Climate-smart greenhouses and their impact on food security in Humla, Nepal

Master thesis

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UiB

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Executive summary

With the basis in two villages in Humla, north-western Nepal, this thesis examined how greenhouses are affecting food security in a high mountainous area. The major focus was on the greenhouse project development in Humla and its impact on food security. Greenhouses, their implementation, possible challenges and how they affect gender relations were other focuses of interest. This was examined in the context of natural, social and economic factors in the area.

The current study was based on food security theory and climate-smart agriculture theory, as well as innovation theory and climate change theory. This gave a broad basis for analysing and discussing the research questions.

The areas of study were Chhipra village in Lower Humla and Yalbang village in Upper Humla. Both areas had their own set of natural conditions. This was especially evident in that Chhipra village was to a considerable higher degree than Yalbang village exposed to drought. Furthermore, Chhipra village was Hindu (mainly Chhetri caste), while the Yalbangs village was inhabited by the Buddhist Lama ethnic group. The villages therefore had their own social and economic predispositions as well, as Hindu and Lama societies are distinct in Humla. This became evident that socially Yalbang village was more homogenous than Chhipra village and that economically, Yalbang village was perceived as better-off. This gave a good basis for a comparative study between the villages, as well as interviews with NGOs and literature, allowed for exploring generalization possibilities from the village level to a regional level.

Main findings:

A minimum of 1550 greenhouses have been built in Humla and they produce around 250kg vegetables, with some more production in Lower Humla than in Upper Humla. It is estimated that for households without a greenhouse, there seems to be some “trickle down” both among relatives, to lower castes and poor, because increased availability of vegetables gives greater surplus locally.

- There are some challenges with the greenhouses that needs to be addressed. In two villages, it came forward that that irrigation problems and insect problems was the main challenges, and the NGOs in Humla argued that this was a problem in the whole region. In certain areas, it seems like falling productivity, non-germinating seeds and strong winds can be problematic for the greenhouses as well. However here more research is needed to determine the extent and magnitude of these three phenomena.

- Hindu villagers are not less adaptive to greenhouses than the Lama villagers, because they are more "reluctant" in their attitude to new innovations. They are less adaptive because they have stronger natural, financial and social factors hindering them to be able to implement a greenhouse. This creates a situation where the already less sensitive to climate change, the Lama people in Upper Humla, are getting the most, and the more sensitive to climate change, the Hindu people in Lower Humla, are getting the least. If NGOs don't include these factors in the implementation process, there is a risk of increasing differences between better-off and worse-off households in Humla.

- In the beginning of the implementation of the greenhouses, both the Lama people and the Hindu people were reluctant towards greenhouses, and NGOs were the main driver for implementing greenhouses in Humla. However, after the villagers could see the benefits from owning a greenhouse and how it could benefit them, there has been a shift, and the demand for greenhouses is now high amongst the villagers themselves, both for the Hindu people and the Lama people.

- Women are mainly working in the greenhouse. To be run successfully, a greenhouse seems to be hard work for women, who are often already overburdened with work in Humla. However, it can lead to more financial independence for women if they can sell the vegetables.

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I also want to thank the Buddhas of the three times and ten directions with the prayer on the four immeasurables:

May all beings have happiness and the cause of happiness.

May all being be free from suffering and the cause of suffering.

May all beings always experience happiness, which is free from suffering.

May all beings rest in boundless equanimity, which is free from attachment and aversion.

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Table 12: comparison of production of vegetables inside a greenhouse in Humla

List of abbreviations and common words and phrases

Brahmin = Highest caste in the Hindu caste system

Brassica family = Is a family of plants cultivated from the wild mustard plant; including cabbage, broccoli, cauliflower, kale, brussels sprouts and collard greens

Chhetri = Second highest caste in the Hindu caste system in Humla

DADO = District Agriculture Development Office

Dal bhat = Dal means "lentil soup" and bhat means "boiled rice" in Nepali. This is traditionally served together with a various side dishes and is the main food staple in Nepal.

Dalit = Lowest caste in the Hindu caste system

Darma = A VDC in in the total south of Humla

Dzo = A hybrid between yak and domestic cattle

GLOF = Glacial lake outburst flood

Gompa = A Buddhist monastery

HDI = Humla Development Initiative, which both LI-BIRD and SHIP Nepal is a part of

Jirel = A Buddhist people from the Jirel valley in Eastern Nepal

Lama people = A Buddhist Tibetan speaking people, who mainly inhabits Upper Humla

LI-BIRD = Local Initiatives for Biodiversity, Research, and Development

SHIP Nepal = Self Help Initiative Promotion Centre Nepal

Nepal Trust = A NGO who work with health and community development in Humla district and Sindhupalchowk district

NPR = Nepali Rupee (12.05.2017; 1 USD = 103 NPR)

RIDS-Nepal = Rural Integrated Development Service-Nepal

Simikot = District headquarter of Humla, which is located in the middle of the district (figure 4)

Tunnel = A simple greenhouse made from only wood and plastic

VDC [Village development committee] = A district in Nepal is further divided in to several lower administrative parts, called VDCs

WFP = World Food Program

1 Introduction and presentation of the research questions

Humla is a mountainous district in North-western Nepal. This region has for a long period suffered from food insecurity, because of difficult climatic conditions, a hilly or mountainous landscape that is not ideal for agriculture, land degradation because of continuous droughts the last years, political unrest and the remoteness of the district and its villages (Roy et al. 2009; Nagoda 2015, p. 36-42). To combat the challenge of food insecurity and climate change, greenhouses have started to be implemented in Humla to decrease malnutrition and make vegetables accessible to a larger degree for the inhabitants of Humla. In the literature, greenhouses have been stated as successful in coping with food insecurity in high mountainous regions (Triquet et al., undated; Olofsson, 2014; HDI, 2014; Subedi and Shrestha, 2016; Dolma, 2016). However, most of this literature are from the NGOs normative view about their projects and not from an "objective academic source" about the totality of the greenhouse project in Humla, which this thesis aim to research. More specific, the main focus of research will be on prevalence, effectiveness, extension of growing season and direct and indirect diet effects the greenhouses will give, and this will be examined in the context of food security. Furthermore, if greenhouses are climate-smart, will be an important topic as well. Even if these two topics will be the main areas of theoretical context, three sub-questions of importance will be examined as well. First, the actors, the drivers and the limitations for implementing a greenhouse will be examined in the context of innovation theory. Second, if there is a difference between the two major ethnic groups in Humla; the Buddhist Lama people and the Hindu people, when it comes to greenhouses and eventually why, will be researched. Third, Humla is a rural region with marginalization and inequities based on gender (Nagoda 2015, p. 42). Will this express itself as well when it comes to greenhouses?

