the reason for the significant difference, not because of the legumes in intercropping.

Table 14 Difference in maize yield with N2Africa and farm strata

Group[c]		Number of maize fields	Maize yield[a] (kg/ha)	Sig.[b]
N2 group	N2[c]	35	1750(1750)	0.723
	Non	35	1750(1283)	
Farm strata	L	25	875(1344)	0.000*
	H	45	1750(875)	

[a]Value expressed as Median(IQR)
[b]Mann-Whiteney U test
[c]N2=N2Africa Non=Non-N2Africa, L=Low stratum H=High stratum
*Significantly different at p<0.01

Rotation and intercropping effects with legumes on high maize yield are not significantly proven in this research despite literature supporting this positive relation (Antonio, 2006; Bonsu and Asibuo, 2013; Giller, 2001; Kureh et al., 2006; Matusso et al., 2014; Stanger and Lauer, 2008; Rao and Mathuva, 2000; Yusuf et al., 2009). The absence of effect from intercropping and rotation may be due to other overriding factors such as soil state, farm management, seed quality and amount of inputs used etc. Some literatures explain the impact of rotation and intercropping on higher crop yields through reducing biotic stresses as weeds, pests and disease (Peoples et al., 2009; Kerr et al., 2007; Snapp et al., 1998; Pender, 2007). This aspect has not been investigated in this research.

Confirming expectations from literature, the maize yields found in our study are generally (though not significantly) higher in intercropping or rotation than without, with one

exception, Non-N2 when without intercropping legume (Table 11). Result showing that high stratum has significantly higher maize yields than low strata (Table 14) and that high stratum is overrepresented in Non-N2 without legume in intercropping (Table 11), may account for the unexpected significantly higher maize yield in this category, compared to the Non-N2 with intercropping.

Based on literature, N2Africa has a potential to increase the maize yield in the long term given that N2Africa participation and households practicing intercropping is significantly associated, despite the insignificant association between N2Africa participation and rotational practice. Yet as there is no information on the soil state or other factors affecting maize yield, more accurate analysis of the impact of rotation and intercropping on maize yields can only be made after acquiring all relevant information.

4.1.2 Daily calorie intake from legumes and its stability

4.1.2.1 Contribution of legumes to daily calorie intake

RQ1.2 Did legumes contribute to daily calorie intake/person of the households which adopted legume technology of N2Africa?

RQ3.2 Did the contribution of legume to daily calorie intake/person differ between the farm types of the households adopting legume technology of N2Africa?

We asked how much legumes and maize households consumed from their own fields, during one month, and how many members the household was composed of. It was asked twice before and after the maize harvest for stability research question 1.7a. The two values are aggregated to average for this research question. All kinds of legumes which they cultivate in their field are identified. The amount they consume for each legume and maize is asked accounting for whether the food was from own cultivation, market or gift for a better recall. What missed here are the other sources of food (e.g. pumpkin, sweet potato or leafy vegetables) except maize and legume, and legumes which a household does not cultivate, but just buys from the market for consumption. Therefore, the actual calorie intake can be higher than the result.

With the calorie content of each crop per 100 g in Table 15, calorie consumption from all kinds of legume and maize is calculated respectively for a month. Further, calorie intake from maize and legume per person per day in the household is calculated dividing the total by number of household members. The minimum dietary energy requirement (MDER) of 1700kcal/person/day (FAO Statistic Division) is applied to observe whether the household members meet the value. There is no distinction for children and adult for the MDER, but the value applied is the weighted average of the minimum energy requirements of the different gender-age groups in the population in Malawi.

Table 15 Calorie of maize and grain legumes per 100g

Crop	kcal/100g[a]
maize	342
groundnut	570
soybeans	446
cowpea	550
common bean	333
pigeon pea	343[b]
ground bean	390[c]

[a] Calorie data except b&c are from Brand (2011)
[b] USDA (n.d.)
[c] Hillocks et al (2012)

Table 16 shows the average ratio between legume and maize for the daily calorie intake per person. Legume accounts on average for 27% of the daily calorie intake and maize for

the remaining 73% for all households. The portion taken by the maize is higher than what Smale (1993) indicated as 66% for the daily calorie intake of maize in Malawi. This is probably due to the omission of accounting for other sources of food in our study. For the households which meet the MDER, 30% of the MDER is satisfied by legumes while those under the MDER satisfy their diet only for 21% by legumes, and this is a significant difference (0.001). It infers that legume contributes to meeting the MDER. Low stratum consumes significantly more amount of legumes per day than high stratum (p=0.009).

In Table 16, the contribution of legumes to daily calorie intake per person is significantly higher in N2Africa households than for those without the project, both for low and high strata. Looking into more in detail, the portion difference for N2Africa is higher in the low stratum (36-25=11%) than high stratum (27-20=7%). The impact of N2Africa is higher to the low stratum than high stratum for the legume contribution to daily calorie intake/person, and at least significant in low stratum as well as high stratum.

Table 16 Average ratio of legume and maize contributing to daily calorie intake per person in each group

Group[a]	Number	Legume[b]	Sig[c]	Maize[d]
N2	50	31%	0.002**	69%
Non-N2	50	22%		78%
N2low	24	36%	0.017*	64%
Nonlow	24	25%		75%
N2high	26	27%	0.036*	73%
Nonhigh	26	20%		80%
Above MDER	60	30%	0.001**	70%
Below MDER	40	21%		79%
Low	48	30%	0.009**	70%
High	72	23%		77%
Overall		27%		73%

[a]N2=N2Africa Non=Non-N2Africa, MDER=minimum daily energy requirement
[b,d]Value expressed as mean ratio
[c]Independent t-test
*Significantly different at p<0.05 **at p<0.01

4.1.2.2 Stability of daily calorie intake before and after maize harvest

RQ1.7a Was the contribution of legumes to daily calorie intake per person stable across before and after maize harvest of the households which adopted legume technology of N2Africa?

RQ3.7a Was the seasonal stability (before and after maize harvest) of the contribution of legumes to daily calorie intake of the households which adopted legume technology of N2Africa different between farm types?

As for the contribution to daily calorie intake according to Table 17, there is little difference in the contribution of legume to daily calorie intake between before (27%) and after (26%) the maize harvest. The ratio of legume is always higher in N2 compared to

Non-N2 both before and after maize harvest. However, there is significant difference in the ratio of legume consumption between N2 and Non-N2 only after the maize harvest (p=0.006), not before maize harvest (p=0.097). The p-values of 0.05 which are almost significant at p<0.05 after maize harvest in both strata, show that the significantly higher value of N2Africa after maize harvest arises from both strata. The significant difference after the maize harvest is owing to the increased legume ratio after maize harvest in N2 households, and on the contrary to this, legume ratio decreased after maize harvest in Non-N2 households though not significant. The increase after maize harvest in N2 is mainly due to the similar time of maize and legume harvests, showing that consumption of legumes by N2 is not influenced by the availability of maize. The decrease in Non-N2 can be explained that Non-N2 tends to consume less legumes when there is abundance of maize. However there are no significant differences of legume ratio before and after the maize harvest within N2 (p=620) and Non-N2 households (p=0551). The stability of legume consumption will be tested again with relevant to the livelihood questions at the later section 4.2.1 with the question *d*. food lacking in the hungry season.

Table 17 Average legume ratio contributing to the daily calorie intake per person compared to maize before and after harvest with group factors of N2Africa and farm strata

		N2[a]	Non-N2	Sig[b].	Overall
Before maize harvest		30%	23%	0.097	27%
After maize harvest		32%	21%	0.006*	26%
Sig[c].		0.620	0.551		0.877
Before maize harvest	Low	36%	26%	0.163	31%
	High	25%	21%	0.350	23%
After maize harvest	Low	36%	24%	0.050	30%
	High	28%	19%	0.050	23%

[a]N2=N2Africa, Non-N2=Non-N2Africa
[b]Independent t-test
[c]paired t-test
*Significantly different at p<0.01

4.1.3 Legumes on household income

RQ1.3 Did legumes substantially contribute to the household income of the households which adopted legume technology of N2Africa?

RQ3.3 Did the contribution of legume to the household income differ between the farm types of the households which adopted legume technology of N2Africa?

Respondents were asked to report the amount of any crops they sold last year, and their lowest farm gate price and the highest one. The different average prices aggregated by each group shown in Table 19 are applied to calculate the income of a household in Table 18 since not every household reported the prices. The price is only for the grain of the crops. The ratio is calculated with the total legume income divided by the total cropping income. Income from legumes includes only groundnut, cowpea and soybean, the legumes intervened by N2Africa. In the total cropping income, legumes, maize, cotton

and tomato are taken into account. The legume income ratio shows the contribution of income from legumes in the household 'cropping' income.

In Table 18, there is no significant difference (p=0.930) between N2 and Non-N2 in the legume contribution to the household cropping income. There is no significant different impact of N2Africa to different farm types (low; p=0.266 and high; p=126) in the legume contribution of the household cropping income. N2Africa does not significantly contribute to the household cropping income from legumes, and neither is there the significantly different impact of N2Africa on different farm types. The big difference between N2low (25%) and Non-N2low (59%) is mainly due to the small total cropping income of Non-N2low. Besides the role of N2Africa on the household cropping income, it is revealed that the proportion of legume income among the total cropping income is significantly higher (p=0.023) in low stratum than high stratum. This proves that legumes are more important for low stratum household cropping income than for high stratum.

Table 18 Average annual legume income and its proportion among the total cropping income

	Number	Median of legume income (KW[a]/kg)	Median of total cropping income (KW/kg)	Median of legume income proportion	Sig.[b]
N2[c]	25	18467	86917	19%	0.930
Non	25	10379	50030	20%	
N2low	12	9967	50955	25%	0.266
Nonlow	12	7860	23470	59%	
N2high	13	20304	116615	17%	0.126
Nonhigh	13	19883	98565	11%	
Low	24	8998	32253	32%	0.023*
High	26	19927	107590	16%	

[a]KW=Malawian kwacha
[b]Mann-Whitney U test for the legume income proportion
[c]N2=N2Africa, Non=Non-N2Africa
*Significantly different at p<0.05

To investigate more in detail about the higher share of legume income in low compared to high stratum, Table 19 shows that high stratum generally makes more profit from each crop resulting from higher amount of crop sold. The difference in income between low and high strata is noticeable particularly in maize. Therefore, the significantly higher contribution of legume for the household cropping income for low stratum (Table 18) than for high stratum is mainly due to the high cropping income from maize for high stratum. The difference in the amount of sold in maize is the biggest compared to other crops, while the price of maize is the lowest among the crops. When a household sells maize, it is sold in bulk. It is assumed that those who sell maize intend to sell maize from the planting, not as a coincidence from the leftover or surplus of maize after their consumption. Low stratum may have problems to produce for markets and will use maize for household food supply, unlike high stratum. Furthermore, there are highest differences in the number of households selling more maize in the high stratum than low stratum.

This implies that maize can be sold only by some particular households when they have a field large enough to feed their family considering that high stratum owns bigger size of arable land than low stratum. It is also attributed to the input costs incurred in the maize cultivation, thus those who can afford the costs tend to easily cultivate maize in their extra field.

Based on Table 19, the big difference in legume income proportion between N2low (25%) and Nonlow (59%) in Table 18 is owing to the considerably lower income of Nonlow in cotton and maize sales than N2low leading to high income proportion of legume of Nonlow among the total cropping income.

Table 19 Number of households, average amount sold and average farm gate prices and income for different crops in N2 and Non-N2 households for different strata

		Low				High			
Legume	group[b]	number of household	amount sold (kg)	price (KW/kg)	Income[a] (KW)	number of household	amount sold (kg)	price (KW/kg)	Income (KW)
groundnut	N2	12	53.4	199.6	10663	12	124.8	208.6	26040
	Non	10	50.7	140.4	7119	11	127.5	191.2	24385
cowpea	N2	9	18.3	144.0	2641	11	56.5	210.8	11919
	Non	7	25.6	245.1	6268	6	42.5	178.9	7604
soybean	N2	3	36.7	202.5	7425	5	27.2	196.3	5340
	Non	1[c]	250.0	160.0	40000	0			
Average of legumes	N2	24(8)[d]	36.1	182.1	6910	38(13)	69.5	205.2	14433
	Non	18(6)	38.1	192.8	6694	17(6)	85.0	185.1	15995
cotton	N2	7	327.1	168.3	55069	9	382.2	197.3	75393
	Non	2	150	225.0	33750	9	428.9	170.4	73072
tomato	N2	2	38.5	892.9	34375	2	37.0	588.5	21750
	Non	1	27.7	1298.7	36000	4	65.8	905.0	59583
maize	N2	4	237.5	92.4	21941	7	745.7	136.5	101790
	Non	3	108.3	92.1	9979	9	711.1	89.2	63440

[a]KW=Malawian kwacha, Income = amount sold * price
[b]N2=N2Africa, Non=Non-N2Africa
[c]This value is excluded in the calculation of the proportion in Table 18 as it is an outlier
[d]The numbers in brackets are the average number of households selling legumes, which are generated by dividing the total number of households selling legumes by the number of grain legumes as 3; groundnut, cowpea, soybean.

As for processing of legumes, 93% of households cultivating groundnut processed it into flours and 80% of households cultivating soybean processed it into flours or rarely into milk. Most of the households cultivating cowpea dry the cowpea leaves to keep for a long time, and once in a while mill the cowpea grain into flours. However, only one household sell processed legumes, the groundnut flour at the little shop they own. There is no effect

of processed legume in the contribution to household income as it is rarely sold.

4.1.4 Dependency on farm inputs

RQ1.4 Did legumes decrease the dependency on inputs of the households which adopted legume technology of N2Africa?

RQ3.4 Did the role of legume decreasing dependency on inputs differ between farm types of the households adopting legume technology of N2Africa?

Respondents were asked to choose one of answers among Strongly Agree, Agree, Uncertain, Disagree, and Strongly Disagree with the statements from *a* to *i*. The statement *a* is to compare the easiness of procuring seeds of legume and maize. The statement *b* asks about the input required in comparison with the two crops for fertilizer in *b1*, seeds in *b2*, labor in *b3*. All costs incurred in producing the two crops are asked in the statement *c*. The statement *d* is to compare legume and maize for the independence from the external input for growing. The statements from *a* to *d* are made to evaluate the dependency of legume and maize comparatively. The statement *e* is to ask the contribution of legume to soil fertility. The statements f and g are about the dependency from the fertilizer of legume. Statement *h* is about the different roles of legumes compared to maize and statement *i* summarizes the dependency questions. It is worth asking the perception about dependency for inputs, besides the objective information of input costs asked separately and will be reported in this section later.

Answers are presented in Table 20 with medians. It is verified by Mann-Whitney U test that the distributions of opinions on each answer (a to i) do not significantly differ by each group comparison. N2 and Non-N2 households do not have different opinions on the legume's dependency. There are neither different opinions between low strata of N2 and Non-N2, and high strata of N2 and Non-N2. As there are no significant differences in the distribution of answers by groups, overall answers are worth notice for general perception on legumes regardless of the N2Africa participation and strata. Compared to maize, the legume seed is not easier to acquire (a), legume does not require more fertilizer than maize (b1) to produce the same amount. It is uncertain whether legume requires more seeds than maize to produce the same amount (b2). Legume does not require more labor (b3) and legume is not more costly (c) than maize to produce the same amount of each grains. All respondents answer to the questions *d* to *i* is 'Strongly agree'. For these statements as well as b1, respondents have consistent opinion on the fertilizer effect of legume no matter which group they belong to. They also strongly agree that legume plays more roles in households than maize (h).