These are the five research questions that will be explored in this master thesis:

Main research questions:

1. Whether and to what extent have greenhouses impacted food security in Humla?
2. Are greenhouses in Humla climate-smart?

Sub-research questions:

1. Who are the actors and what are the drivers and limitations for implementing greenhouses in Humla?
2. Whether and to what extent is there a difference between Hindu villages and Lama villages in Humla, when it comes to actors, drivers and limitations for implementing greenhouses?
3. Does greenhouses impact gender roles in Humla?

2 Theoretical Approach

2.1 Defining and conceptualizing food security

In the literature, there is a good basis for understanding food security and its different aspects. This thesis will follow the definition of FAO (1996) for food security: "*when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life"*. The present situation is that in 2015, it was estimated that 795 million people are suffering from chronic hunger (FAO et al. 2015, p. 4). Malnutrition is a considerable challenge as well, as data from 2000 – 2003 shows that 53 % of the cause of death in children under five years old, is associated with malnutrition (Müller and Krawinkel 2005). There are two main types of malnutrition. The first is protein–energy

malnutrition, where inadequate calories or protein intake in the childhood is linked to three main categories: First, underweight is a condition that is known by weight being under the normal weight for that age; second, stunting is a condition when height for weight is under normal. Third, wasting is the condition for when weight for height is under normal (Pinstrup–Andersen et al., 1993). Of all children under 5 years old living in developing countries, approximately 38 % have stunted growth, 31 % are underweight, and 9 % experience wasting (Brabin and Coulter, 2003, p. 561-580). Second, micronutrient deficiencies are a major global challenge as well, and approximately 2 082 000 children die every year of Vitamin A, Zinc or Iron deficiencies (World Health Report, 2002, p. 54 - 56). Bhandari and Banjara (2015) presents the danger with Iron, Zinc and vitamin A deficiency: *"Iron deficiency: Iron deficiency anemia, reduced learning and work capacity, increased maternal and infant mortality, low birth weight, impaired human function at all stages of life. Zinc deficiency: Poor pregnancy outcome, impaired growth (stunting), genetic disorders, decreased resistance to infectious diseases. Vitamin A deficiency: Xerophthalmia (night blindness, Bitot's spot, corneal ulcer, keratomalacia, xerosis), increased risk of morbidity and mortality, increased risk of anemia"* (Bhandari & Banjara 2015).

Now that we have stated the problem, the framework for understanding will be based mainly on The Food and Agriculture Organization (FAO) conceptualized framework for understand food security and its different aspects. Here four main focuses of approach are presented. Availability is the first aspect. Availability can be defined as: "*availability at all times of adequate world food supplies of basic foodstuffs to sustain a steady expansion of food consumption and to offset fluctuations in production and prices*" (United Nations 1975). This is when supply is the focus and is based on stock levels, food aid, level of production and net trade (FAO 2006). Originally, availability was the main matter of concern, however later it was discovered that this was not enough for global food security. Access became an important new area of approach, because it was discovered that different access factors still hinder food security, even if availability was adequate. This is based on entitlements. Entitlements are defined as: "*the set of all commodity bundles over which a person can establish command given the legal, political, economic and social arrangements of the community in which they live*" (FAO 1996). The entitlement to access food can for example vary between genders, ethnic groups, sexuality, age, caste, social group

and/or religion; dependent on the area in which they live. Furthermore, utilization became the third aspect, because type and handling of food was discovered to be important as well for food security. The diversity of the diet, food distribution in the household, preparation of food, food processing, feeding practices and the biological utilization of the food consumed, as well as clean water, adequate sanitation and health care are important aspects here (FAO 2006). Fourth and last is stability. Availability, access and utilization for sufficient food security should be stable over time. A population, household or individual must have access to adequate food at all times to be fully food secure and cyclical events and abrupt shocks, for example drought or conflict, should not be a risk for losing food security (FAO 2006).

Finally, conceptualising how food security should be accomplished in practise is important. Rosengrant and Cline (2003) argues that both the local and community level is important to involve for achieving food security. On the local level, there is a need for collective action and on the community level, governmental and nongovernmental organizations are important actors for achieving food security. More specific they argue that an increased investment is important to amplify food security in food insecure areas. Where it is important to invest in education for agriculture technology, crop-management techniques and livestock improvements, for an increasing rate of production and income. IUCN (2013) argues that social justice is as well important for policies to consider if global food security is the goal. They see that too much technical focus has had its negative effects, and they see the importance of good governance, economic fairness, human rights, solidarity, equality and equity in different strategies for ensuring food security. They state: "*Where social justice is weak, there is a high risk of food insecurity among vulnerable groups*" (IUCN 2013). Next, IUCN (2013) sees that there is a need for incorporating ecosystem factors in food security policy making, and one area of importance is diversity when it comes to ecosystems in a landscape and the biological resources in these systems. This can help local communities in lowering risks and sensitivity to shocks, because it can help diversify livelihoods and give a larger range of adaptive activity to change.

2.2 Climate change – potential increase of food insecurity and malnutrition

Directly linked to food security is climate change. Here the definition of IPCC (undated) will be used: "*A statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period*". IPCC is the leading panel on climate change and they have documented a warming of between 0.65 and 1.06 from 1880 – 2012 globally (IPCC 2007). Furthermore, IPCC predicts an increase in global temperature of an estimated increase of 1.8 – 4 degrees' Celsius, as the global average by 2090 – 2099. This warming will not be equal over the world, as IPCC has modelled some areas to potentially be more exposed to a warmer climate than the global average, the Himalayas being one of these areas (IPCC 2007). The World Food Program (undated), have documented how climate change is being directly linked to food security and all its aspects: First is availability, because a warmer planet will impact yields and create new rainfall patterns that could impact crop quality and quantity. Second, availability will affect access, because of a possible increase in the price of major crops and for the ones that are already worse-off, lower outputs are expected from their agriculture, so a larger spending must be used on buying food. Utilization is the third aspect, where adequate caloric intake in chronic food insecure areas is already climate-related, and a changing climate may also create cycles of disease and hunger, in addition to that nutrition is likely to be effected, because of dietary diversity, health and other climate related impacts on food security. Fourth and finally, it is estimated that stability will affect household and governmental strategies, because of more frequent and intense weather events can create insecurity, both when it comes to availability, access and utilization. Furthermore, IPCC has only globally stated that we are heading towards a climate that is negative for the planet and its inhabitants, thus locally climate change can as well be positive for some areas. One example is Northern Norway, where exposure to higher temperatures is expected to improve the availability from agriculture (Torvanger et al. 2004). However, globally for the people in most countries in Africa, Asia, and Latin America, climate change will further reduce access to drinking water, negatively affect the health of poor people and will pose a real threat to food security, because likely regional impacts from climate change are more droughts and floods (Abeygunawardena et al. 2009).

2.3 Conceptualizing innovation

World Bank use now the term "innovation system" and it can be defined it as:" *A network of organizations, enterprises, and individuals focused on bringing new products, new processes, and new forms of organization into economic use, together with the institutions and policies that affect their behaviour and performance*" (World Bank, 2006, p. 16). It includes all the actors for innovation and how they operate in a network. Innovation can come from all the actors in the system and not only top-down, as older innovation approaches suggested. The new approach includes identifying the different actors, drivers and limitation factors for innovation, as well at the same time identify how innovation are connected and changing over time, to focus on the non-traditional agricultural sector and finally to understand that innovations can be triggered in many ways; for example by the market, villagers need, the government or Non-governmental organizations (NGOs). (World Bank, 2006, p. 15). Critique has been directed towards innovation system, because it does not include natural factors. Aase et al. (2012) argues that natural factors cannot be separated from the theoretical framework when analysing innovation in agriculture, where natural factors such as water, resources or climate etc., are essential parts of farming. They advise going beyond innovation system and instead moving towards what they call "innovative place", where both social, economic and natural aspects are used in the analysis, which they argue provides a better framework for understanding innovation in agriculture than innovation system, which only focuses on social and economic factors.

For the framework of implementation, Everett Rogers has done extensive work on the diffusion of innovation, and categorized two major systems that will react differently to innovations, and therefore different practises are needed for successfully implement innovations in these two systems. The first system, is a heterophilous system. Here variables differ from one another and Rogers argues that for this type of system it is best to target the elite and innovative opinion leaders first and then this will be imitated by the others in the systems by itself, in the form of a domino effect, where others in the system wants to imitate and adopt the new invention the elite and

innovative opinion leaders have implemented (Rogers, 1995, p. 289). Because the villagers are the variables that differ from one another, and some of them will be more traditional and/or isolated in their social system and therefore interact with people that have traditional values as themselves, this leads them to adapt innovations at a much slower rate, and only after they see the more well-off villagers being successful with the innovation (Rogers, 1995, p. 286 - 293). In the other system, a homophilous system, the variables are similar to each other and Rogers argues that in these systems, pre-existing norms is to a larger degree controlling attitudes, than opinion leaders, as there is only a general attitude that depends on pre-existing norms (Rogers, 1995, p. 286 - 288). If the norms make the attitude open for that innovation, then the innovation will be implemented fast; however, if the norms make people reluctant to the innovation, then measures must be taken to convince the opinion leaders that the innovation can be compatible with the pre-existing norms (Rogers, 1995, p. 288). Networking and communication will be different between the two systems, because Rogers argues that people and systems that are more alike, will have better communication and a stronger network between them for faster implementation of innovations; while in heterophilous system, there is isolated sub-groups, that limits communication in the whole group, which delays innovation (Rogers, 1995, p. 287).

2.4 Innovation, food security and climate change – climate-smart agriculture

The different aspects and challenges with food security, climate change and innovation have now been presented. This is the foundation for understanding how agriculture can cope with these challenges, which is a combination of these three aspects. This is called climate-smart agriculture and can be define as: "*Agriculture that sustainably increases productivity, resilience (adaptation), reduces/removes greenhouse gases (mitigation), and enhances the achievement of national food security and development goals*" (FAO, 2013, p. 548). This means that essential all methods, innovations and skills, that transform agriculture practices towards a changing climate can be labelled as climate-smart (Neufeldt et al. 2013). A Global shift in precipitation and temperature threaten agricultural production and increases the vulnerability of people who are

dependent on agriculture for their livelihoods, which includes most of the developing countries. The capacity to adapt is important for eliminating or decreasing the possible negative effects of climate change and to further strengthen resilience and resource usage, while lowering greenhouse gas emissions from the agriculture sector (Lipper et al. 2014).

There has been identified some key concept that is important to determine vulnerability and adaption possibilities:

Exposure is the first factor. It can be defined as: "*the nature and degree to which a system is exposed to significant climatic variations*" (McCarthy et al., 2001, p. 987). Both intensity and length of the climate variation determines the risk and the focus is on the natural factors in background and how climatic conditions affects how the system operates and possible changes in those conditions (Fellmann, 2012, p. 39). Different types of risks can as well be found on different scales, where the type and magnitude of exposure can vary greatly from the household level to the regional or national level (IPCC, 2013). IPCC (2012, p. 32) sees that exposure can as well be direct or indirect. They use the example that food insecurity may as well result from a change in the global market; that is driven by drought or flood impacts on crop production in another location. This means that climatic changes and hazards, don't need to directly affect one area to make it exposed, it can indirectly be affected by for example changes in the global market, because of a risk elsewhere. Finally, exposure does not need to be exclusively negative, as exposure to a climate variation for some areas can change in a positive direction.