Legume's dependency on 'fertilizer', based on the answer from *b1*, and *d* to *i*, respondents think that legume is obviously independent from fertilizer or even can work as a fertilizer which makes households free from the cash constraint (c). The independence of legume on fertilizer explains one of reasons in section 4.1.3 of Table 18. Low stratum makes more profit from the sale of legumes while the households of high stratum which can afford the costs of fertilizer for maize makes profit more from maize. This independency of legumes on fertilizer also contributes to the stability (RQ1.7c) in terms of maintaining resources in the long-term. It is due to the trait of legumes biologically fixing nitrogen. Less

dependency of legume on 'labor' than maize is proven on the answer b3. However for the dependency on 'seed' input, discrepancies exist between different groups: low stratum claiming that access to legume seeds is difficult whereas high stratum sees no problem. Whether this is an issue of price availability cannot be distinguished based on the question asked. Apparently, N2households did not perceive legume seeds as easily accessible

Table 20 Medians of each group for dependency on inputs

		Compared to maize										
Median[a]	Num-ber	a. Easy to get legume seeds	b1. Legu-me requir-es more fertiliz-er	b2. Legu-me requir es more seeds	b3. Legu-me requir es more labor	c. Legu-me is more costly	d. Legu-me grows better with-out extern-al input	e. Legu-me affects soil fertility	f. Feel safer with legum-e when fertiliz er in short	g. Plant legum-e, not purch-asing fertiliz-er when expen-sive	h. Legu-me plays more differe-nt roles	i. Legu-me helps house holds indepe-ndent from extern-al input
Over-all	50	D	S.D	Un.C	D	D	S.A	S.A	S.A	S.A	S.A	S.A
N2[b]	25	Un.C	S.D	Agree	D	S.D	S.A	S.A	S.A	S.A	S.A	S.A
Non	25	D	S.D	Un.C	D	D	S.A	S.A	S.A	S.A	S.A	S.A
N2 low	12	D	S.D	Un.C	D	S.D	S.A	S.A	S.A	S.A	S.A	S.A
Nonlo w	12	D	S.D	S.A or A	Un.C	S.D	S.A	S.A	S.A	S.A	S.A	S.A
N2 high	13	Agree	S.D	Agree	D	D	S.A	S.A	S.A	S.A	S.A	S.A
Non high	13	Agree	S.D	D	D	D	.Agre e	S.A	S.A	S.A	Agree	S.A

[a]S.D=Strongly Disagree, S.A=Strongly Agree, D=Disagree, Un.C=Uncertain
[b]N2=N2Africa, Non=Non-N2Africa

Table 21 demonstrates the mean rank of each input to produce 1 ton of grain of each crop. Before mean rankings are determined, the raw data are firstly generated by the average amount of input required in order to produce 1 ton of grain calculated from the reported production costs of all respondents. The statements *b1, b3* and *d* (Table 20) of the overall answers about legumes are to be confirmed based on the objective data.

For 'manure and fertilizer', there are three homogeneous subsets marked with different alphabet. Groundnut is produced with significantly less manure and fertilizer than maize, tomato, and soybean. Soybean is produced with significantly more manure and fertilizer than cotton, less than maize. Cowpea is produced with significantly less manure and fertilizer than maize. Maize is produced with significantly highest manure and fertilizer than the three legumes and the rest of crops presented. It confirms the answer of question *b1* Table 20.

As for 'pesticide', there are four subsets. Groundnut is cultivated with significantly less pesticide than all the other crops except soybean. Soybean is produced with significantly less pesticide than cowpea, tomato and cotton. However, cowpea is grown with significantly more pesticide than maize. It is because cowpea is considered to suffer most

from insect (Singh and van Emden, 1979). Therefore, it is difficult to conclude that legume requires more pesticide given the varying values depending on the type of legume. Only groundnut is cultivated with significantly less pesticides than maize.

For 'labor' expressed as the number of working days, there are three subsets. Maize is engaged with significantly the least labor days compared to the other crops. Groundnut, soybean and cowpea are produced with significantly more labor than maize and cotton. This does not accord with the previous answer in Table 20 that respondent does not think that legume require more labor than maize. This discrepancy can be explained by the quantity and the quality of labor asked in each question. The quantity, the number of working days is asked for this question whereas it is just asked as 'more labor' in the previous perception question. Thus, the respondents' understanding of 'more labor' might differ with 'the number of working days'. During the interview, respondents often commented that maize cultivation is involved with various operations which are more demanding qualitatively. It is also not obviously shown in other research by Kamanga et al (2014) conducted in the central region of Malawi whether the labor requirement has been increased after inclusion of legumes according to the farmer's perception. Synthesizing the results from Table 20, legumes are more independent from fertilizer than maize. It was not clearly proven whether legume requires more labor than maize. Only groundnut is proven to be cultivated with significantly less pesticide than maize. The dependency of legume on external input in general may vary with the type of legumes and the type of external inputs such as fertilizer and pesticides. However, respondents perceive as legumes grow better without external input than maize (Table 20; d), which implies that external input is mainly understood as fertilizer for the respondents.

Table 21 Mean rank* of each crop for input amount to produce 1ton of grain of each crop

Input	unit	groundnut (n=46)	soybean (n=12)	cowpea (n=42)	maize (n=50)	cotton (n=32)	tomato (n=9)
manure+fertilizer	kg input/ton grain	70th^{a}	84th^{b}	72th^{ab}	164th^{c}	70th^{a}	91th^{b}
rank order	groundnut,cotton,(cowpea) < soybean,tomato,(cowpea) < maize						
pesticide	ml input/ton grain	56th^{a}	56th^{ab}	135th^{c}	66th^{b}	147th^{c}	173th^{d}
rank order	groundnut,(soybean)<maize,(soybean)<cowpea,cotton<tomato						
labor	day/week/ton grain	125th^{c}	111th^{c}	123th^{c}	44th^{a}	83th^{b}	151th^{c}
rank order	maize < cotton < groundnut,soybean,cowpea,tomato						

*The different alphabet within the each row denotes the different subset group at $p<0.05$ by the Kruskal-Wallis test

Among the five categorized ways, 1=buying, 3=keeping and 5=payment as seeds from casual labor are seen as 'Independent way', while free seeds 2=from NGO or government and 4=gift are seen as 'Dependent way'. The respondents could name multiple ways of getting seeds. The way each household procuring maize seeds and legume seeds is reported. It is categorized as buying, receiving from NGOs or government, keeping seeds, gift and payment as seed from casual labor (Table 22).

In Table 22, it shows that overall households get seeds mostly from buying, keeping, and payment from casual labor, namely in independent ways. Higher ratio of N2Africa households is dependent (consequently lower ratio is independent) for their access to both legume (28% versus 20%) and maize seeds (32% versus 21%) than Non-N2 households. It is the same patterns both for low and high stratum. This is logical as N2Africa households get free access to legume seeds by N2Africa until 2012/2013. N2Africa seems to influence the households having legume and maize seeds in more dependent ways.

Lower ratio of overall answer both of N2 and Non-N2 households, is dependent in access to legume seeds than that of maize seeds (N2; 28% versus 32%, Non-N2; 20% versus 21%). This is due to the high strata, whereas higher ratios of low strata are dependent in access to legume seeds than that of maize seeds (N2; 27% versus 24%, Non-N2; 24% versus 19%). It is due to the fact that low stratum, which is more likely to have difficulty securing maize, tend to focus on acquisition of maize seeds above other crops through buying, keeping and getting payment as maize seeds. This is a confirmation of the question *a* in Table 20, that low stratum disagrees that legume seeds are easier to access than maize seeds while high stratum agrees.

Table 22 Percentage of household acquiring legume and maize seeds in different ways

	Legume		Maize	
	1,3,5 Independent[a]	2,4 Dependent[b]	1,3,5 Independent	2,4 Dependent
Unit	#of household[c]	#of household	#of household	#of household
N2[d]	72%	28%	68%	32%
Non-N2	80%	20%	79%	21%
N2low	73%	27%	76%	24%
Nonlow	76%	24%	81%	19%
N2high	71%	29%	64%	36%
Nonhigh	83%	17%	76%	24%

[a]Independent way: 1=buying, 3=keeping, 5=payment as seeds
[b]Dependent way: 2=NGO or government, 4=gift
[c]Each household could choose multiple answers
[d]N2=N2Africa, Non-N2=Non-N2Africa

4.1.5 Quality of diet and its stability

4.1.5.1 Contribution of legumes to quality of diet

RQ1.5 Did legume increase the quality of diet of the households which adopted legume technology of N2Africa?

RQ3.5 Did the role of legume increasing quality of diet of the households which adopted legume technology of N2Africa differ between farm types?

Diet Dietary Score (DDS) is calculated based on Woman Diet Diversity Score (WDDS) in which the food groups are aggregated into 9 groups from 16 groups (Appendix 2). The food groups in WDDS reflects micronutrient intake, whereas 12 food groups in

Household Diet Diversity Score were made to show economic access to food. However, WDDS can also reflect to some extent the household economic access to food (FAO, 2010). Nutritional status of a woman, a mother in a household, can be an indicator for the status of a household food security since in food insecure homes, mothers prioritize their children's needs over their own (McIntyre et al., 2003; Stevens, 2010).

As indicated in the guideline, 5 households, in which women are out of the age range 15 to 49, are excluded in the score. The ingredients in the composite foods are counted as contributing to the corresponding food group, for example groundnut flour in the maize flour porridge is counted in legume food group. The amount of condiments which is assumed to be very small does not matter in the WDDS since WDDS does not include a specific food group for condiments.

There is no significant difference in WDDS, micronutrient intake between N2Africa and Non-N2Africa, neither its different impacts on different farm strata (Table 23). Irrespective of grouping, the median of the score is 4 out of 9, with only difference in the N2low group slightly higher as 4.5. Despite the difference in median, there is no significant difference between low stratum of N2 and Non-N2. The reason for the difference in median of N2low is explained later by Table 25 revealing some food groups consumed.

Table 23 Median of WDDS in each group before and after maize harvest

WDDS Median(IQR)	Number	Before	After	Sig[a].
N2[b]	22	4 (1.3)	4 (2.0)	0.560
Non	23	4 (2.0)	4 (2.0)	0.810
Sig[c].		0.576	0.423	
N2low	10	4.5 (2.0)	4.5 (2.0)	0.748
Nonlow	12	4 (1.5)	4 (1.8)	0.327
Sig[c]		0.580	0.451	
N2high	12	4 (1.0)	4 (1.0)	0.429
Nonhigh	11	4 (2.0)	4 (1.0)	0.587
Sig[c]		0.797	0.897	

[a]Wilcoxon Signed Rank test (comparison vertically)
[b]N2=N2Africa, Non=Non-N2Africa
[c]Mann-Whitney U test (comparison horizontally)

Table 24 shows the frequency consumption of legumes for women in general. There are no significant differences between N2 and Non-N2, low and high in N2 and Non-N2 respectively in any of the legumes intervened by N2Africa. Overall, frequency consumption of groundnut is higher in N2 households than Non-N2, and in high stratum than low stratum. The higher groundnut consumption in N2 households occurs in both strata. More frequent consumption of soybean of N2Africa is mainly due to the consumption in high stratum of N2africa. Soybean is more often consumed by high stratum in both N2 and Non-N2. There is a significantly more frequent groundbean consumption in high strata of N2 than Non-N2 ($p=0.029$). Groundbean is not a crop

targeted by N2Africa. Groundbean production is low as it is usually grown for home-consumption (Mwangwela et al., n.d.), and it is found in our data that there are only 5 households which produce groundnut out of 50 households. Thus, it is assumed that groundbean consumption is made mainly through purchasing at market where often commanding the high price (Hillocks et al., 2012). It is considered in Malawi that there are higher demands for groundbean than supply (Mkandawire, 2007). Groundbean consumption could implicitly reflect the economic power. However, no specific reasons for groundbean consumption are found within this research.

Little difference in the frequency of legume consumption between N2 and Non-N2 shows that the culture of legume consumption stems from the tradition, or habit. This is confirmed by Reynolds (2000) stating that grain legumes are traditionally grown in Malawi among smallholders. Also it is because changing the eating habit is a long time procedure, while the N2Africa has worked since the year 2009. The insignificant differences of women's frequency in consumption of legumes respectively by N2Africa project and strata underpin the insignificant differences in dietary diversity score by the groups in Table 23.

Table 24 Frequency of legume consumption (time/month) in each group

	N2[a] (n=25)	Non-N2 (n=25)	Sig[b].	N2low (n=12)	Non-N2 low (n=12)	Sig.[b]	N2 high (n=13)	Non-N2high (n=13)	Sig[b].
					Median(IQR)				
Ground-nut	60(72)	24(52)	0.170	33(74)	20(42)	0.581	60(60)	32(82)	0.287
Soybean	8(29.5)	2(23)	0.378	1.5 (52.5)	1.5(20.5)	0.930	12(15)	4(26.5)	0.287
Cowpea	16(8)	16(12)	0.054	20 (8)	16(16)	0.115	16(20)	16(10)	0.336
Common- bean	8(14)	8(11)	0.411	12 (11.5)	8(8)	0.813	8(17)	8(12)	0.362
Ground-bean	4(16)	2(4)	0.158	0(14)	2(4)	0.805	6(14)	2(4)	0.029*
Green-bean	1(2)	0(6)	0.833	2(3.5)	1(7)	0.854	0(2)	0(6)	0.920
Pigeon-pea	0(3)	0(30)	0.075	0(5)	0(0)	0.113	0(2.5)	0(0)	0.479

[a]N2=N2Africa, Non-N2=Non-N2Africa
[b]Mann-Whitney U test
*Significantly different at p<0.05

4.1.5.2 Stability of diet diversity before and after maize harvest

RQ1.7b Did the contribution of legumes to stability of the quality of diet both before and after maize harvest of the households which adopted legume technology of N2Africa?

RQ3.7b Was the seasonal stability of the contribution of legumes to the quality of diet differerent between farm types of the households which adopted legume technology of N2Africa?

There is no difference in the median of WDDS before and after the maize harvest (Table 23). It seems like that there is no contribution of N2Africa towards stability of quality of diet since in both groups of N2 and Non-N2 there is no significant difference of WDDS. Rather, it shows that there is stability of quality of diet for every group. However, it cannot be concluded that everyone in Salima has stable provision of diet diversity before and after the maize harvest. It is owing to the timing of interviews which was close to the maize harvest, and the strategy of households picking some food from the fields before the major harvest. Hungry season occurs in the weeks prior to the harvest in many places in the rainy season, when the previous harvest stocks have dwindled and little food is available on the market leading to high price of it, and crops cannot be harvested yet (Action Against Hunger, 2008; Trickle up, 2009). Respondents indicated this period is usually in January or February in Malawi, when non of the crops are matured yet not allowing them to pick some before the harvest. It is assumed that the differences between before and after maize harvest might have been estalished when the first interview was conducted in January or February.

To investigate the WDDS in more in detail, the percentage of household that consumed certain food groups, meat/fish, tea/coffee, legume and vitamin A rich vegetables, fruits and tuber are shown in Table 25.. The main vegetable foods consumed for the vitamin A rich group are orange-fleshed sweet potato and pumpkin. Meat/fish is also a good source of vitamin A (National Institutes of Health, 2013), but it is separated in the grouping of WDDS.

Table 25 % of households consuming specific food categories before and after maize harvest

	Meat/fish		Tea/coffee		Legume		Vitamin A rich	
Group[c]	Before	After	Before	After	Before	After	Before*[b,low]	After
N2*[a,meat/fish]	18	46*[a]	18	41	86	82	41	23
Non-N2	13	13	26	26	87	83	44	26
N2low*[a,meat/fish]	20	70*[a,b]	20	60*[a]	90	70	50	20
Non-N2low	8	8	17	17	92	75	42	8
N2high	17	25	17	25	83	92	33	25
Non-N2high	18	18	36	36	82	91	46	46

[*a]Significant correlation at p<0.05 between N2Africa participation and the food group
[*b]Significant correlation at p<0.05 between timing of the maize harvest and the food group
[c]N2=N2Africa, Non-N2=Non-N2Africa

The lack of significant correlation between the number of N2 households and Non-N2 household in legume consumption (Table 25) can be partly explained by the fact that eating grain legume is part of their culture as Jager (2013) stated that the consumption of grain legumes varies depending on the agricultural practices, climate, season and tribal customs. It is confirmed by Reynolds (2000) grain legumes are traditionally cultivated in Malawi. Particularly, the stable consumption of legume through-out the season, which is not significantly correlated with the timing of maize harvest (Table 25), is of importance especially before the maize harvest. Since it is when various nutrients are less likely to be

taken and grain legume provide protein, a variety and concentrations of micronutrients (vitamin B, iron, calcium, zinc) and fat which is usually deficient in African diets (Jager, 2013).

There is a significantly higher ratio of N2 households which consumed meat/fish than Non-N2 households, especially the difference after maize harvest is highly significant (46% versus 13%) (Table 25). This difference is particularly significant in low stratum of N2 households, and after maize harvest (70% versus 8%). This may account for the slightly higher WDDS of N2low in Table 23. Higher consumption of meat/fish is mainly attributed to an increased economic access given meat/fish are not always necessary food in every meal, but rather luxurious. This significant correlation in N2low (70%) 'after maize harvest' than Non-N2low (8%) can be explained by the timing of selling produce. It is assumed that N2low sells their produce right after harvest of N2low based on their lower farm gate price than Non-N2low except maize prices that are same (Table 19). Lower farm gate price implies farmers just sell their produce right after harvest when the price of produces is relatively low due to the high supply. It applies same to the significant correlation in tea/coffee consumption as higher number of N2low consume it than Non-N2low after maize harvest, since high consumption of tea/coffee which are usually purchased for consumption also reflects the increased economic access. However, tea/coffee category was not included for the calculation of WDDS. Interestingly, more households in low stratum of N2Africa seem to enjoy more luxurious food after the harvest than high stratum of N2Africa. This can be also explained by the higher farm gate prices in high stratum which does not sell their produce right after harvest, but waits until the price goes up (Table 19). And, according to Brand who conducted a research in Malawi, she observed that people tended to eat more meat after harvest since they captured rats and mice running out of the field when they burned the stalk in the field after harvest. Low stratum which is relatively difficult to afford to buy meats tended to consume meat this way especially after harvest compared to high stratum.

Another significant correlation is revealed between the vitamin A rich food consumption and the timing of maize harvest in low strata regardless of N2 and Non-N2. Higher ratio of households in low stratum significantly consumes vitamin A rich foods before the maize harvest (46%; average of N2low and Non-N2low) than after the maize harvest (14%; average of N2low and Non-N2low) (Table 25). As mentioned in the section 2. Research site and background, sweet potato was cultivated 4th largest crop area in Salima. And sweet potato was easily found at the market, or at street vendors at a reasonable price. Sweet potato production is running throughout the year, and from March its production starts to be dominant (Sindi et al., 2013). Farmers grow sweet potatoes and pumpkins to consume before maize matures as they are earlier-maturing crops compared to maize (Kamanga, 2002). The decreased consumption of these after maize harvest is due to the small amount of harvest as they are not usually planted as sole stands. People often substitute their meal with sweet potatoes, pumpkins and legumes before the maize harvest on account of their earlier maturity. Low strata whose last year produces are relatively consumed quickly due to the small amounts, is benefited distinctively from sweet potato and pumpkin of their early maturity. This infers that the adoption of the legume technology would be facilitated by low stratum when the varieties of legumes have a

characteristic of early maturity.

Legumes generally mature earlier than maize. Thus, the pattern of legumes and vitamin A rich group is similar, while legume consumption is the highest as a whole (Table 25). The consumption of legumes slightly decreases after the maize harvest in N2 and Non-N2 households. However, the legume consumption decreases in low stratum while it increases in high stratum. The increase in high stratum is due to the similar harvest time of maize and legumes. The decrease in low stratum can be explained by their strategy to consume less legumes which were already consumed when there was scarcity of food to combat hunger with legumes. It suggests a particular role of legume for low stratum in combatting hunger before harvest. This is supported by Table 16 in the section 4.1.2 as well, that the percentage of calorie intake from legume was significantly higher in low stratum than high stratum.

Although every group showed the same WDDS before and after maize harvest in Table 23, the differences in provision of specific nutrients across the maize harvest season are investigated in this part. The provisions of protein, a variety and concentrations of micronutrients (vitamin B, iron, calcium, zinc) and fat by grain legumes are stable through-out the maize harvest season irrespective of N2Africa participation. Vitamin A intake is stable for N2Africa household in general, and low stratum in particular as the decrease in consumption of vitamin A rich foods is compensated by an increase in meat consumption. Before the maize harvest, vitamin A consumption is significantly high through sweet potato and pumpkins for low stratum both of N2 and Non-N2. After the maize harvest, vitamin A from meat/fish is provided significantly for N2low than Non-N2low. Although the patterns are not significantly correlated, it generally applies to all groups.

4.1.6 Women empowerment

RQ1.6 Did legume enhance the women empowerment of the households which adopted legume technology of N2Africa?

RQ3.6 Did the role of legume enhancing women empowerment of the households which adopted legume technology of N2Africa differ between farm types?

There are two steps to answer for this question. First is to investigate whether N2Africa enhance women empowerment in legume and/or maize related decisions, and the next is whether the women empowerment leads to more household income spent on food-related (food, kitchen utensil) and care-related (education, health) items.

Three domains, Production, Resource and Income, of women empowerment scales are included in the women empowerment score in this research with equal weight among the five domains of WEAI. The calculation of women empowerment score is specified in Appendix 3. There are two different types of analyzing for this data in order to compare the scores by N2Africa participation, strata, and land ownership respectively. First is to examine the differences by the group factors in women empowerment ‘only for legume production’. Secondly, it is to look at the women empowerment ‘in general regardless of the crop difference’. Land ownership is included as one of factors since it is assumed to

influence the women empowerment based on the statement that land owners are considered to have a higher status in a household (Gough, 2004). Data of a household comprised of a brother and a sister is excluded in this section.

Prior to the two major analyses, it is proven that women are comparatively more empowered in legume production than in maize production in a household. There is a significant difference between women empowerment score for legume and maize at $p<0.05$ (Table 26). It is in line with Kanesathasan (2012) and Mapfumo et al (2001) stating that legume is regarded as a female crop in sub-Saharan Africa.

Table 26 Women empowerment score by crops

Crop	Number	Median(IQR)	Sig.
Legume	49	0.500(0.396)	0.008*
Maize	49	0.292(0.521)	

*Significantly different at $p<0.01$ by the Wilcoxon signed-rank test

For the women empowerment score calculated 'only for legume production', group factors are applied. Table 27 indicates that there is no significant difference for women empowerment score for legume between any groups. Land ownership, N2Africa participation do not influence the women empowerment significantly, neither the different impact of N2Africa on different farm strata. When the land is owned by husband, and the household participating in N2Africa, households have higher women empowerment score of legume compared to counterparts although not significant.

Table 27 Women empowerment score of legume with different group factors

Group[a]		Number	Mean (s.d)	Sig.[c]
Land ownership[b]	1	13	0.583 (0.333)	0.574
	2	28	0.458 (0.469)	
N2Africa	N2	25	0.478 (0.300)	0.348
	Non-N2	24	0.401 (0.268)	
	N2&Low	12	0.500 (0.303)	0.382
	Non&Low	12	0.392 (0.289)	
	N2&High	13	0.458 (0.309)	0.675
	Non&high	12	0.410 (0.259)	

[a]1=husband owns land,2=wife owns land, N2=N2Africa Non-N2=Non-N2Africa
[b]This information for 9 households is missing
[c]Independent t- test

For the women empowerment score in general, without classification of the crops, there is neither significant difference of each group comparison (Table 28). Largely, the scores are smaller than those of legumes in Table 27. The trend is similar with what is shown in Table 27 except within the each strata of N2Africa participation. When the land is owned by husband and the household participating in N2Africa, the score is higher than the opposites though not significant (Table 27; Table 28). However, within the each strata of N2Africa, low stratum shows higher general score whereas high stratum shows lower score than Non-N2 (Table 28) unlike the women empowerment score for legume production (Table 27).

Table 28 Women empowerment score in general with different group factors

Group[a]		Number	Mean(s.d)	Sig.[c]
Land ownership[b]	1	13	0.425 (0.172)	0.239
	2	28	0.376 (0.255)	
N2Africa	N2	25	0.419 (0.237)	0.312
	Non-N2	24	0.351 (0.230)	
	N2&Low	12	0.444 (0.279)	0.163
	Non&Low	12	0.293 (0.229)	
	N2&High	13	0.396 (0.199)	0.888
	Non&High	12	0.408 (0.227)	

[a]1=husband owns land,2=wife owns land, N2=N2Africa Non-N2=Non-N2Africa
[b]This information for 9 households is missing
[c]Independent t- test

In addition to calculation of the score, answers are provided for each question for the same data in Table 29 to investigate where in detail the differences exist despite the insignificant role of N2Africa on the women empowerment score. The number indicates the ratio of women contribution for each question, with the maximum value 1. The overall answers demonstrate that land size and input decisions mainly hinge on husbands, while other decisions are equally decided by husbands and wives. This is confirmed in *Gender Inequalities in Rural Employment in Malawi An Overview* (2011) that gender inequalities in access to land and land ownership is considerable despite the dominant matrilineal system in Malawi. The significantly higher women empowerment in legume production shown in Table 26 could be attributed to the higher women's decision on the *d.* input for legume (25%) than for *e*. maize (0%) despite the low decision below 50%, given that it is the only difference between the pair comparison of legume and maize. While there were no significant differences in women empowerment score by N2Africa in Table 27 and Table 28, N2Africa significantly increased the women decision power on the input for legume (d) (Table 29). The significant impact of N2Africa on the women's decision on the input for legume is more of importance since women has overall low decision making power on input use. The insignificant differences in women empowerment scores by land ownership factor (Table 27; Table 28) are revealed here again that none of the questions (from a to i) significantly influence the women's decision makings by land ownership. Strata do not influence the different women's decision making on any questions.

Table 29 Medians of women decision ratio on each question with different group factors

Median(IQR)[a]		a. What legume to plant	b. Land size for legume	c. Land size for maize	d. Input for legume	e. Input for maize	f. Amount of legume to sell	g. Amount of maize to sell	h. Expenditure from legume	i. Expenditure from maize
Land owne-rs-hip	Wife (n=28)	0.5 (1)	0 (0.75)	0.5 (1)	0.5 (1)	0 (0.5)	0.5 (0.75)	0.5 (0.88)	0.5 (0.5)	0.5 (0.75)
	Husband (n=13)	0.5 (0.94)	0 (0.5)	0 (0.5)	0.5 (0.88)	0.5 (0.5)	0.5 (0.88)	0.5 (0.75)	0.5 (0.19)	0.5 (0)
N2-Africa	N2[b] (n=25)	0.75 (0.63)	0.5 (1)	0 (0.63)	0.5*(1)	0 (0.5)	0.5 (0.88)	0.5 (1)	0.5 (0.25)	0.5 (0.5)
	Non (n=24)	0.5 (0.88)	0 (0.75)	0 (0.5)	0 (0.5)	0 (0.5)	0.5 (0.75)	0.5 (0.56)	0.5 (0.5)	0.375 (0.81)
	N2low (n=12)	0.75 (0.5)	0.5 (1)	0.5 (1)	0.625 (0.94)	0 (0.5)	0.625 (0.75)	0 (1)	0.5 (0.56)	0.5 (0.63)
	Nonlow (n=12)	0 (0.88)	0 (0.44)	0 (0.38)	0 (0.88)	0 (0.44)	0.5 (0.75)	0.25 (0.5)	0.5 (0.38)	0 (0.88)
	N2high (n=13)	0.75 (0.88)	0 (0.88)	0 (0.5)	0.5 (1)	0 (0.5)	0.5 (1)	0.5 (0.44)	0.5 (0.25)	0.5 (0.56)
	Nonhigh (n=12)	0.5 (0.81)	0 (0.75)	0.5 (0.75)	0.125 (0.5)	0.25 (0.5)	0.5 (0.63)	0.5 (0.56)	0.5 (0.63)	0.5 (0.63)
Overall		0.5 (1)	0 (0.75)	0 (0.5)	0.25 (0.88)	0 (0.5)	0.5 (0.75)	0.5 (0.75)	0.5 (0.31)	0.5 (0.75)

[a]1=100% woman, 0.75=75% woman & 25% man, 0.5=50% woman & 50% man, 0.25=25% woman & 75% man, 0=0% woman

[b]N2=N2Africa, Non-N2=Non-N2Africa, *Significantly different at p<0.05 by the Mann-Whitney U test

While the land ownership solely does not significantly influence the women empowerment, Fisher's Exact test is followed to examine the relationship between N2Africa participation and land ownership on each question. There is a significant correlation between N2Africa and land size for legume (b). When the women own the land, women of N2 households tend to have more decision power for the land size for legume than those of Non-N2 households. Given that land size both for legume and maize is mainly decided by husband (Table 29), this correlation infers that it is important for N2Africa to target women to increase plot size of legume especially when the land is owned by women in the household

Table 30 Distribution of the number of household for the question (b).Land size for legume by N2Africa participation when wife owns the land in a household

				b. Land size for legume					
landownership				.0[a]	.25	.50	.75	1	Total
wife owns	N2Africa	N2[b]	Count	4	0	3	0	5	12
			% within N2Africa	33.3%	0.0%	25.0%	0.0%	41.7%	100.0%
		Non-N2	Count	9	1	1	3	1	15
			% within N2Africa	60.0%	6.7%	6.7%	20.0%	6.7%	100.0%
	Fisher's Exact test		Sig.	0.038*					

[a]1=100% woman, 0.75=75% woman & 25% man, 0.5=50% woman & 50% man, 0.25=25% woman & 75% man, 0=0% woman
[b]N2=N2Africa, Non-N2=Non-N2Africa
*Significantly correlated at p<0.05

As women's decision making power might differ depending on whether the crop is a cash crop. Legumes as cash crop and women's responsibility in a household are further investigated in Table 31. The decision associated with legume is mainly a responsibility of women compared to maize (Table 26). It is also confirmed in Table 31 showing that in more than half of the households (38), women are in charge of legume cultivation. In spite of the high numbers of women (30) responsible for legume when it is a cash crop in Table 29, sometimes the seeds of legumes with commercial value are more distributed to male farmers than female farmer (de Wolf, 2014). And farmers reported as 'cash crop' even when a small portion is sold. Therefore, it is important as recommended by de Wolf (2014), to distribute more commercial legumes to women and assisting women to have more access to market and financial services to commercialize their legume cultivation. It indicates the potential of N2Africa contributing to women empowerment since N2Africa focuses on marketing the legume as one of the strategies for dissemination of the legume technology in Phase 2 by making legume as cash crop. However, this would be true only if it is proven that women still holds responsibility for legume cultivation even when legumes become main cash crops.

Table 31 Number of household depending on the legume as a cash crop and women in charge of legume cultivation

Category	Number
cash crop & women in charge of legume	30
cash crop & women not in charge of legume	9
no cash crop & women in charge of legume	8
no cash crop & women not in charge of legume	2
Total	49

As a second step for this research question, it is investigated whether the women empowerment contributes to food security. The assumption is that women would spend more household income on food-related, care practices (education, health) items than men would. Items of household expenditure are ranked by their preferences from the 1st (the most desirable) to the 15^{th} (the least desirable) by husband and by wife respectively in a household, imagining that they can spend the household budget on whatever they wish.

Firstly, the 15 groups of items of household expenditure are ranked significantly differently within women ($p=0.000$) and within men ($p=0.000$) by the Friedman's test. It means that items get indeed a different preference. The homogeneous subset groups are presented in Appendix 4.

Pair-wise comparison of a husband and a wife in the same household is proceeded for each item (Table 32). 5 households are excluded for this comparison where the

comparison of the husband and the wife in the same household is impossible. Husbands significantly prefer household expenditure on health and livestock compared to wives for these items. Wives significantly prefer household expenditure on kitchen utensils than husbands do. Compared to the assumption that women would spend household expenditures more on food-related items, education for children and health-related items, it is proven only for the food-related items as more preference on kitchen utensil. It is revealed the other way around for the expenditure on health. Even though it is not significantly different ($p=0.068$) for expenditure on food, the difference in median of ranks is big showing that wives have a higher preference to spend the income on the food item compared to husbands. It implies that there are big variations in the answers. It is due to some respondents putting lower preferences on food by associating the expenditure on food with their farming. Respondents often commented that they do not want to spend money on food but rather grow and consume their own food.