The second factor is sensitivity. Here McCarthy et al. (2001, p. 993) definition is used: "*sensitivity is the degree to which a system is affected, either adversely or beneficially, by climate-related stimuli. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea level rise)"*. Sensitivity is then the extent to which a system is altered or transformed by disturbances (Adger, 2006). If the current system is not responsive to climate change, then it can be non-sensitive even to larger climatic changes; however, if the current system is to a large degree responsive to climate change, than the current system can be sensitive to even slight changes in climate (Fellmann, 2012, p. 39). An example

here is one system that is using highly drought resistant crops and another system that is using highly drought sensitive crops, are located in areas with equal climate, with the same background factors and the same expected climate change of more flooding and more droughts in the future (all other factors staying the same). Then the one system that is using highly drought sensitive crops are more likely to be responsive to a negative change in frequency and length of droughts, while the system that is using highly drought resistant crops, might be non-sensitive or only sensitive to a smaller degree to the same change in exposure, as the system that was using highly drought sensitive crops.

The third aspect is adaptive capacity. Adaptive capacity can be defined as: "*The ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences*" (McCarthy et al., 2001, p. 982). It is important that adaptive capacity allows for development of the system, in order to successfully adapt to environmental hazards and changes (Adger 2006). Of not, even small changes can have larger negative effects on a non. Adaptive capacity furthermore depends on socio-economic factors of the inhabitants in the system, the systems bio-physical factors, as well as institutions, governance and management in the area, knowledge on how to adapt, technology, skills, current infrastructure and innovations for the adaption itself (Fellmann, 2012, p. 40). Furthermore, Smit and Wandel (2006) argues that in a society, adaptive capacity can be understood as the reflection of different scales, for example on the more local scale, it often reflects broader influences; however, some affects are mainly local, as for example the presence of strong kindship networks in some local systems.

Vulnerability is the fourth aspect. Vulnerability is defined by IPCC (2012, p. 564) as: "*The propensity or predisposition to be adversely affected*". Furthermore, IPPC (2012, p. 564) argues that vulnerability is: "*dynamic, varying across temporal and spatial scales, and depend on economic, social, geographic, demographic, cultural, institutional, governance, and environmental factors. Individuals and communities are differentially exposed and vulnerable based on inequalities expressed through levels of wealth and education, disability, and health status, as well as gender, age, class, and other social and cultural characteristics*". Exposure,

sensitivity and adaptive capacities together defines the areas vulnerability to risk, although not as independent factors, thus as interdependent factors, where they are connected and affected related to each other (Smit and Wandel 2006). Furthermore, Lipper (2012) argues that vulnerability is context-specific, which means that the factors that is making a system vulnerable to climate change or extreme events, are dependent on the attributes of that specific affect and that specific system. Finally, Adger (2006) sees that even if IPPC have stated that developing countries are more vulnerable than developed countries, this is not the necessarily right in all situations, because Adger argues that IPCC have overlooked that in the literature, there is much evidence claiming that developing countries and their different communities, have an inherent capacity to adapt to climatic changes, based on indigenous knowledge and skill.

The fifth and last aspect is adaptation. Adaptation can be defined as: "*in human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate*" (IPCC, 2012, p. 556). Adaptation is then the expression of adaptive capacity, to reduce vulnerabilities for a system (Smit and Wandel 2006). For successful adaptation Lipper, et al. (2014) argues that four important focuses of approach must be included. First, building evidence and assessment tools. Lipper, et al. (2014) argues further that the current evidence base is inadequate to support policy making and too inaccessible for different actors on the local or national levels. Here a problem-oriented approaches to adaptation planning is needed, as well as tools for evaluating the adaptation and mitigation potential of different policies and technologies from local to global scales. Second, strengthening national and local institutions. To achieve this, it is important to support adaptive capacity by increasing access to assets and information. When it comes to information it is particular important to reduce costs and remove barriers that hinders access to information. The third aspect is developing coordinated and evidence-based policies. Here building a sufficient policy and a regulatory framework is important to increased coordination for climate change, agriculture and food system policies. The fourth aspect is increasing financing and its effectiveness. This is important because investment for financing climate-smart agriculture is not sufficient to meet the demand, and is frequently poorly targeted.

This theoretic framework is not without criticism. Smit and Wandel (2006) have criticised these terms to only have a modest practical effect on dealing with vulnerability. This is because climate change is not alone the reason for adaptation in most cases, and especially not when adaption is only important for the decision makers. Furthermore, Smit and Wandel (2006) argues that scale is important to include in a framework for climate-smart agriculture. If we examine different scales - for example household, community, region and nation -, they might be facing different challenges and have different motivations for adaptation. Furthermore, O'Brien et al. (2015) argues that facing the impacts of climate change is only a part of the problem. They argue that a major part of a successful adaptation, that have been sidestepped, is the underlying causes for vulnerability and they need to be confronted to be able to have a successful adaptation for all groups. This depends on the societal context in which these changes are occurring, and more specifically O'Brien et al. (2015) argues that decision makers need to target social, economic and political relations and inequalities in a system, to be able to successfully adapt to climate change. Lastly, Neufeldt et al. (2013) have critiqued the concept of climate-smart agriculture and its sub groups (exposure, sensitivity/vulnerability and adaptive capacity) to be too insufficient "in itself" as the theoretic framework for climate-smart agriculture. This is because, with this framework, that for example improved use of limited raw materials can be considered as climate-smart, as long as it increases food security here and now. In addition to this, then almost any form of agricultural can be labelled as climate-smart in some way and be perceived as a "win-win" situation. However, they fail to comprehend that some will lose, that there always is a trade-off in these matters and that it is as likely here as elsewhere, the likelihood of conflicting agendas (Neufeldt et al. 2013).