To synthesize the several results for this section 4.1.6, women are generally more empowered in legume than in maize production (Table 26). N2Africa does not significantly contribute to women empowerment score which contains the domains of production, resource and income (Table 29). N2Africa only significantly correlated with higher decision making power of women for the input decisions for legumes (Table 29), and correlated with higher decision making power of women on the land size for legumes only when the land is owned by the wife in the household (Table 30). The higher proportion of landownership by wife (68%) in our data, which reflects the dominant matrilineal system in Malawi, suggests a reason for N2Africa to target women and their empowerment to expand the land area for legume cultivation. Strata factor is not shown to be significant in any of the results. N2Africa does not make significant contribution to women empowerment score, and does not significantly correlated with the women's decision making power for household expenditure (Table 29). Hence, N2Africa does not ensure the higher household income spent on kitchen utensil (Table 32).

Table 32 Median of each item ranked[a] by wife and husband of household**s**

Respondent	food (n=45)	water (n=43)	education (n=45)	health (n=46)	transport fare (n=44)	fuel for cooking (n=42)	leisure (n=43)	farm implement (n=45)	livestock (n=45)	storage (n=45)	housing (n=45)	electronics (n=45)	transport (n=45)	Kitchen utensil (n=45)	clothe (n=45)
Wife	2 (7.00)	11 (6.00)	8 (7.50)	9 (6.00)	11.5 (5.25)	13 (4.50)	14 (4.50)	3 (5.00)	6 (4.00)	12 (3.25)	4 (5.00)	10 (4.50)	6 (3.25)	5 (3.25)	5 (3.00)
Husband	6 (8.50)	9 (5.00)	8 (6.50)	7 (7.25)	12 (5.50)	13 (3.25)	14 (3.00)	4 (4.50)	4 (5.00)	11 (5.00)	4 (5.50)	10 (6.50)	5 (5.00)	7 (4.00)	6 (4.50)
Sig.	0.068	0.332	0.668	0.028*	0.510	0.397	0.263	0.995	0.030*	0.133	0.856	0.337	0.793	0.027*	0.076

[a]The smaller the rank, the more preferred

*Significantly different by the Wilcoxon Signed Rank test at $p<0.05$

4.2 Livelihoods of N2Africa participants

Respondents were asked to answer questions by providing a rating of very low, low, moderate, high and very high. Questions related to each of the three main topics; 'vulnerability context', 'asset base' and 'policies, institutions and process (PIP)'. For households participating in N2Africa, each question was asked 'before N2Africa participation' and 'after N2africa participation', while respondents of Non-N2Africa were just asked to evaluate the current situation. The livelihood impacts of N2Africa's were evaluated based on two comparisons; before and after N2Africa participation, and between Non-N2 and after N2Africa participation. Impacts of N2Africa are acknowledged in this thesis only when there are significant differences in both comparisons. Medians of each question for respondents in each group are identified. When comparing Non-N2 and N2after groups, the significant differences marked with star (*) indicate that there are significantly higher or lower numbers of respondents answering the question in higher or lower directions. Hence, sometimes there are significant differences between the groups while there are no differences in median. In this case, mean ranks are presented together. The difference between this section's results and those presented in section 4.1 in investigating impacts of N2Africa with respect to food security is that this section highlights the perceptions respondents having relating to their livelihoods as a broader picture of food security.

Because it is often difficult to recall situations before N2Africa participation, the differences that respondents recall between the before and after N2Africa participation categories may be influenced by external factors. Questions investigating the reasons for their response followed to minimize the external factors.

4.2.1 Vulnerability context

According to Table 33 below, comparing before and after N2Africa reveals that all vulnerability context points (a, b, c, d, e, f, g) are improved. Comparing Non-N2Africa and N2after results in the significant differences in decreasing crop damage by floods/drought (a), crop damage by pests/disease at field (b), budget affected by price fluctuation (c), feel insecure when there are less employment opportunities (e). As we decided that only the overlapping significant differences are the attributions of N2Africa, vulnerability context of *a, b, c, e* are improved by N2Africa. The stable provision of food in the hungry season (d) both in N2 and Non-N2 is in line with the result in section 4.1.2.2 Table 17, that there is no significant difference in the consumption of legume before and after the maize harvest.

Among the significant impacts of N2Africa (a, b, c, e), low stratum of N2Africa has a significant impact only on decreased crop damage by pests/disease (b), while high stratum of N2Africa has significant impacts on of the N2Africa improvements.

Table 33 Median[a] of respondents' evaluation for vulnerability context

Questions[b]	**a. crop damage by floods/drought**	**b. crop damage by pests/disease at field**	**c. budget affected by price fluctuation**	d. food lacking in the hungry season	**e. feel insecure when less employment chances**	f. treat produce with storage pesticide	g. depends on external resources
Non[c]	Moderate*	Moderate*	High* (30^{th})[e]	Moderate or High	V.high*	Moderate or High	Low
N2before[d]	Moderate	High	High	High	High	Low	Moderate
N2after	Low*	Low*	High* (21^{th})[e]	Low*	Low*	Moderate*	Low*
N2low before	Low	High	High	High	High	V.low or Low	Moderate
N2low after	Very low	Low*	Moderate	Moderate	Low or Moderate	Moderate*	Low
N2high before	Moderate	Moderate	High	High	High	Low	Moderate
N2high after	Low*	Low*	High*	Low*	Low*	High*	Low

[a]V.high=very high, V.low=very low
[b]Questions in bold are those in which N2Africa impacts are perceived
[c]Non and N2after comparison by Mann-Whitney U test
[d]Before and after comparisons by the Wilcoxon Signed Rank test
[e]Mean rank, the higher the mean rank, the higher the vulnerability context
*Significantly different at $p<0.05$

4.2.2 Asset base

According to Table 34 below, comparing before and after N2Africa reveals that all assets presented except the ability of their children going to school (b) are improved. In comparison with Non-N2 and N2after, the assets are improved in N2after in *c*. health status of household members, *d*. work with other households for crop cultivation, *f*. size of legume field, *g*. yield of legume, *h*. yield of maize and *j*. household income. The size of legume field is what replaced other crops by legume. These 6 assets (c, d, f, g, h, j) are acknowledged as impacts of N2Africa by the significant differences both in the two comparisons. The significant perceived impact of N2Africa on increasing the yield of maize (h) is contradicting the result in section 4.1.1 Table 14, demonstrating that there is no significant difference in maize yields between N2 and Non-N2. This may be attributed to confusion of the N2 respondents regarding the impact of N2Africa and the change in other factors such as more fertilizer provided by FISP. Another reason could be that the maize yield is higher in N2 than Non-N2 but only to the extent that N2 households could perceive because it is not significantly different. The significant impact of N2Africa on increasing the legume yield (g) may account for the result in section 4.1.2 that the contribution of legumes to daily calorie intake/person is higher in N2 than Non-N2.

Half of the improvements occur in natural capital (f, g, h). The improved assets in natural capitals apply to both low and high stratum of N2Africa. It is somewhat reasonable since N2Africa is an agricultural intervention, therefore most likely to affect natural capital. Crop damages by pest and diseases are perceived as significantly reduced in both strata

(Table 33 above). This accounts for the increased yield of legumes and maize. However, improved assets of health status of household member (c), working with other household for crop cultivation (d), and household income (j) only improved significantly in high stratum. Health status of household members (c) is evaluated as fairly good by low stratum of N2 both before and after participation of N2Africa. In spite of different medians in working with other households for crop cultivation (d) between before and after of N2low, it is not significantly different. The unchanged low level of household income (j) for low stratum before and after N2Africa indicates that the increased yield of legume and maize are not enough to sell in the market but just for self-consumption due to the lack of resources. This confirms the result in section 4.1.3 by the explanation of Table 19.

Overall respondents (N2 after and Non-N2) have high knowledge for growing crops and access to extension services based on the median of 'High' in both. In addition there is an insignificant difference in the distribution of answers between Non-N2 and N2after. Impacts of N2Africa regarding access to extension services (e) should be carefully viewed, since extension workers were translators and were involved in household selection in the current study which may influence the answers about the accessibility to extension services. The children of each household are sent to school always (b). This reflects one of the features of Chewa, that they put importance on and highly value education, while girls are often excluded for education in the Yao tribe in Salima as observed in this research. Soil fertility of legume field (i) is moderate overall.

Table 34 Median[a] of respondents' evaluation for assets

Questi-ons[b]	a. knowledge of crop cultivation	b. children going to school	**c. household members' health**	**d. work with other households**	e. access to extension services	**f. size of legume field**	**g. yield of legume**	**h. yield of maize**	i. soil fertility of legume field	**j. household income**
Capital	Human	Human	Human	Social	Social	Natural	Natural	Natural	Natural	Finan-cial
Non[c]	High	High	Moder*	Moder*	High	Low*	Moder*	Moder*	Moder	Low*
N2-before[d]	Low	High	Low	Low	Low	Low	Low	Low	Low	Low
N2after	High*	High	High*	High*	High*	High*	High*	High*	Moder*	High*
N2low before	V.low or Low	Moder or High	Moder or High	Low	Low	Low	V.low or Low	Low	Low	Low
N2low after	High*	High	High	High	High or V.high*	Moder or High*	High*	High*	Moder*	Low
N2high before	Low	High	Low	Low	Low	Low	Low	Low	Low	Low
N2high after	High*	High	High*	High*	High*	High*	High*	High*	High*	High*

[a]V.high=very high, V.low=very low, Moder=Moderate
[b]Questions in bold are those in which N2Africa impacts are perceived
[c]Non and N2after comparison by Mann-Whitney U test
[d]Before and after comparisons by the Wilcoxon Signed Rank test
*Significantly different at $p<0.05$

Social capital was further investigated by asking interviewees about groups household members belong to. Women participate in 53% of the groups representing their household, and only in 28% of the groups households are represented by men. 7% of the groups are represented both by women and men. There is no information for the remaining 12%. This demonstrates that social groups are better utilized by women than men.

With respect to the roles of social group, more than half (58%) of the groups are recognized as able to share food, seed or labor, while the rest of the groups are regarded as being unable. Among the 58%, 31% account for sharing seeds, 21% for sharing labor and 6% for sharing food. The highest proportion, sharing seeds through social groups suggests one way for N2Afria to continue to circulate legume seeds among households. This role of social group becomes more crucial for N2Africa given that the most common reason farmers do not grow legumes is a lack of access to seeds (Kamanga et al., 2014). More than half of the groups sharing food, seed or labor implies that social groups could play a strong role in overcoming resource constraints. It is confirmed in Bantilan and Padmaja (2007) that building social capital improves access to resources. Kamanga et al (2014) reveal that reason for farmers to stop growing legumes due to the lack of legume seeds is more common reason among less well-resourced households than better-resourced households. Based on this, social groups have more importance for the low stratum as they have difficulty to acquire legume seeds (Table 20). It is also shown in this study that most of the low stratum households hold the importance of social groups for farming as 'Very high', and most of the households of high stratum as 'high'. However, in Table 32, the significant role of N2Africa on the level of working with other households for crop cultivation (d), does not apply to low stratum of N2, while high stratum of N2 significantly changed 'working with other households' (b) from 'Low' to 'High'. This demonstrates the lack of social capital or network formed by N2Africa which could also encompass the low stratum.

To complement the results of section 4.2.1 vulnerability context (Table 33) with the results of the assets in Table 34, the impacts of N2Africa on the household budget affected by price fluctuation of crops and inputs and their insecurity when there are less employment opportunities are due to the increased household income. The unchanged levels of those among low stratum of N2Africa are in line with the unchanged level of household income for low stratum.

4.2.3 Policies, institutions, and processes

N2 respondents evaluate that after N2Africa they have significantly higher market access to sell legumes and other crops, access to input for farming position of women for decision making and amount and frequency of legume consumption (a, b, c, d, e, f) than before. To compare with Non-N2, the level of answers of after N2Africa is significantly higher in access to input for farming and amount and frequency of legume consumption, which are the improved categories (c, e, f) within PIP by the introduction of N2Africa. These are demonstrated in Table 35. There is nearly no difference in the position of women for decision making in both groups. The unchanged position level of women for decision making is in line with the result in section 4.1.6 (Table 27; Table 28) indicating no significant difference in women empowerment score between N2 and Non-N2. Increase in legume yield (Table 34; g) leads to high and frequent consumption of legumes

in N2Africa households (Table 35; e, f). It is assumed that the provision of legume seeds by N2Africa and higher household income (Table 34; j) increase the access to input for farming in N2 households only for high stratum. This is confirmed by question c in Table 35. In low stratum, household income was not significantly increased (Table 34; c), and therefore they could not afford inputs (Table 35; c).

Table 35 Median[a] of respondents' evaluation for policies, institutions and processes

Questions[b]	a. market access for legume sale	b. market access for other crop sales	**c. access to input for farming**	d. position of women for decision making	**e. amount of legume consumption**	**f. frequency of legume consumption**
Non[c]	Low or Moderate	High	Low*	Moderate	Moderate*	Moderate*
N2before[d]	Low	Low	Low	Moderate	Low	Low
N2after	High*	High*	High*	Moderate*	High*	High*
N2lowbefore	Low	Low	Low	Low or Moderate	Low	Low
N2lowafter	High*	High*	Low	Moderate	Moderate or High*	High*
N2highbefore	Low	Low	Low	Moderate	Low	Low
N2highafter	High*	High*	High*	Moderate*	High*	High*

[a]V.high=very high, V.low=very low
[b]Questions in bold are those in which N2Africa impacts are perceived
[c]Non and N2after comparison by Mann-Whitney U test
[d]Before and after comparisons by the Wilcoxon Signed Rank test
*Significantly different at p<0.05

4.2.4 General remarks on livelihood

There are several aspects which were not improved for the in low stratum of N2Africa. Looking at vulnerability context, N2Africa affects 4 parameters. However, low stratum of N2Africa only benefitted from 1 out of 4 parameters, namely decrease in crop damage by pest and disease, whereas high stratum of N2Africa benefitted from all 4 attributes of N2Africa. As for assets, 6 parameters were attributed to N2Africa. Low stratum of N2Africa only benefitted from 3 out of 6 parameters. The three parameters are size of legume field and yield of legumes and maize which all belong to natural capital. High stratum of N2Africa received all the benefits. With regard to PIP, it was concluded that N2Africa positively affected 3 parameters. Low stratum of N2Africa benefitted from 2 parameters, amount and frequency of legume consumption, out of 3 parameters while high stratum of N2Africa benefitted from all 3 parameters. This difference is mainly due to the shortage of resources of low stratum meaning they do not receive as many benefits of N2Africa. Particularly, the unchanged level of low stratum in working with other households for better crop cultivation (Table 34; b) and access to inputs for farming (Table 35; c) implies a need of social capital or networks to enable the low stratum to benefit from the agricultural intervention. This also coincides with the information that the low stratum highly appreciated the social network for their farming compared to high stratum. Although no questions were asked about the seed provision in the livelihood section, the farmers' groups and lead farmers in villages can be seen as unintentional

positive changes in the field of social capital and can also positively affect access to legume seeds after N2Africa stops providing free seeds.

5. Integration and discussion

5.1 Integration for food security

In this section, results are integrated with the four pillars of food security by answering the three research questions. The second research question on livelihood is organized into the four pillars of food security on the basis of the theoretical framework suggesting food security is one of the outcomes of livelihood. All results showing significant differences are briefly summarized in Table 36.

RQ1. Did households which adopted legume technology of N2Africa improve the household food security, taking into account the multidimensional definition of food security?

RQ2. Did the households which adopted legume technology of N2Africa improve their livelihood?

RQ3. Does the impact of the legume technology of N2africa on food security and people's livelihood differ between farm types?

5.1.1 Availability

The role of rotation and intercropping with legumes contributing to high maize yield is not significantly proven in this research, but merely shows a higher maize yield when rotation or intercropping techniques are used (section 4.1.1; Table 8, Table 12). This is due to the fact that the effect is realized in the long term and there are other factors influencing maize yield such as soil state, input usage, etc. This is shown in the significantly higher maize yield in high stratum which is more likely to use more fertilizer and hybrid maize seed, than low stratum (Table 14). Yet as there was no information on other factors affecting maize yield in this research, a more accurate analysis of the impact of rotation and intercropping on maize yield can only be made after acquiring all relevant information. However, significant correlation between intercropping practices and N2Africa participation (Table 9) implies the contribution of N2Africa for high maize yield. This is supported by the literature claiming the role of legumes in intercropping and rotation (Antonio, 2006; Bonsu and Asibuo, 2013; Giller, 2001; Kureh et al., 2006; Matusso et al., 2014; Stanger and Lauer, 2008; Rao and Mathuva, 2000; Yusuf et al., 2009). This is supported by the positive acknowledgement of N2 households towards the contribution of rotation and intercropping to high maize yield. It seems that there is no difference regarding the impact of N2Africa on different strata with regard to rotation and intercropping.

The contribution of legumes to the daily calorie intake per person is significantly higher in N2Africa households compared to Non-N2Africa households (section 4.1.2; Table 16). The significant impact of N2Africa is present in both low and high stratum. As for the livelihood section, the yield of legumes and maize are perceived as increased by N2Africa (section 4.2.2; Table 34). The perceived impact of N2Africa on increasing the yield of maize contradicts the result in section 4.1.1 Table 14, demonstrating that there is no significant difference in maize yields between N2 and Non-N2. This may be attributed to

the possibility that the N2 respondents were confused with the impact of N2Africa and the change in other factors such as more fertilizer provided by FISP. Another reason could be that the maize yield is higher in N2 than Non-N2 only to the extent that N2 households could perceive while it is not significantly different. The significant impact of N2Africa on increasing the legume yield (g) may account for the result in section 4.1.2 that the contribution of legumes to daily calorie intake/person is higher in N2 than Non-N2. Besides the role of N2Africa, legumes contribute to satisfying MDER since the calorie contribution of legumes is significantly higher when satisfying MDER compared to when not (section 4.1.2; Table 16). And legumes contribute to daily calorie intake/person significantly more for low stratum than high stratum (Table 16).

In short, N2Africa contributes to availability of legumes shown with the significantly higher contribution of legume to daily calorie intake/person, and the significantly increased yield of legumes found in N2 than in Non-N2. As for availability of maize, N2Africa participation is significantly correlated with more chances of intercropping practice which contributes to high maize yield. Although the rotation and intercropping are not demonstrated in this research to cause high maize yield owing to the lack of information regarding other overriding factors affecting maize yield, the effect is proven in other literature. It seems that there is no difference of N2Africa's contribution on availability of legumes and maize on varying farm types.

5.1.2 Access

N2Africa does not significantly contribute to the household 'cropping' income through legumes based on the result of section 4.1.3 in Table 18, neither is there a significant difference between low and high stratum of N2Africa. The insignificant differences are also indicated in the WDDS, which can partly reflect the household economic access to food (section 4.1.5; Table 23). There is no effect of processed legume in the contribution to household income because processed legume products are rarely sold. Nevertheless, the contribution of income from legumes to the household 'cropping' income is significantly higher for low stratum than high stratum (section 4.1.3; Table 18). However, it is shown in section 4.2.2 Table 34 that respondents perceive that household income is significantly increased by N2Africa, but not necessarily from legumes.

There is no significant difference in the perception of the dependency on inputs between N2 and Non-N2 households (section 4.1.4; Table 20), neither a significant difference between low and high stratum of N2Africa. Instead, it is revealed that legumes are significantly less dependent on fertilizers than maize, while it is not clearly proven whether legume requires more labor than maize (Table 20, Table 21). Groundnut is also significantly less dependent on pesticide than maize. The reason for significantly higher contribution of income from legumes to household cropping income of low stratum than high stratum (section 4.1.2; Table 18) is due to the large total cropping income of high stratum resulting from the sales of maize (section 4.1.4; Table 19). Selling maize to secure household food is not an easy option for the low stratum owing to the high input costs incurred by maize and limited resources. This explains the higher importance of legumes in household income for the low stratum, compared to the high stratum.

In section 4.2.2 Table 34, N2Africa is perceived to increase the health status of the

household members, cooperation with other households for better crop cultivation, size of legume field, household income, and access to inputs for farming (section 4.2.3; Table 35). However, among these 5 access aspects that are perceived as improved by N2Africa, 4 aspects (except size of legume field) are not perceived as improved in low stratum of N2Africa. The increase in size of legume field is what substitutes the other crop fields, not purchasing a new piece of land. The considerable biased benefit of increasing access only to the high stratum demonstrates the need of institutions which can also encompass benefits for the low stratum. One of the most promising institutions is social capital or network given that low stratum highly valued the role of social networks compared to high stratum, and the role of social groups which can share seed, labor or foods.

In addition, women's access measured in terms of decision making power is significantly higher in legume production than maize production (section 4.1.6; Table 26). For the women empowerment score used in this research which includes and aggregates the aspects of production, resource and income, N2Africa does not significantly contribute to women empowerment (section 4.1.6; Table 27, Table 28). This is also demonstrated in the livelihood assessment of the position of women for decision making (section 4.2.3; Table 35). However, N2Africa significantly contributes to higher decision making power of women in input decisions for legumes (section 4.1.6; Table 29), and land size for legumes only when women own the land in the household (Table 30). There are no significant differences in the impacts of N2Africa on increasing women's access between farm types (Table 27; Table 28; Table 29).

To summarize, N2Africa does not significantly contribute to economic access through legumes and there is no significant difference between farm types. N2Africa is perceived to improve the access pillar through increasing the health status of the household members, cooperation with other households for better crop cultivation, size of legume field, household income, and access to inputs for farming. The household income perceived as increased by N2Africa may not arise from increased legume income. However, N2Africa does not significantly often benefit the access dimension for the low stratum. Women's access is significantly increased by N2Africa with respect to 'resource' use associated with input and land size for legumes. The significant increase in women's access to land size for legumes however, is only valid when women own the lands in the household. Regarding this, there is no significant difference varying with farm types.

5.1.3 Utilization

N2Africa does not significantly contribute to diet diversity and frequency of legume consumption (section 4.1.5; Table 23, Table 24). There is no significant difference in impact of N2Africa on different farm types. Looking into the specific food categories in Table 25 , there is no significant correlation between N2Africa participation and number of household consuming legumes. The results show that the culture of legume consumption stems from tradition, or habit. It underpins the insignificant difference in diet diversity between N2 and Non-N2. This is confirmed by Reynolds (2000) stating that grain legumes are traditionally grown in Malawi among smallholders. It implies that people in Salima in general take various nutrients from legumes such as protein, micronutrients (vitamin B, iron, calcium, zinc) and fat which is usually deficient in African diets (Jager, 2013). N2Africa households significantly consume more meat/fish

than Non-N2, especially the low stratum of N2Africa which may account for their slightly higher WDDS (Table 25). In addition, the low stratum of N2Africa consumes more tea/coffee than that of Non-N2. Tea/coffee is not included in the calculation of WDDS. However, respondents of N2Africa assessed that they consume legumes more frequently than before N2Africa and higher quantity of legumes (section 4.2.3; Table 35). Even though they perceive it as such, the greater amount and frequency of legume consumption are not enough to be significantly different between N2 and Non-N2. Sufficient food consumption is also crucial to be free from health risk. It is proven that in N2Africa households, the legumes contribute to the daily calorie intake (section 4.1.2; Table 16).

Even though it is proven that significantly higher women's priority on the use of household income on kitchen utensils compared to men (section 4.1.6; Table 32), this is not ensured by N2Africa. This is because there is no significant correlation between N2Africa and women's higher decision making power on household expenditure (Table 29) as well as the insignificant women empowerment score (Table 27, Table 28). There are no different impacts of N2Africa on different farm types.

To summarize the utilization pillar, N2Africa does not significantly contribute to utilization with respect to the diversity of diet and women's decision making power on household expenditure improving utilization. Although the quantity of nutrients are significantly higher (section 4.1.2) in N2Africa than Non-N2, the improvement in nutritional status cannot be confirmed with the increased calorie intake alone since nutritional status is improved together with other determinants (Smith & Haddad, 2000). There is no significant difference with varying farm types for the contribution of N2Africa on utilization.

5.1.4 Stability

N2Africa does not significantly contribute to the stability of daily calorie intake/person from legumes, neither is there a significantly different impact on different strata across the maize harvest season (section 4.1.2.2; Table 17). It is in line with the result showing that availability of food in the hungry season is not perceived to be significantly increased by N2Africa, but rather stable for all, irrespective of N2 or Non-N2 (section 4.2.1; Table 33). While the daily calorie intake from legumes is stable both within N2 and Non-N2, N2 shows a significantly higher daily calorie intake/person from legumes after maize harvest compared to Non-N2. It is perceived that crop damage by flood/drought and pest/disease is significantly reduced by N2Africa, which may ensure the stability of availability in times of seasonal fluctuations caused by unpredictable weather conditions. The decreased crop damage by floods/droughts does not apply for low stratum.

N2Africa is significantly perceived to contribute to the stability of economic access, since N2Africa households feel less insecure when there are less employment opportunities (seasonal stability), and their household budget is less affected by price fluctuation of crops and inputs (transitory stability) (section 4.2.1; Table 33). However, it is ensured only for the high stratum, not for low stratum.

There is no significant difference in the contribution of N2Africa to the stability for diet diversity (section 4.1.5.2; Table 23), neither a difference across farm types. Although

every group shows the same WDDS before and after maize harvest in Table 23, a significantly higher ratio of N2 household consumes meat/fish than Non-N2 households after the maize harvest. This difference is particularly significant between the low stratum of N2Africa and that of Non-N2 after the maize harvest (Table 25). Another significant correlation is revealed between the vitamin A rich food consumption, usually in forms of orange-fleshed sweet potato and pumpkin, and its significantly higher ratio of low strata both of N2 and Non-N2 for consumption before the maize harvest than after. The provision of 'vitamin A' is stable only for 'low stratum of N2Africa' irrespective of maize harvest season. Before the maize harvest, vitamin A is taken significantly through sweet potato and pumpkins for low stratum both of N2 and Non-N2. After the maize harvest, there is a reduction in vitamin A supply because of the significantly reduced consumption of sweet potato and pumpkin. However vitamin A consumption is compensated by significantly higher meat/fish consumption in N2low than Non-N2low. In spite of the insignificant impact of N2Africa for the stability of diet diversity, the role of legumes for provision of variety of nutrients through-out the maize harvest season is noticeable, which is not significantly correlated between timing of maize harvest. Therefore, the provisions of 'protein, a variety and concentrations of micronutrients (vitamin B, iron, calcium, zinc) and fat' by grain legumes are stable through-out the maize harvest season irrespective of N2Africa participation. It is worth notice especially before the maize harvest when nutrient intake is less likely to be diverse and various nutrients in legumes. This will, in the long term, improve the health of household members.

Besides the role of legumes for stable nutrient variety and provision, legumes significantly contribute to resource maintenance since the fertilization effect of legumes (section 4.1.4) attributes to stability in the long term. Although stability of daily calorie intake/person by legume (section 4.1.2.2) and the stability of quality of diet (section 4.1.5.2) are proven to be stable across the maize harvest season irrespective of N2Africa, it needs to be noticed that the timing of interview was close to the maize harvest, which enables people to harvest at a small scale from their field.

Summarizing the stability pillar, N2Africa does not significantly contribute to stability of availability with respect to daily calorie intake/person from legumes across maize harvest seasons. However, N2Africa households significantly perceive that crop damage is decreased from pest/disease and flood/drought, which ensures the seasonal stability against unpredictable weather and cropping patterns. Conversely, the reduced crop damage by floods or drought is not the case for low stratum. The role of N2Africa for the significant stability of economic access is acknowledged through ensuring transitory and seasonal stability, but it is not perceived as such in low stratum. N2Africa does not significantly contribute to the stability of diversity of diets. The stable provision of vitamin A is only significant in low stratum of N2Africa. Besides the role of N2Africa on stability, the significant role of legumes for stability is found with respect to diversity of diet which will ultimately contribute to stability in terms of human health, and resource maintenance.

5.1.5 General remarks on N2Africa and its contribution to the 4 pillars

N2Africa contributes to the 'availability' of legumes, increasing 'access' (but not economic access through legume income), 'stability' of crop availability across the maize

harvest season (but not for daily calorie intake from legumes across maize harvest season) and stability of economic access regarding household income regardless of price fluctuations and decline of labor demand, however, N2Africa does not contribute to ‘utilization’. Among the contributions of N2Africa supporting the 4 pillars, it is often the case that the benefits of N2Africa does not reach the low stratum. There is no significant difference in the impacts of N2Africa between varying with farm types in ‘availability’ and ‘utilization’, however the low stratum is often excluded from N2Africa benefits in ‘access’ and ‘stability’. One exception that benefits the low stratum significantly more than the high stratum is the stability of vitamin A provision.

The role of legume, in addition to the impacts of N2Africa, are significantly found in the 4 pillars. As for ‘availability’, legumes significantly contribute to satisfying the MDER. The contribution of legumes to daily calorie intake is significantly higher in low stratum than high stratum. The significantly lower dependency of legumes on fertilizer, and pesticide which is only in the case of the groundnut, leads to significantly higher ‘economic access’ for low stratum to legumes than maize. In addition, the lower fertilizer dependency of legume will contribute to resource maintenance in the long run. Legume cultivation is significantly more involved with women’s decision making than maize cultivation. With respect to utilization, legumes provide various nutrients regardless of the harvest season of maize, which is the stability of utilization’s contribution. This will in the long run ensure the health of household members.

Table 36 Results for research questions at a glance

	RQ1.1	RQ1.2	RQ1.3	RQ1.4	RQ1.5	RQ1.6	RQ 1.7 a	RQ 1.7b	RQ 2[a]. Vulnerability		RQ 2. Assets		RQ 2. PIP[b]	
4 pillars	Availability	Availability[c]	Access	Access	Utilization	Utilization & Access	Stability of availability	Stability of utilization	Stability of availability	Stability economic access	Access	Availability	Access	Utilization
N2-Africa	Intercropping; Yes Rotation; No	Daily calorie intake/person; Yes	No	No	No, but only for meat/fish and tea/coffee	Access; No, but only for (i) input decision for legume (ii) land size for legume when wife owns land Utilization; No	No	No	Yes By decreased crop damage from (i) flood, drought, (ii) pests and disease	Yes By decreased affect from (i) price fluctuation and (ii) job opportunity	Yes By (i) health status, (ii) cooperation with others, (iii) size of legume field, (iv) household income	Yes By increased yield of (i)legume and (ii) maize	Yes For access to input for farming	Yes For (i) amount and (ii) frequency of legume consumption
(RQ 3) N2-Africa on strata		Both	No difference	No difference	No, but only for tea/coffee by low	No difference	No difference	No, but only vitamin A only in low	No change in low for (ii)	No change in low for both	No change in low for (i) (ii), (iv)	Both	No change in low	Both
Additional results about the role of legume outside of N2Africa														
Legume	No	MDER; Yes	.	'fertilizer[d]' 'pesticide'(ground-nut)		Yes	No	Stable provisio-n of various nutrient						
Legume on strata	.	Daily calorie intake/person; Low	More cropping income; Low											

[a]Only significantly different items are mentioned for RQ2, [b]PIP=Policies, institutions and process, [c]Utilization aspect included, [d]Stability research question for 1.7c is proven

5.2 Discussions

5.2.1 Different impacts of N2Africa on the 4 pillars of food security

By including the four pillars of food security, it enables this research to examine the legume technology of N2Africa from various angles. N2Africa does not make significant contributions to the utilization pillar. This is in accordance with the FAO (2012) stating "agriculture interventions do not always contribute to positive nutritional outcomes." Utilization in this research is mainly concerned with the nutritional aspects in the quality of diet, without much attention to other aspects of utilization. Insignificant impacts of N2Africa regarding nutrition may be due to the tradition of Salima district in Malawi where the cultivation and consumption of grain legume are traditionally carried out (Reynolds, 2000). It can also be attributed to the agricultural intervention which is difficult to translate into improvements in nutritional status. In the review by Masset et al (2012) about the improved nutritional status by agricultural intervention, there was little change in the diet of poor even when interventions with focused on agriculture producing higher nutrient improvements. The two current review papers (Masset et al., 2012; Webb, 2013) both point out problems in study design, such as a lack of methodological rigor and low statistical power showing the weak attribution of nutritional improvements to agriculture-based intervention even though positive impacts were achieved. These past studies allows this research to reflect the methodological weakness because only the measuring quality of diet in terms of WDDS and frequency consumption are included as indicators for utilization, while the commonly used indicator for utilization pillar, the anthropometry for children is not measured. It is distinctively recommended by Webb (2013) to explore the pathway of agricultural intervention, or more importantly the mechanism of it, in order to lead the agriculture intervention to nutritional improvements.