2.5 Greenhouses - an innovation for coping with food insecurity and climate change in high mountainous areas

A part of the food security initiative is greenhouses, which have been argued successful in high mountainous areas (Triquet et al., undated; Olofsson, 2014; HDI, 2014; Subedi and Shrestha, 2016; Dolma, 2016). It focuses on low cost, so the greenhouses are built with local stones and local wooden beams, however they need a UV stabilized plastic, nails, ventilators, garden pipe, sprinklers, water cans, seeds and training (Fuller and Zahnd, 2012; HDI, 2014, p. 7). They can also be built only from wood - called a tunnel -, and this method is at even lower cost, however it is not suitable or effective for the coldest areas (own data). For the tunnels the construction is simple, with thick half rounded timber as the main carrying beams and smaller half rounded timber for the facing of the walls and roof, which can easily be adjusted in size to fit the need of the household (own data) (see picture 2). There seems to be two types of greenhouses built in the Himalayas, if we exclude the tunnel. The first is the Tom Wagner type greenhouse. The size of a Tom Wagner type greenhouse will be approximately 6.6 by 4.5 m, with a growing area of around $18m^2$ (depends a little on the specific place), with a single stone wall, half rounded timber for isolation and inged insulated panels on the south-facing wall to reduce heat loss at night (McKay et al. 2007). The second is a Ladakh type greenhouse (also called GERES/LEHO type greenhouse). Here the size is approximately 5 by 10m, with a growing area of $25m^2$, with a thick 30cm double stone wall in the back and the sides of the greenhouse, so no isolation panels was used in the walls, rough planks are used as the wooden layer of the roof and finally, double glazing is added to the greenhouse to reduce heat loss during the night and extra ventilation flaps have been added in the front corners of the greenhouse to counter high temperatures during the day (Candy et al. 2012).

Even if the greenhouses have been argued to be a success in the Himalayas for vegetable production (Subedi and Shrestha, 2016; HDI, 2014; Triquet et al., undated; Olofsson, 2014; Dolma, 2016), there are some problems mentioned in the literature (McKay et al., 2007; HDI, 2014, p. 3; Candy et al. 2012). First, poor seeds can lead to a bad harvest. Second, the greenhouses can still

be overheated with too little ventilation or freeze with too little isolation. Third, building a green-house, is for a poor village still a big expense relative to their level of poverty. Fourth and last, too much snow in the winter can break the plastic.

Picture 1 and 2: on the left, greenhouse made with stone; on the right, tunnel type greenhouse.

3 Area description

3.1 Nepal – a country with great challenges for food security and climate change

While Nepal is known for its beauty and the highest mountains in the world, there is also a recent dark history, with a bloody civil war from 1996 - 2006 and the devastating earthquake in 2015. Nepal is as well one of the poorest countries in the world and is highly food insecure, in fact two out of every three Nepalese suffer from food insecurity at some time during the year (Feed the Future undated). If we look at malnutrition, it is observed that 41 % of children under five years

are stunted, 11 % wasted and 29 % are underweight in Nepal (Ministry of health 2011). The Nepali diet consist mainly of white rice and bread, so the micronutrient requirements in the daily diet is often not met (Bhandari & Banjara 2015). Sanghvi (1996) identifies that Nepal is in the high-risk zone for Iodine, vitamin A and Iron deficiency. Iodine was though to no longer be a problem in Nepal, because in the 1970s the Government of Nepal with the help of India, managed to distribute fortified salt to all the different districts; however, it was discovered that there is still an illegal trade in non-iodized salts, especially areas close to Tibet, and in 2005 it was revealed that in reality, only 58 % of the Nepali population had access to the salt fortified with iodine (Saxer and Maximilian 2013). Micronutrient deficiency is critically low in Nepal for iron and zinc, and vitamin A deficiency is still a problem in Nepal, as it is estimated that 35 % of women and 46 % of children have iron deficiencies, 87 % of children and 61 % of pregnant women have Zinc deficiencies and that 8.5 % of children and 7 % of pregnant women have vitamin A deficiency (Bhandari and Banjara 2015).

The soil in Nepal has large deficiencies in certain micro-nutrients as well, which effects agricultural production, animal health, plant fertility and available nutrients for humans. Andersen (2007) found large deficiencies in boron (80-90 %), zinc (20-50 %) and molybdenum (10-15 %) in general in Nepal. Zinc, molybdenum and boron deficiencies are a large problem in Nepal for another reason as well; the Nepali diet is already low in protein, and deficiencies in these minerals reduce protein availability from the crops (Andersen 2007).

Nepal is as well facing major challenges with climate change. This is because global warming has not been equal over the world, as seen in the Himalayas, where there has been an estimated warming of 0.6 degrees Celsius the last decades (Eriksson et al., 2009, p. 4). In the next 82 years, a global warming is expected to be upwards to a maximum of 4-degree Celsius on the global average, however this is expected to be stronger in the Himalayas, where a possible warming of upwards to a maximum of 5.5-degrees Celsius to 2099 is modelled as the worst-case scenario (IPCC 2007). This would be a major challenge for the inhabitants of Nepal, because of the topography, which can lead to landslides and avalanches; retreating glaciers, which can lead to GLOFs; and changes in the monsoon based rainfall intensity and variability, which can lead to droughts, landslides, floods and erosion.

3.2 Introducing the research site – Humla

Humla is a remote and mountainous area, which is geographically located north-west in Nepal (se figure 1). The district is located at an altitude ranging from between 1524 m above sea level to 7031 m above sea level (Fuller and Zahnd 2012). Humla is located partially in the rain shadow, where high mountains block most of the district from the southern monsoon rain (Roy, 2010, p. 11). Humla can be divided into two main ecological regions, Upper Humla in the north and Lower Humla in the south, where Lower Humla has a warmer climate and land that is more suited for agriculture (Nagoda, 2015, p. 37). Humla is ranked as the third poorest district in Nepal, with a per capita GDP of 72 US $ and is highly food insecure (Fuller and Zahnd, 2012; McKay et al., 2007). The population of Humla is 50 858 divided in to 9479 households (NPHC, 2011, p. 15). Culturally there are the Buddhist Lama people and Hindus in the Humla, where Hindus represent 82 % of the population and Buddhist represent 18 % of the population (UNFCO 2013). The Hindus are mostly of the Chhetri caste, Brahmin caste, Thakuri caste and Dalit caste; while the Buddhist are mainly from the Lama ethnic group, with strong roots both linguistically and culturally from Tibet (Nagoda, 2015, p. 38). In Humla there is practised a form of patron-client relationship, called the adhiya system, where better-off land owners - mostly Lama people and people from the Higher castes - have a tenancy relation to the worse-off, including low castes and poor, and allow them to cultivate on their land for 50 % of the yield (Onta and Resurreccion 2011). Related to the adhiya system, is the lagi system, where Dalits have a form of bonded labour, based on inherited relationships to higher castes or lama people; where they get some foodstuff or money for the service provided (Nagoda, 2015, p. 10).