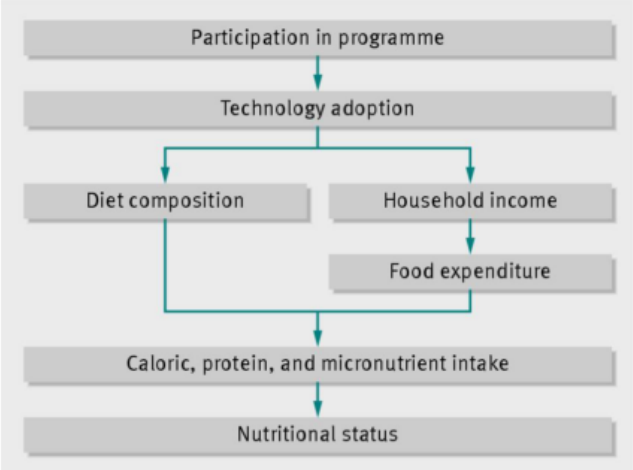

Figure 5 Pathways of effect on agricultural intervention on nutrition

Source: Masset et al (2012)

Presenting one pathway's effects of agricultural interventions on nutrition in Figure 5 above, it suggests that the increased household income by N2Africa may not have been used for food-related expenditure. This research shows there is no significant change in diversity of diet in section 4.1.5 by N2Africa, although it is proven in section 4.1.6 that women intend to prioritize household expenditure more on food and significantly on

kitchen utensil than men. This implies that respondents reported the interview and how they actually behave could be different. Observing the actual income use with a different methodology may have better represented the different household expenditures of women and men, rather than questioning their expected usage of household budget.

5.2.2 Potential of N2Africa to benefit low stratum as well as high stratum

In comparison with the impacts of N2Africa on the 4 pillars, the impacts of N2Africa often occurred in both strata for 'availability', while the impacts of N2Africa for 'access' and 'stability' are mostly not delivered to low stratum. This reveals the limitations of the N2Africa project as it has unequal impacts on the socio-economically disadvantaged group. This is especially evident given that the access is particularly related to the low stratum resource constraints as mentioned in the theoretical framework. This also illustrates examples of technology which are closely linked to the asset base, as some of assets are required to adopt new technologies (Adato and Meinzen-Dick, 2002). This is in line with previous research results claiming that the adoption rate of legume technology of N2Africa will be high in medium/high resource endowment households since low resource endowment is risk-averse and limited in resources to invest in and adopt the new technology (Franke et al., 2014; Tittonell et al., 2010). However, N2Africa has already shown significant impacts on both strata in several aspects of availability. Furthermore, legume technology intervention of N2Africa has a great potential to solve this inequality based on the research of Adato & Meinzen-Dick (2002). This authors point out that technologies which do not require many purchased inputs may be more accessible to households with low income. It is proven in section 4.1.4 that legumes are considered to be more favorable for low stratum than high stratum. Legumes are less dependent on fertilizers than maize resulting in making income easily for low stratum. Given the relatively ease of access to legume cultivation for low stratum, the role of legumes combatting hunger for low stratum when there is scarcity of foods and their various nutrients are worth notice.

However, the significant role of N2Africa on working with other households for crop cultivation does not apply to low stratum of N2 (section 4.2.2; Table 34) It shows a lack of proper social capital or network formed by N2Africa which could also encompass the low stratum. At this point, the need for N2Africa to build the social capital and social group is emphasized, since social groups can function as a starting point for collective action which will facilitate the impacts of agricultural technology even for the low stratum (Knox McCulloch et al., 1998). It is also confirmed in Bantilan and Padmaja (2007) that social capital is important for both adoption and impact to occur since it improves access to resources. Interestingly, the low stratum evaluated the importance of social groups for farming as 'Very high', and most of the households of high stratum as 'high' in this research. This gets more importance considering the significantly higher contribution of legumes to daily calorie intake and higher income ratio from legume sales among the household cropping income for low stratum than high stratum (section 4.1.2, section 4.1.3).

Moreover, 71% of women represent their households as social group participants, while only in 29% of the groups' households are represented by men. It is in line with Adato and

Meinzen-Dick (2002), who states that women tend to use social network more often than men to compensate for their limited access to credit and cash. Furthermore, women participating in various social groups were more involved in decision-making in their household which results in empowering women (Bantilan and Padmaja, 2007). It is also proven in their research that collective action was enhanced with the increased involvement and participation of women. This demonstrates that N2Africa even has an opportunity to contribute to women empowerment as well as providing equal opportunity to low stratum by working on building the social groups.

5.2.3 Literature reflection with theoretical framework

According to Adato & Meinzen-Dick (2002), agricultural technology of N2Africa should not only be expected to improve, but also be evaluated on whether they aggravate the situation since new technologies can increase vulnerability when new varieties are more susceptible to crop failure. During the interviews, it was revealed that the expectations of farmers for legume varieties differed. One of respondents was not satisfied with the introduced early-maturing cowpea since it is vulnerable to the pests and disease and the leaves of the new cowpea variety cannot be consumed, unlike the local cowpea varieties. For this household, there is a possibility that the legume technology of N2Africa may increase the vulnerability context. It is recommended for N2Africa to include farmers opinions or participation vigorously even at the beginning of the research to reflect the fine-tuned farmer's interest.

Sustainable livelihood framework (SLF) is a useful tool to understand food security as one of the livelihood outcomes. This interacts with food security pillars in that other successful livelihood outcomes could be sorted out as four pillars of food security. This framework enables this research to broaden the view of food security as a big picture, to not miss out other potential influences of N2Africa on the concept of food security as asserted by Adato and Meinzen-Dick (2002). The interaction between the livelihood assets and the vulnerability contexts are shown in the process of N2Africa. The reduced crop damage (vulnerability context) by N2Africa increases the yield of legume and maize (natural capital), and this again contributes to the higher household income from the sales of crops, improving financial capital. One of disadvantages of SLF is that it shows only a snapshot approach which is compensated with two-time-point assessments. SLF also interacts with the farm stratification, as livelihood strategies are adapted with the different livelihood groups (ACF International, 2010) which can be seen as the farm types. In large, the farm typology stratified with socio-economic variables to link with biophysical dimensions can be understood as the part of SLF. This can be evaluated in such a way that different livelihood groups (or farm types) perform differently with their assets and their reaction to vulnerability context shaping, for instance the research of Tittonell et al (2005), the different reaction to soil fertility management (Figure 6).

The women empowerment score which is developed on the basis of the WEAI by Alkire et al (2012) is a helpful measurement to capture the role of women in various domains which are important factors for women empowerment. In this research, score is composed of three domains (production, resource, income). The leadership domain of women in N2Africa in Malawi is implicitly shown in the result of the Woomer et al (2014) stating that involvement of men and women in farming activities in Malawi is balanced

compared to the N2Africa baseline survey.

Farm stratifications of Tittonell et al (2005) and Brand (2011) are well applicable to assess food security and livelihood. They claim that the adoption rate of N2Africa is likely to be higher in medium/high resource endowment households. However, several impacts of N2Africa such as the daily calorie intake/person, increase in legume and maize yield, and perceived amount and frequency of legume consumption exist in both strata. Langyintuo & Mungoma (2008) prove empirically that there is a non-linear relationship between wealth and adoption of new agricultural technologies. They also reveal that factors influencing the adoption and use of the new agricultural technologies vary between the poorly and well-endowed households. Despite the fact that these authors compared the adoption with only wealth indicators, the study suggests that agricultural interventions which target mainly the medium/high resource endowment households for higher adoption would be partial since the variables influencing the adoption are different between groups.

Figure 6 is generated to describe how the 4 pillars of food security, women empowerment and farm stratification could be placed in the sustainable livelihood framework. The positions of 4 pillars indicate how RQ 2 is placed with food security improvements. The interaction with farm stratification is already mentioned above. Women empowerment is understood as the change in PIP which interacts with the assets particularly enhancing human capital which will contribute to utilization. With a comprehensive view of food security, the possible livelihood outcomes shown in Figure 6 can be attributed to improved food security.

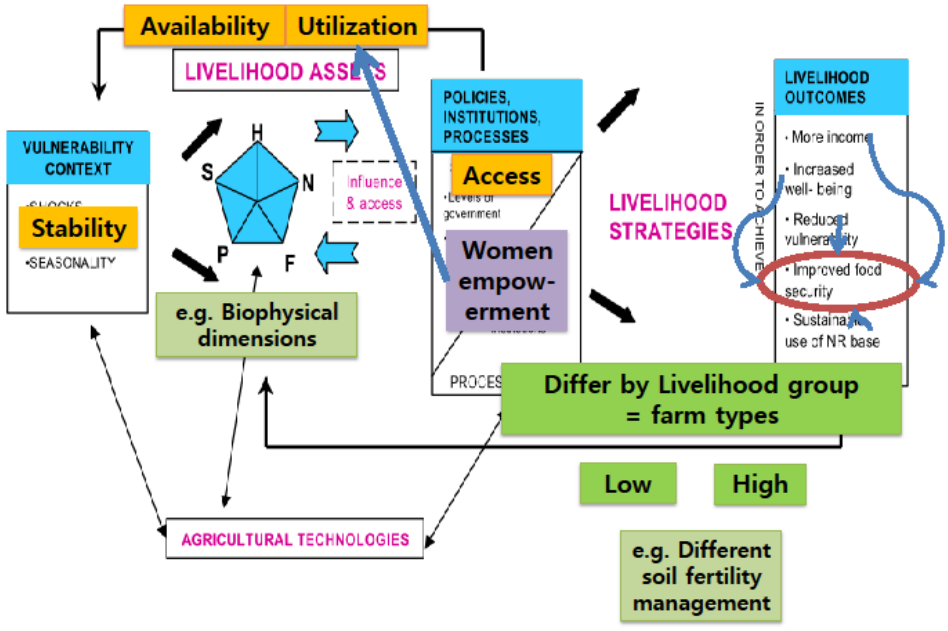

Figure 6 Adapted sustainable livelihood framework from Adato and Meinzen-Dick (2002) which is marked with interactions with the 4 pillars of food security, farm stratification and women empowerment

5.2.4 Research limitations

To create a valid assessment of the design and obtaining the picture of the counterfactuals, two key elements are necessary (Gertler et al., 2011); First, the two time-points of data collection enable the researchers to calculate the extent to which impact indicators have changed over the course of the project implementation. Another is to have a control group to facilitate the attribution of changes to the project. There are several limits of this research design regarding the impact assessment of food security, yet adjustment measures are taken.

Firstly, as there was no baseline assessment beforehand, the research was conducted with the alternative design called 'Post only with control group'. Data collected for time points for before relies on the respondents' recall to compensate the lack of two time points. The accuracy for the objective information can be rather weak, but the same contents are asked in different questions to verify the information. The equivalent of the control group is obtained through randomization of selection of households not participating in N2Africa. Nevertheless, limitations exist in the sample. The selected sample is not completely random. The Non-N2Africa samples are not zero-base interventions. Most of the households in Salima are already participating in other projects at the same time, or had participated. The other projects are about conservation agriculture, agroforestry, post-harvest loss management, rearing livestock, irrigation, and village savings and loan. It is confirmed that there are no legume interventions among these.

The impact of N2Africa on different farm strata should be concluded carefully. The farm typology made here is rather rough as farms are aggregated into only two types, while usually it is with five different strata. Not all specific differences between farms are identified. The extreme in low stratum, farm type 1, and the extreme in high stratum, farm type 5 shown in Brand (2011) are largely missed in this study's data.

6. Conclusions and recommendations

N2Africa contributes mainly to the availability of legumes. Economic access in terms of income from legume is not significantly increased by N2Africa. Women's access to input and size of land for legumes is significantly increased by N2Africa. Increased women's access to size of legume field is only valid when women own the land in the household. Enhanced health status of household members, higher cooperation with other households for better crop cultivation, increased size of legume field, household income and access to inputs for farming are other improved aspects by participating in N2Africa regarding the access domain of food security by N2Africa. N2Africa does not contribute to utilization in terms of quality of diet and women's decision making power on household expenditure improving utilization. N2Africa contributes to stability of crop availability by reducing crop damages regardless of weather conditions and pest/diseases, but does not affect daily calorie intake per person from legume. Household income is recognized as stable when crop and input prices fluctuate and decline of employment by participating in N2Africa. However, N2Africa does not contribute to stability of utilization.

The insignificant impact of N2Africa to utilization can be attributed to the tradition of Salima district in Malawi where the cultivation and consumption of grain legume are traditionally carried out (Reynolds, 2000). Another possibility can be laid on the methodological imperfection and low statistical power in this research as only quality of diet of women diet diversity score is included as an indicator for utilization, and the commonly used indicator for utilization pillar, the anthropometry for children is not measured. However, poor study design and method, and low statistical power (sample size) to identify impacts are often mentioned as common points which hamper the outcome for the positive nutritional improvement of agricultural intervention. Besides the methodological problems, it is recommended to explore the mechanisms of effect on agricultural intervention on nutrition to improve nutritional status through agricultural intervention (Webb, 2013).

However, in the access and stability pillars, the benefits of N2Africa are often not reach the low stratum, which is related to their resource constraints. This is in line with the result of the Franke et al (2014) claiming the limited adoption of N2Africa technology by low resource-endowed, since they are risk-averse and limited in resources to invest to adopt the new technology. However, legume technology intervention of N2Africa has a great potential to solve this inequality based on Adato & Meinzen-Dick (2002), pointing out technologies that do not require many purchased inputs may be more accessible to households with low income. Legumes are significantly less dependent on fertilizer than maize resulting in relatively easy access to legume for low stratum. And several impacts of N2Africa already significantly appeared in both strata.

Through building social network, the expected lower adoption rate by low resource endowed household could be increased, given the role of social groups sharing seed, food or labor and low-input legume technology of N2Africa. And, low stratum in general highly appreciates social capital. Furthermore, it seems necessary to investigate whether the linear relationship of the adoption rate of N2Africa and resource endowment is still valid after including the N2Africa activities for social network. This is supported by

Langyintuo and Mungoma (2008) empirically showing the different variables influencing different farm types for technology adoption in which a non-linear relationship exists.

Women participating in various social groups were more involved in decision-making in their household which results in empowering women (Bantilan and Padmaja, 2007). Given that women tend to more easily create the social network than men also proven in this research, N2Africa even has an opportunity to contribute to women empowerment as well as providing equal opportunity to low stratum by building social groups. It is also proven that collective action was enhanced with the increased involvement and participation of women (Bantilan and Padmaja, 2007). Thus, involvement with building social groups is highly recommended for N2Africa. It would be necessary for further researches to investigate how the social groups or network are built in the sub-Saharan Africa, and the characteristics of the N2Africa group compared to other groups in order to find the effective use of social groups to reduce inequality as well as to empower women.

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8. Appendix

Appendix 1 Sustainability of N2Africa project

In Malawi, Ministry of Agriculture is divided into 28 District Agriculture Development Office (DADOs) as a key part of the decentralization policy, and 154 Extension Planning Areas (EPAs) which is a subdivision of DADOs (Future agricultures, 2008). EPAs are further divided into Sections which is the main point of service-delivery to farmers by extension workers. In Salima District, there are two EPA stations, Makandi and Chingluwe. Households were selected within Makandi EPA consisting of three sections. 21 villages in Makandi EPA are included in the sample. Households in 5 villages out of 21 villages are only Non-N2 households. The information of dropped-out households is only shown for 16 villages (see Figure below). .