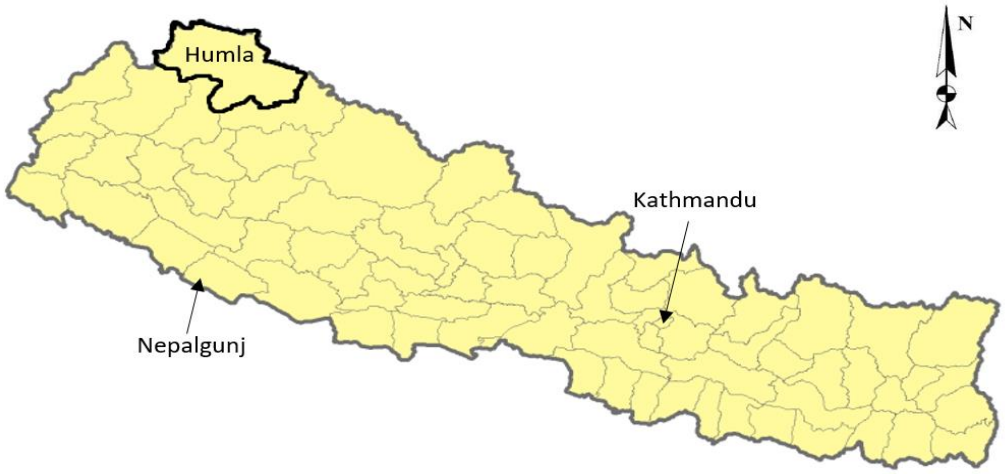

Figure 1: map over Nepal

3.3 Food security in Humla

Because of the high altitude and hilly landscape, there is a low productivity from agriculture and most villages only produce food to meet the dietary requirements for 3-6 months of the year (Roy et al. 2009). This varies a great deal from household to household in Humla, where 10 % of households have sufficient food annually, 18 % for six to nine months, 33 % for approximately six months and 28 % are food sufficient for less than three months (UNFCO 2013). The inhabitants in Humla used to survive almost exclusively on their own limited farming, so to cope with this food shortage, the inhabitants used to have an extensive trade caravan tradition between Humla and Tibet; however, this trade is now getting more difficult because of border movement restrictions and especially the emerging cash economy in Tibet (Roy et al. 2009).

	Winter crops	Sowing	Harvest	Food deficient months
	Naked barley	3rd week of Nov	2nd week of Jul	
	Barley	3rd week of Nov	2nd week of Jul	Mid-Feb to mid-Jun
	Wheat	3rd week of Nov	2nd week of Jul	
	Summer crops			
	Bitter buckwheat	3rd week of Nov	2nd week of Oct	
	Sweet buckwheat	4rd week of Jul	3rd week of Sep	
	Panicum millet	3rd week of May	2nd week of Oct	
	Amaranth	2rd week of Jul	2nd week of Oct	Mid-Aug to mid-Oct
	Foxtail millet	4rd week of Mar	2nd week of Oct	
	Finger millet	2rd week of Apr	1st week of Oct	
	Bean	3rd week of Jun	3rd week of Oct	

Figure 2: main crops in Humla. Based on Roy et al. (2009)

Because of the climate, fresh food can only be produced in short periods, with food shortage periods from mid-February to mid-June and from mid-August to mid-October, at the same time as the food produced is limited to mostly grains (see figure 2). The period and magnitude in Humla when food is deficient depends on the household, more specifically on the amount of land the different households have and how good the productivity is on the land (Roy et al. 2009). To manage this food insufficiency WFP distributed approximately 7 980 metric tons of foodstuff in Humla from 2004 to 2011 (Nagoda, 2015, p. 15). However, critique has been made that on one side food aid helps relief food deficiency in Humla, however at the same time it fails to take in to account the existing social structures in the villages, and therefore aid reflect and benefit more the interests of the better-off, and this risk widening the gap between the most vulnerable and the better-off in Humla (Nagoda, 2015, p. 77; Gautam and Andersen 2017). Because of the low variety of agriculture products and periods of food shortage for most of the households, this can lead to both what is called “hidden hunger” where vitamins and minerals consumed is under the recommended daily intake and to macronutrient deficiencies. This can lead to a series of different health problems (see chapter 2.1) and in worst cases mortality. The supplemented rice, may help with adequate calories in the diet, however not with micronutrient deficiencies, because white polished rice is low in micronutrients.

Even with the supplemented rice, caloric intake in Humla is critically low. It is estimated that the inhabitants of Humla have a caloric intake 48.6 -75.8 % below threshold, and this makes Humla amongst the regions with the lowest caloric intake in Nepal (Central Bureau of Statistics 2006, p. 41). This leads to a high level of stunting, where 72 % of the inhabitants are estimated to have stunted growth in Humla, because of inadequate nutrients during their infancy (Central Bureau of Statistics, 2006, p. 44). Protein-energy malnutrition, in addition effects micronutrient uptake negatively and has a detrimental effect on resistance to infections, immunity and infectious disease (Bresnahan & Tanumihardjo 2014, p. 702-711).

Traditionally, only a few vegetables were consumed in Humla and except mostly some wild edible foods, stinging nettle was the main staple of vegetable consumed throughout the year (Roy et al., 2009). However, in figure 3 it shows a 52.9 % sufficiency of vegetables for household consumption in the mountain region, which Humla is a part of. Critique must be made against this data, because sufficiency is here not determined by some standard; it was asked to the interviewees, if they felt they had sufficient vegetable production for their own consumption. What every household determines as sufficient vegetable consumption might vary greatly and might not in fact be a sufficient consume. These are as well numbers from 2010, and now a high number of greenhouses have been implemented in Humla, so on one hand, this number might be too low for 2017; however, on the other hand, sampling was not done directly in Humla and with such a limited availability of vegetables and only in the start-up face with greenhouses in 2010; 52.9 % sufficiency of vegetables in Humla, is most likely by far, a too high number.

Survey Region	Sufficiency of vegetables for household consumption		
	Yes	No	Total
Mountains	52.9*	47.1*	100*
Hills	56.5*	43.6*	100*
Tarai	41.5*	58.5*	100*

**percent*

Figure 3: vegetable sufficiency in Nepal. Based on, Central Bureau of Statistics, 2010, p. 129)

Furthermore, I was not able to obtain micro-nutrient data from the soil in Humla alone. In Andersen (2007) review of micronutrients in Nepal, high mountainous regions are only represented to a smaller degree and they refer to Karki et al. (2005, p. 26) which have samples from two different mountainous regions in the Western region of Nepal, Mustang and Manang. Here they found that the soil was low in Boron, Copper, Iron, Mangan, Molybdenum and Zinc. If this is the case for Humla as well is unknown (Humla is located in the Midwestern region of Nepal), however these are the only data that I was able to obtain from high mountainous regions in Nepal. Deficiencies in these minerals does not only limits crop production, they also affect crop quality, in the way that micronutrient deficient soil also produce nutrient deficient food (Karki et al., 2005, p. Forward).

3.4 Climate change in Humla

There is limited data about climate change in Humla alone, although there is one weather station in Simikot VDC and one in Darma VDC (Nagoda, 2015, p. 39). However, these data are unfortunately unreliable and incomplete as a source of climate information, because Peter Andersen, professor at the University of Bergen, argued that these stations are not operated correctly. If we examine more general data, there has been an average increase in in the Himalayas of 0.6 degrees Celsius per decade and the Himalayas is in general expecting to get more highly intense rainfalls in the future; which will likely lead to more floods, landslides and debris flows (Eriksson et al. 2009).

While meteorological climate data about Humla is limited, there are anecdotal data from the villagers in Humla and crop yield data, that can throw some light on climate change. In Humla, panicum millet significantly decreased from 231 tons in 2001 to 193 tons in 2008, despite a slight increase of 5 ha of land for cultivation (DAO 2008). The villagers are also stating that there has been a market decrease in yields of wheat, naked barley, panicum millet, and buckwheat (Onta

and Resurreccion 2011). There has also been observed by Onta and Resurreccion (2011) that Dalits in one village in Upper Himla, is now growing buckwheat twice a year to adapt to a warmer and drier climate, because buckwheat is highly drought resistant. The government of Nepal National Adaptation Programme of Action to climate change (NAPA) has reported the biggest natural risks in Humla. Flood, GLOF and landslides were reported as low risk; however, drought was reported to be a very high risk in Humla (NAPA, 2010, p. 16 - 22). UNFCO (2013) mentions storms, landslides epidemic outbreaks and fires to be a problem as well, and in 2011 damage from fire was NPR 12.3 million, losses due to storms of NPR 7.6 million and landslides NPR 500,000. UNFCO (2013) argues as well that flooding is a problem for Lower Humla. At the time the fieldwork for this master was conducted, a flood damaged many villagers land in lower parts Humla, and this flood was associated with heavy rainfall over a short period. Furthermore, even if Landslide is predicted to be of low risk in Humla, this might also increase with the current heavy rainfall trend (Eriksson et al. 2009). This is the case for drought as well, however drought is already from NAPA (2010, p. 19 - 20) classified as a high risk in Humla.

Drought further considered as highly problematic in Humla, where the crops mostly are snow- and rainfed (UNFCO 2013). Onta and Resurreccion (2011) found in their research that farmers were experiencing droughts the past few years in Humla and that because consistent bad harvest, the villagers had used what had been saved during better times. The situation when the fieldwork for this master was conducted is well summarised in The Himalayan Times 3. of June, where in an interview with the Chief district officer, he stated: "*People from all the 27 VDCs of Humla is being hit hard by the crisis as it has not rained for the last six months*" (The Himalayan News Service 2016).

On the other hand, climate change may also have some positive effects on colder mountainous areas like Humla, that might get a longer growing season because of a warmer climate; although with more droughts, a longer growing season might not outweigh the negative affects from more frequent periods of drought.

Picture 3 and 4: left, dried out water tap in Yalbang village; right, highly damaged crops in Chhipra village because of drought

3.5 NGO interventions in Humla

RIDS-Nepal's family of 4 program was a central project to introduce new technology to Humla. This was to be done in collaboration with the people; where planning, learning and villagers involvement were important factors in the project. The project had originally a package of four main innovations: elementary lighting (from solar or hydro power), a smokeless metal stove, a pit latrine and access to a safe drinking water system (McKay et al. 2007). This was the old package, and later the family of 4 plus program was introduced. Here two new projects were incorporated; a health program and food security initiatives, greenhouses being part of the food security initiatives (Fuller & Zahnd 2012). There are other organisations as well working in the Humla, who also promote innovation for better livelihoods. In this master, ADARA Nepal, LI-BIRD, SHIP Nepal, DADO, Nepal Trust and Woman Welfare Service, was found to be great contributors as well (own data). Other important projects in Humla have been rabbits, health posts, chickens, mix-cropping systems, apple trees, a seed bank, electric mills, women groups and beekeeping (HDI, 2014; McKay et al., 2007).

3.6 Climate-smart agriculture in Humla

Humla has been mapped after the climate-smart criteria of exposure, vulnerability and adaptive capacity. Humla is ranked as having a low overall exposure to risk, very low overall sensitivity to climate change and very low overall capability to adapt to climate change (NAPA, 2010, p. 19 - 29). What is important to comment, is that specifically the exposure to drought is the only risk that is ranked as very high for Humla. Socio-economic adaptation capability of adaption to climate chance is ranked as very low and technological adaptation capability is ranked as low. Then, even if the overall exposure to risk is ranked as low and overall sensitivity to climate change is ranked as very low, even small changes can make Humla vulnerable, because of the very low capability to adapt to climate change; droughts here being a particular risk.