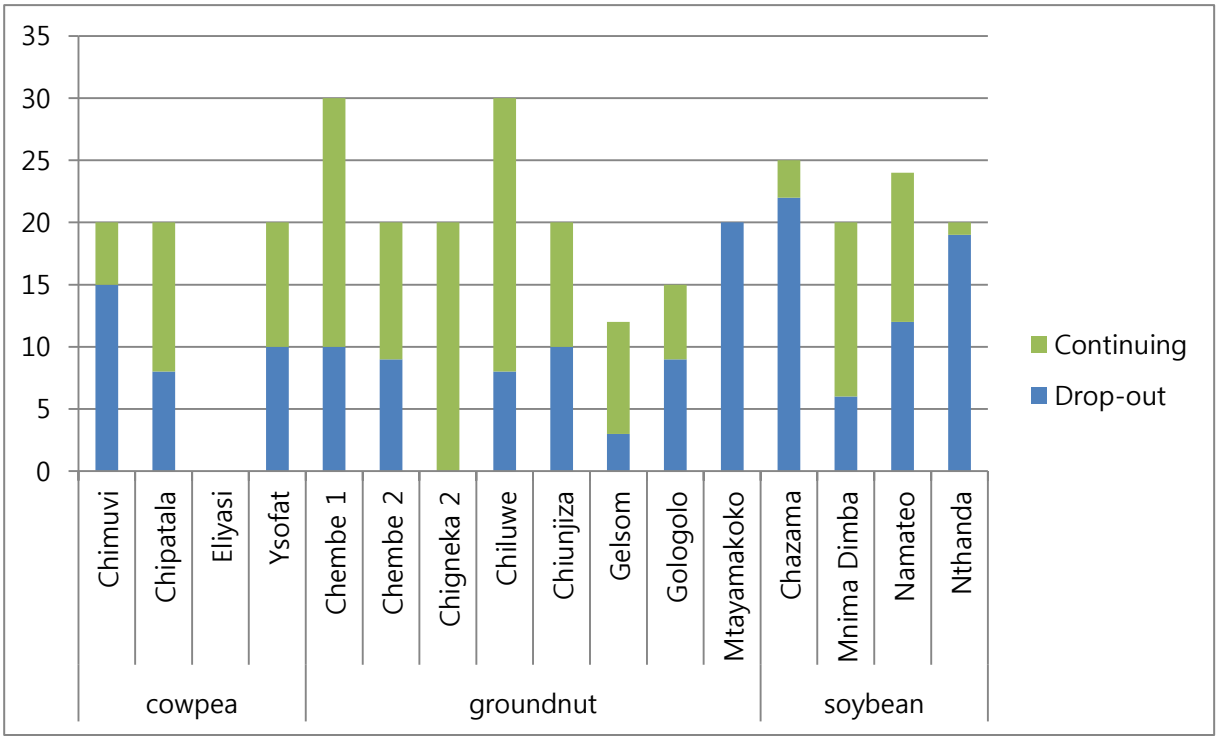
Speaking of drop-out(or continuing) rate, at a village level shown in the Table 4, 8 villages provided with groundnut 4 villages each provided with cowpea and soybean are included. In average, 58% of the households in the village provided with groundnut continue to use the same variety provided by N2Africa. This is the highest ratio among other provided grain legumes. Among the four grain legumes provided by N2Africa, common bean was not provided due to the climate condition in Salima. In the sample, groundnut is the crop of which the continuation rate is the highest as well. This can be attributed firstly to the variety which is given by N2Africa. Apart from the groundnut variety, other grain legume varieties are all newly introduced by N2Africa a few years ago. Therefore, farmers are accustomed to use the same variety of groundnut as they had previously. And there is high seed availability in the market of this groundnut variety as it has existed in the village. Secondly, as mentioned previously in the site description, groundnut is traditionally cultivated by people in Malawi, Salima. Farmers are easily continuing to use the same variety. Thus, the drop-out rates of the villages depend on what kind of grain legume is provided and the tradition of the legume in the village.

Most drop-out households articulate that nothing or low amount of the grain legume was harvested owing to the poor rainfall patterns. There are two reasons behind this. First is that farmers did not prioritize the grain legumes. The higher the importance they put into the crop, they plant earlier with the very first rain. If they could not harvest or less due to the poor rainfall pattern, there is high possibility that time of planting legume was late. Another explanation is due to the late delivery of the inputs from N2Africa. Farmers claimed that they missed the good time for planting because of the late delivery as all inputs come from the head-office of IITA located in Kenya. Though this does not hold for the reason for this year 2014 since N2Africa stopped providing seeds in Malawi, this could have effects the first two years when seeds were given by N2Africa.

In the Chimuvi village, a lead farmer collected all seeds from the satellite farmers and kept those for next season, which means when the lead farmer fails to keep seeds the whole village cannot cultivate the legume unless satellite farmers buy the same variety at the market. This shows the importance of the operation of the project at a village level at the site. Lead farmer is the leader of the N2Africa group in the village delivering the knowledge acquiring from the N2Africa trainings. Satellite farmers are those who

participate in N2Africa.

Therefore the success story of sustainability of the N2Africa project depends on the type and variety of the grain legume, how farmers perceive the legumes' importance and the effective operation at a village level.



The number of N2Africa continuing (or Drop-out) households in the villages in Salima district where the samples are included

Appendix 2 Aggregation of food groups in WDDS

There are 16 food groups in dietary diversity questionnaire. Among these, some are aggregated for the Women's Dietary Diversity Score (WDDS) shown in the table below. The food groups not included in WDDS are as follows; 14. Oils and fats, 15. Sweets, and 16. Spices, condiments, beverages.

Aggregated food groups in WDDS

Food groups in dietary diversity questionnaire*	Aggregated food groups in WDDS
1. Cereals, 2. White roots and tubers	Starchy staples
4. Dark green leafy vegetable	Dark green leafy vegetables
3. Vitamin A rich vegetables and tubers, 6. Vitamin A rich fruits and red palm oil if applicable	Other vitamin A rich fruits and vegetables
5. Other vegetables, 7. other fruits	Other fruits and vegetables
8. Organ meat	Organ meat
9. Flesh meats, 11.Fish and seafood	Meat and fish
10. Eggs	Egg
12. Legumes, nuts and seeds	Legumes, nuts and seeds
13. Milk and milk products	Milk and milk products

*Number indicates the question number in the original 16 food groups
Source: FAO (2010)

Appendix 3 Calculation of women empowerment scores

Based on the definition of the domains, questions are made specific to legume production. Each question is weighed differently to give weight equally to each domain. The division of the questions into different domains is referred from the WEAI. The two different scores are generated; one is the women empowerment score by crops, another is the women empowerment score in general irrespective of the comparison between legume and maize. The total number of women empowerment score is three; one for maize, another for maize, the last for in general. The weight is given to each question depending on the two different scores in order to have the equal weight of the domains. The question *a* is excluded in the women empowerment score by crops because there is no pair question for comparison with maize.

Women are asked to choose one answer among the different degrees in quartile of their part compared to their husbands. Each weight of the question is multiplied by the degree which the respondent chose. For example, if the respondents choose 75% for the question *a*, and if the women empowerment score in general is to be calculated, the score for question *a* is calculated as multiply 0.75 by 4/36. The final women empowerment score is generated by summing up all the scores of each question, thus the maximum score is 1.

Division of each question into domains of women empowerment and its weight depending on the women empowerment score by crops and in general

、	Productio n	Weight of each	Resource	Weight of each	Income	Weight of each	Tota l
Women empowerment by crops							
Legume	f	2/6	b,d	1/6	h	2/6	1
Maize	g	2/6	c,e	1/6	I	2/6	1
Women empowerment in general	a,f,g	4/36	b,c,d,e,	3/36	h,i	6/36	1

Appendix 4.1 Homogeneous subsets for desired household expenditure by women

Homogeneous Subsets									
		Subset							
		1	2	3	4	5	6	7	8
Sample[1]	farmimplement	4.323							
	food	4.552	4.552						
	housing	4.802	4.802						
	clothes	5.313	5.313	5.313					
	kitchen	5.583	5.583	5.583					
	transport		6.271	6.271					
	livestock		6.604	6.604	6.604				
	education			7.917	7.917	7.917			
	health				8.917	8.917	8.917		
	water					9.906	9.906	9.906	
	electronics					10.573	10.573	10.573	
	farefortransport					10.708	10.708	10.708	
	storageofproduce						10.823	10.823	
	fuelforcooking							11.542	11.542
	leisure								12.167
Test Statistic		7.529	13.158	9.250	4.667	11.021	7.337	7.221	3.000
Sig. (2-sided test)		.110	.022	.055	.097	.026	.119	.125	.083
Adjusted Sig. (2-sided test)		.296	.054	.156	.400	.077	.316	.329	.479

Homogeneous subsets are based on asymptotic significances. The significance level is .05.

[1]Each cell shows the sample average rank.

Appendix 4.2 Homogeneous subsets for desired household expenditure by men

Homogeneous Subsets										
		Subset								
		1	2	3	4	5	6	7	8	9
Sample[1]	farmimplement	4.714								
	housing	4.762	4.762							
	livestock	5.131	5.131	5.131						
	transport	5.655	5.655	5.655						
	clothes	6.167	6.167	6.167	6.167					
	food	6.202	6.202	6.202	6.202					
	health		7.250	7.250	7.250	7.250				
	kitchen			7.286	7.286	7.286				
	education			7.821	7.821	7.821	7.821			
	water				8.774	8.774	8.774	8.774		
	electronics					9.393	9.393	9.393		
	storageofproduce						10.619	10.619	10.619	
	farefortransport							10.690	10.690	
	fuelforcooking								12.274	12.274
	leisure									13.262
Test Statistic		8.105	10.595	12.827	8.735	8.871	9.029	6.657	8.048	4.667
Sig. (2-sided test)		.151	.060	.046	.120	.064	.029	.084	.018	.031
Adjusted Sig. (2-sided test)		.335	.143	.096	.274	.181	.104	.279	.086	.209

Homogeneous subsets are based on asymptotic significances. The significance level is .05.

[1]Each cell shows the sample average rank.

Appendix 5 Questionnaire

Impact of legume technology of N2Africa on food security and livelihood

·Date: ·Phone number:

·Name of the household head :

·Village: ·Farm ID:

·Expected date for maize harvest *NB*: If the respondents differ by each question, write down who

☺ Any kinds of comments from farmer's side relevant to the questions are welcome ☺

■ Sample grouping: N2Africa project participation			
□ Yes (When you have participated even once in the past)			
Ⅰ Now?	□	Ⅱ. Not any more at the moment	□
When did you start participating? (dd/mm/year)		When was it? (dd/mm/year)	from to
*Sample selection Household who has participated once including i)continuing and ii)dropping out should be first contacted. But if they are few, household now currently participating can be included.		Do you still follow the N2Africa recommendation?	□Yes / □No
		If Yes, which ones do you follow? Tick all if you follow several.	□ Variety □ Fertilizer □ Inoculum □ Other:
		If No, what's the reason?	
□ No, Group Ⅲ (Currently, household must NOT be participating any of projects. Households that haven't participated any projects are preferred)			
Name other projects if you have ever participated in the past			
For how long?			
What was mainly targeted and improved in that project?			
Have you heard about N2Africa project? If yes, Are there any reasons that you are not participating?			

■ Farm strata			( )Low	( )High
A. Endowment				
Housing type	Wall: earth / bricks / cement Roof: thatched / iron sheets Floor: earth / cement			
Size of arable land (~~RQ1.3. D~~ 2.1)				
Livestock ownership	Type	Number	Price	
	Poultry Goat Cow Pig Others		`	

				Sum
Assets owned	Type	Number	Price	
	Farming tools Hoe Machete Spade Sprayer Oxcart Irrigation pump Watering can Slasher Ax Sickle Wheelbarrow Radio Mobile phone Television Bicycle Car Other:			
				Sum
B. Production orientation (RQ1.2 a & f)	Subsistence / Subsistence+Market / Market			
C. Main source of income (RQ1.3 A)	Mixed / Off-farm / On-farm Off-farm			

■ N2Africa impact on livelihood in the household

These are the questions to ask how legume technology of N2Africa shapes livelihood of your household. 'B' stands for 'Before' participating N2Africa and 'A' stands for 'After' participating N2Africa. **Please answer as just how you feel and think.** ☺

A. Livelihood interaction with agricultural research	time	point	Very low	Low	Moderate	High	Very high
1. Vulnerability context			Comments (why, how etc)				
a. Crops in my household are damaged by floods or drought	B						
	A						
b. Crops in my household are damaged by pests and diseases.	B						
	A						
c. Household is seriously affected by the price fluctuation of crops and inputs.	B						
	A						
d. Foods lack in the hungry season (several weeks prior to harvest) in the household.	B						
	A						
e. I feel insecure for my household when there are less employment opportunities.	B						
	A						
f. My household treat produce with storage pesticide.	B						
	A						
g. My household depends on external resources.	B						
	A						
h. Please describe any vulnerability context other than those above, over							

which you have limited or no control.				
2. Asset base				Comments(why, how etc)
H	a. I know how to grow crops productively or efficiently.	B		
		A		
H	b. My children can go to school	B		
		A		
H	c. Household members have good health status (RQ1.5)	B		
		A		
S	d. My household cooperate closely together with other household for better crop cultivation	B		
		A		
S	e. My household can reach the agricultural extension services easily.	B		
		A		
N	f. Size of legume field in my household	B		
		A		
N	g. Yield of legume produced in my household	B		
		A		
N	h. Yield of maize produced in my household (RQ 1.1)	B		
		A		
N	i. Soil fertility in my household's field where legume in cultivated.	B		
		A		
F	j. Household income (RQ 1,3)	B		
		A		
m. What else (assets) were improved or deteriorated by participating N2africa?				
3. Policies, institutions, processes				Comments(why, how etc)
a. Market access for legume		B		
		A		
b. Market access for other crops		B		
		A		
c. Access to input(fertilizer, pesticides, seeds etc) for farming		B		
		A		
d. Position of decision making by women(wife) in your household		B		
		A		
e. In my household, we eat many legumes. (RQ1.2, RQ1,5)		B		
		A		
f. In my household, we frequently eat legumes. (RQ1.2, RQ1,5)		B		
		A		
4. Other outcomes(or changes) either good or bad after participating N2Africa?				

5. Social capital

a. Please name any of the social organizations/groups(a group of people meeting regularly) your household members belong to and the purpose of each.(what members do normally when they meet)

group name purpose

b. How did you become a part of members of the social organizations/groups ?

c. Are these social organizations/groups helpful when your household is in crisis such as food shortage, crop damage, floods, drought or
c. Are these social organizations/groups helpful in crisis, such that when there is food shortage, can they share food? When there is no seed available in your household, can they share seed? When there is need of labor in case when the main laborers are sick?

d. How much of these social organizations/groups are important for your household in terms of farming?

Very low Low Moderate High Very high

□ ☐ ☐ ☐ ☐

e. Did the N2Africa project influence your social organizations/groups? If yes, how?

B. General evaluation of legume technology of N2Africa

1. What kind of legume technology intervention do you want? Or what should be improved in N2Africa?

2. If you want, were you just able to join the N2Africa? Or re there any assets you missed to be able to adopt legume technology of N2africa?

3. Are there any constraints you faced to be able to adopt legume technology of N2africa?

■ N2Africa impact on livelihood in the household

[Group III] These are the questions about livelihood of your household. Please read the statement and tick one of boxes on which you agree.

A. Livelihood interaction with agricultural research	time	point	Very low	Low	Moderate	High	Very high
1. Vulnerability context			Comments(Why, how etc)				
a. Crops in my household are damaged by floods or drought	B						
b. Crops in my household are damaged by pests and diseases.	B						
c. Household budget is seriously affected by the price fluctuation of crops and inputs.	B						
d. Foods lack in the hungry season (several weeks prior to harvest) in the household.	B						

	e. I feel insecure for my household when there are less employment opportunities.	B		
	f. . My household treat produce with storage pesticide.	B		
	g. My household depends on external resources.	B		
	h. Please describe any vulnerability context other than those above, over which you have limited or no control.			
	2. Asset base			Comments(Why, how etc)
H	a. I know how to grow crops productively or efficiently.	B		
H	b. My children can go to school	B		
H	c. Household members have good health status (RQ1.5)	B		
S	d. My household cooperate closely together with other household for better crop cultivation	B		
S	e. My household can reach the agricultural extension services easily.	B		
N	f. Size of legume field in my household	B		
N	g. Yield of legume produced in my household	B		
N	h. Yield of maize produced in my household (RQ 1.1)	B		
N	i. Soil fertility in my household's field where legume in cultivated.	B		
F	j. Household income (RQ 1,3)	B		
	3. Policies, institutions, processes			Comments(why, how etc)
	a. Market access for legume	B		
	b. Market access for other crops	B		
	c. Access to input(fertilizer, pesticides, seeds etc) for farming	B		
	d. Position of decision making by women(wife) in your household	B		
	e. In my household, we eat many legumes. (RQ1.2, RQ1,5)	B		
	f. In my household, we frequently eat legumes. (RQ1.2, RQ1,5)	B		

4. Social capital

a. Please name any of the social organizations/groups(a group of people meeting regularly) your household members belong to and the purpose of each.(what members do normally when they meet)

group name purpose

b. How did you become a part of members of the social organizations/groups ?

c. Are these social organizations/groups helpful in crisis, such that when there is food shortage, can they share food? When there is no seed available in your household, can they share seed? When there is need of labor in case when the main laborers are sick?

d. How much of these social organizations/groups are important for your household in terms of farming?

Very low	Low	Moderate	High	Very high
□	☐	☐	☐	☐

e. Did the N2Africa project influence your social organizations/groups? If yes, how?

RQ 1.1 Maize yield affected by legume

A. Rotation

1. What was planted in the field during the last years where maize is now planted? If you have several maize fields, indicate all.

Year	2011	2012	2013	2014
Field 1				Maize
Field 2				Maize
Field 3				Maize

2. Why do you choose the crop for rotation?

3. Please fill in the blanks below.

	Size of the maize field in 2014 (acres)	Yield of maize in 2014 (bags)
Field 1		2nd visit
Field 2		2nd visit
Field 3		2nd visit
Sum	*	2nd visit

4. (2nd visit) Do you think the yield of maize is higher when the legume is in rotation?

5. Do you rotate more after participating N2Africa? How's before and after?

B. Intercropping

1. Do you plant other crop together with maize in the same field? ☐Yes / ☐No

Why?

2. Which crops do you intercrop with maize?

3. Why do you choose the crop for intercropping?

4. How long have you been intercropping?

5. Tick one of boxes on which you agree.	Strongly agree	Agree	Uncertain	Disagree	Strongly disagree
a. Maize when intercropped has bigger grains Why?	☐	☐	☐	☐	☐
b. Maize when intercropped is less susceptible to pest and disease. Why?	☐	☐	☐	☐	☐

6. Do you think the quality of maize (grain size, disease infection) is particularly high when a specific crop is intercropped? ☐ Yes / ☐No

→ If yes, which crop is it?

7. Do you use more intercropping after participating N2Africa? How's before and after?

RQ 1.2 Calorie intake from legume

Please fill in the blank. The answer should be based on last month recall in your household.

Number of household members who shared meal last month:

	Legume 1	Legume 2	Legume 3	Maize	Sum
LAST MONTH					
a. Maize/legume consumed in the last month from household production (bags)					
b. Amount of maize/legume purchased from market					
c. Purpose of the purchase					
d. Amount of maize/legume receiving as in-kind payment					
e. Other sources of maize/legume to a household, Specify:					

RQ 1.3 Legume on household income,

A. Source of cash income

Please fill in the blanks below on the ***ANNUAL BASIS***: From the last harvest until now before harvest.

First, please identify what kinds of source of cash income your household has. And, identify the types of crop in your household.

ANNUAL BASIS			Ranking	Proportional piling	Specific use if it exists
a.	Cropping				
	Ranking				
b.	Livestock				
c.	Fishing				
d.	Remittance				
e.	Casual labor				
f.	Off-farm, specify:				
g.	Other, specify:				

2.1 Are there any differences in SOURCE of income after participating N2Africa? ☐Yes / ☐No

2.2 How is it different?

B. Please fill in the blanks if any of the crops are sold from your household.

1. ***ANNUAL BASIS***: From the last harvest until now before harvest.

ANNUAL BASIS	Legume 1	Legume 2	Legume 3	Maize			
Amount sold*							
Market price**							

*Amount sold is the total amount sold in any markets you approached
**If you sell the crops in several different markets, please write down the lowest and highest prices.

C. Processing of legume

Annual Average

Do you process legume in your household?

Which way are they?	Which legume	How much of the total legume is used for this processing?	How much do you consume and sell it to market?

D. Household expenditure survey

1.1 Household expenditure on food

Weekly Average	Ranking
Cereal or tuber (maize, sweet potato, potato, cassava etc)	
Grain legume (Groundnut, soybean, common bean, cow pea, pigeon pea, Bambara nuts, Bush bean, climbing bean etc)	
Animal product(meat, milk, cheese etc)	
Fish	
Oil	
Fruits	
Leafy vegetables	

1.2 Are there differences in household expenditure on food after participating N2Africa? ☐Yes / ☐No

1.3 If yes, how is it different?

2.1 Production costs for cropping

ANNUAL BASIS		Legumes			Maize			
Size of land planted					Already answered			
Total yield in your household								
Seed price								
Average labor days spent (days/week)	Family labor							
	Hired labor							
	Price	Amount used for each crop can be answered in "Bags" **Total** amount used for each crop						
Mineral fertilizer: ( )								
Mineral fertilizer: ( )								
Manure								
Inoculants								
Biocide								

2.2 Are there differences, in terms of production costs for cropping after participating N2Africa? ☐Yes / ☐No

2.3 If yes, how is it different, in terms of production costs for cropping after participating N2Africa?

3. Household expenditure on others

Annual Average		Ranking
Water		
Education		
Health		
Fare for transport		
Fuel for cooking		
Leisure for recreation		
Purchasing of assets	Farm implements (Hoe, cutting knife, ox/donkey cart, watering cans, tobacco drying shed etc)	
	Livestock facilities and Livestock (Roofed shelter, Fenced shelter without roof etc)	
	Storage of produce (Bags, Earthenware pots, Mud silo/granary etc)	
	Housing properties and power (for floor, roof, bricks, poles or planks, paraffin, battery, electricity, solar power, generator etc)	
	Electronics (Cell phone, radio, television, fridge etc)	
	Transport (Bike, car, motor-cycle etc)	
	Kitchen utensils (pots, plate etc)	

	Clothes, shoes	
Other, specify:		

RQ 1.4 Dependency on external input

1. Refer to the answer D 2.1 in RQ 1.3 for the production costs of legume and maize.

2. How do you get seeds of each crop? Please describe all the different ways if you have several.

For legume,

For maize,

3. Tick in one of boxes on which you agree.

	Strongly agree	Agree	Uncertain	Disagree	Strongly disagree
a. It is easier to get legume seeds than maize seeds. Comment:	☐	☐	☐	☐	☐
b1. Legume requires more fertilizer than maize to produce same amount Comment	☐	☐	☐	☐	☐
b2. Legume requires more seeds than maize to produce same amount Comment	☐	☐	☐	☐	☐
b3. Legume requires more labor than maize to produce same amount Comment	☐	☐	☐	☐	☐
c. Legume is more costly than maize to produce same amount Comment	☐	☐	☐	☐	☐
d. Legume grows better without(or less) external input than maize Comment	☐	☐	☐	☐	☐
e. Planting legume makes soil fertile comment:	☐	☐	☐	☐	☐
f. When fertilizer is in short, I feel safer when I have legume in my field Comment	☐	☐	☐	☐	☐
g. When the price of fertilizer is high, I would plant legume in my field instead of purchasing fertilizer Comment	☐	☐	☐	☐	☐
h. Legume plays more different role in a household than maize does. comment	☐	☐	☐	☐	☐
i. I think having legume makes my household more independent from external inputs. Comment	☐	☐	☐	☐	☐

RQ 1.5 Quality of diet

A. Please describe the **foods** (meals and snacks) that ***you*** **ate** or **drank** yesterday (from the moment he/she woke up yesterday till she woke up this morning), at **home or outside** the home. Start with the first **food or drink** of the morning. Mind the food how it's cooked.

A) Think about when ***(NAME)*** first woke up yesterday. Did ***(NAME)*** eat anything at that time? *IF YES*: Please tell me everything ***(NAME)*** ate at that time. *Probe:* Anything else? *Until respondent says nothing else. If no, continue to question b).*

B) What did ***(NAME)*** do after that? Did ***(NAME)*** eat anything at that time? *If yes:* Please tell me everything ***(NAME)*** ate at that time. *Probe:* Anything else? *Until respondent says nothing else. Repeat question b) until respondent says the she went to sleep until next day.*

C) *After the dishes are mentioned and written down, then ask for the composite dishes (porridge, sauce, stew) mentioned:* What ingredients were in that **(mixed dish)**?" *Probe:* "Anything else?" *Until the respondent says "nothing else".*

D) *In case ingredients are unknown, ask:* Where was the dish bought or prepared? *Write this down under remarks in the table.*

E) *Finally, ask:* Did ***(NAME)*** yesterday eat any fruits at home or outside of the house? *Write this down in the table by fruits. And ask:* Did ***(NAME)*** yesterday eat any snacks at home or outside of the house? *Write this down in the table at the bottom line. Write down all food and drinks mentioned.*

Time	**Dish**	**Ingredients**	**Description**
Breakfast			
Snack			
Lunch			
Snack			
Dinner			
Snack			

Fruits			
Snacks			

B. Frequency of consumption of legumes by women:

Use the table below and fill in yes (Y) or fill in no (N) for column 1 to 4 and fill in a number for column 5 and 6. Do not fill in the last column.

	Legumes	Eats?	Daily?	Weekly?	Monthly?	Number of days?	Times per day?	Total/ month
a.	Groundnut							
b.	Soybean							
c.	Common bean							
d.	Cowpea							
e.	Any other legumes, specify:							
f.	Any other legumes, specify:							

RQ 1.6 Women empowerment

A. Legume and women empowerment

· Which crops in your household you are mainly in charge of?

· What are the cash crops in your household?

· Between wife(you) and husband, who has moved to her/his village? Who owns the cultivated land?

1. Tick in the box on the degree which you agree.

	Women 100% Man 0%	Women 75% Man 25%	Women 50% Man 50%	Women 25% Man 75%	Women 0% Man 100%
a. Who does decide what kind of **legume** to plant?	☐	☐	☐	☐	☐
b. Who does decide the size of land for **legume** cultivation?	☐	☐	☐	☐	☐
c. Who does decide the size of land for **maize** cultivation?	☐	☐	☐	☐	☐
d. Who decides which inputs to buy and those amounts for **legume**?	☐	☐	☐	☐	☐
e. Who decides which inputs to buy and those amounts for **maize**?	☐	☐	☐	☐	☐
f. Who decide how much of **legume** to sell?	☐	☐	☐	☐	☐
g. Who decide how much of **maize** to sell?	☐	☐	☐	☐	☐
h. Who decide on expenditure of money from sale of **legume**?	☐	☐	☐	☐	☐
i. Who decides on expenditure of money from sale of **maize**?	☐	☐	☐	☐	☐

2. Please check who sell the legumes of household production. ☐Women / ☐Man

3. How many days of your labor hours per week are put into each crop? Legume ( )days / Maize ( )days

4. Tick in one of boxes on which you agree.

	Very low	Low	Moderate	High	Very high
a. How much you have control on legume cultivation?	☐	☐	☐	☐	☐
b. How much you have control on maize cultivation?	☐	☐	☐	☐	☐
c. How much do you have control over use of income in your household?	☐	☐	☐	☐	☐

5. Would you like to have more legumes in your household? ☐Yes / ☐No

→ If yes, Why you don't have enough legume now?

How do you intend to get more legumes?

→ If no, Why not?

6.1 Do you think that you would have more control over resources if legume is more cultivated? Why?

6.2 Do you think that your position in the household would be higher if legume is more cultivated? Why?

· General impression:

B. N2Africa and women empowerment

1. Do you think you are actively involved in N2Africa?

3. Do you think that you have had more control over resources after participating N2Africa? Why?

5. Do you think that your position in the household have been higher after participating N2Africa? Why?

C. Relationship between women empowerment and food security

First, grade the rankings among *a.Food* to s.*Other, Specify* with the number 1(the most desirable) to 19(the least desirable) and their percentage in a total sum 100%. Within *a.Food* determine the ranking and proportion of specific items.

1.1 Desired household expenditure by Women

Household expenditure by WOMAN			Ranking
a. Food			
Ranking	Proportion		
		Cereal or tuber	
		Grain legume	
		Animal product	
		Fish	
		Oil	
		Fruits	
		Other, specify:	
b. Water			
c. Education			
d. Health			
e. Fare for Transport			
f. Fuel for cooking			
g. Leisure for recreation			
Purchasing of assets		h. Farm implements (Hoe, cutting knife, ox/donkey cart, watering cans, tobacco drying shed etc)	
		i. Livestock facilities and Livestock (Roofed shelter, Fenced shelter without roof etc)	
		j. Storage of produce (Bags, Earthenware pots, Mud silo/granary etc)	
		k. Housing properties and power (for floor, roof, bricks, poles or planks, paraffin, battery, electricity, solar power, generator etc)	
		m. Electronics (Cell phone, radio, television, fridge etc)	
		n. Transport (Bike, car, motor-cycle etc)	
		o. Kitchen utensils (pots, plate, spoon etc)	
		p. Clothes, shoes	
s. Other, specify:			

1.2 If you have more control over resources in your household, on which household expenditure do you want to decrease the most and increase the most compared to your current household expenditure?

2.1 Desired household expenditure by Man

First, grade the rankings among *a.Food* to s.*Other, Specify* with the number 1(the most desirable) to 19(the least desirable) and their percentage in a total sum 100%. Within *a.Food* determine the ranking and proportion of specific items.

Household expenditure by MAN			Ranking
a. Food			
Ranking	Proportion		
		Cereal or tuber	
		Grain legume	
		Animal product	
		Fish	
		Oil	
		Fruits	
		Other, specify:	
b. Water			
c. Education			
d. Health			
e. Fare for Transport			
f. Fuel for cooking			
g. Leisure for recreation			
Purchasing of assets		h. Farm implements (Hoe, cutting knife, ox/donkey cart, watering cans, tobacco drying shed etc)	
		i. Livestock facilities and Livestock (Roofed shelter, Fenced shelter without roof etc)	
		j. Storage of produce (Bags, Earthenware pots, Mud silo/granary etc)	
		k. Housing properties and power (for floor, roof, bricks, poles or planks, paraffin, battery, electricity, solar power, generator etc)	
		m. Electronics (Cell phone, radio, television, fridge etc)	
		n. Transport (Bike, car, motor-cycle etc)	
		o. Kitchen utensils (pots, plate, spoon etc)	
		p. Clothes, shoes	
s. Other, specify:			

2.2 If you have more control over resources in your household, on which household expenditure do you want to decrease the most and increase the most compared to your current household expenditure?

9. Declaration

I,

Hyejin Lee

Born on 13.09.1989

Matriculation number 566272

hereby declare on my honour that the attached declaration,

Master Thesis

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.

Dr. Stefanie Lemke

Supervisor:

Assessment of changes in households food availability, access, utilization and stability using farm stratification associated with the introduction of legume technology in Salima district, Malawi

Thesis topic:

Winter semester, 2014/2015

Semester

I declare, here within, that I have transferred the final digital text document in the format pdf to my mentoring supervisor and that the content and wording is entirely my own work. I am aware that the digital version of my document can and/or will be checked for plagiarism with the help of an analyses software program.

Furthermore, I agree with displaying the document in the library of institute 430B implying the possibility of its exploration and borrowing by others.

Stuttgart, 1. December, 2014. Lee Hyejin

City, Date, Signature