In Humla, some NGOs have been active in making Humla more food secure, with climate-smart innovations as part of their programs. Key projects for more climate-smart agriculture have been more drought resistant crops, mixed cropping systems, agricultural land restoration, clean water taps, and greenhouses (Zahnd et al., 2006; Fuller and Zahnd, 2012; HDI, 2014; Roy et al., 2009; Subedi and Shrestha, 2016).

3.7 Greenhouses in Humla

Different NGOs and DADO have greenhouses as a part of their program in Humla, and in the years prior to 2016, there has most likely been a drastic increase in implementation amongst the villagers; because in a paper published in 2012 by Fuller and Zahnd (2012), they state that 62 greenhouses have been implemented in Humla at that time - here it is important to mention that this is only based on anecdotal data and observations -, while in 2016 LI-BIRD published an article stating that they have themselves built 281 greenhouses in Humla - based on anecdotal data as well -, and they are only one of many organizations implementing greenhouses in Humla (Subedi and Shrestha 2016). The most common type of greenhouse in Humla is the Tom Wagner model

and the Ladakh model, however some are also simple, built of only wood, and will be referred to in this thesis as a tunnel. When a household invest in a greenhouse, they are also provided with simple material for the greenhouse; a bucket if the water source is far away or a pipe is close, schooling, seed, UV plastic and tape for smaller holes in the plastic (HDI 2014, p. 7; own data). If they need a new UV plastic, they must pay some of the expense themselves, although this varies from NGO to NGO how much (own data). In a model greenhouse (Ladakh type), the effects of a greenhouse have been tested in Humla; however, it is important to note that the model greenhouse was bigger and more advanced then what the villagers get (Fuller and Zahnd 2012). Here they found many advantages with using a greenhouse in Humla. In January, the soil temperature was 7-9 degrees higher in the greenhouse than outside, also 600 mm down in the soil and the temperature did not fall under 10.3 degrees, as well as the air temperature was 7.5 degrees higher in the greenhouse than outside (Fuller and Zahnd 2012). Fuller and Zahnd concluded from this, that some vegetables and beans can be grown also in winter times at high altitudes. This can have a large impact on food security and micronutrient supply, especially for Upper Humla where temperatures are low. There are three different estimates from the literature, about how much vegetables a greenhouse can produce annualy. First, it is estimated by Fuller and Zahnd (2012), that a Ladakh type greenhouse can produce approximately 30 - 40 kilos of vegetables every year in a well-kept greenhouse. Second, HDI (2014, p. 7) reports that according to a study they conducted about the average production from the Tom Wagner greenhouses in Lower Humla, they found that an average of 567 kg vegetables was being produced annually. Third, Candy et al. (2012) found that during the winter months in Humla - December 2009 to March 2010 was measured -, approximately 13 kg was produced every month in a Ladakh type greenhouse. 13 kg * 12 months = 156 kg annually. This number is expected to be higher, because these production numbers are from the winter times only.

While Fuller and Zahnd (2012) states: "*Most of the components for a family-sized greenhouse are locally sourced and often can be obtained for little or no cost except for family labor*". Candy et al. (2012) gives another picture. The stone cost approximately 24 000 NPR, the wood approximately 7 500 NPR, the plastic and other material for the greenhouse approximately 13 500 NPR and labour (excavation, masonry and transportation) approximately 17 500 NPR. More specifically, HDI (2014, p. 7) argues that in the district headquarter Simikot, a greenhouse cost in total

150 000 NRP. Then, even if Fuller and Zahnd (2012) argues that most of the components for a greenhouse are obtained for little or no cost, this seems in reality ro be a major investment for the villagers in Humla

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Picture 5 and 6: left, greenhouse and tunnel in Chhipra village; right, greenhouse in Yalbang village

4 Methodology

4.1 Case study

To answer my research questions, I decided on a simple form of case study, that lasted for three weeks in the field. This was because implementing greenhouses in Humla is a temporal phenomenon that needs a field study to understand the intricate variables that affects my research questions, as well as an examination on the micro level. Yin (1981, p. 58 - 65) argues that a case study is important, when the boundaries that exists between phenomenon and context is not always clearly evident, and a case study can be useful to understand these boundaries and therefore be able to determine the cause-effect relationships to a larger degree. Furthermore, my research was conducted in a comparative style, which made me able to test theory in two different villages and compare them to each other. This was mainly done on the micro level, where villagers were interviewed and where greenhouses and greenhouse practise was observed. In addition, three NGOs, two key informants and different literature, were helpful in going from the village level, to more general trends in Humla.

The research was conducted in the following way: I landed in Kathmandu 28 of April, where I planned my journey to Humla and had a productive meeting with my first key informant, who gave valuable information about greenhouses in Humla and how I could answer my initial research question in the best possible way. He had previously worked for HDI in Humla and was therefore well informed about the matter. I then travelled to Humla on the 5. May. 2016 and my visit lasted until 26. May. 2016. After arriving with plane in Simikot, I soon travelled to Chhipra village in Chhipra VDC, where I conducted 17 interviews with the villagers. Then I had a few days in Simikot and had an interview with SHIP Nepal there. Then I travelled to Yalbang village, in Muchu VDC, where I conducted another 17 interviews with the villagers there. Lastly, before leaving, I spend again a few days in Simikot, where I conducted interviews with LI-BIRD and ADARA Nepal.

4.2 Mix method approach

To further be able to answer my research questions, a mixed method approach was used. A mix method approach can be defined as **"***the class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study"* (Johnson & Onwuegbuzie 2004). In this study, a mix methods approach was used, including both qualitative methods and quantitative methods. In this way "*words, pictures, and a narrative can be used to add meaning to numbers*" (Johnson & Onwuegbuzie, 2004, p. 21). This was done to give a better understanding of *what* and at the same time *why,* when answering my research questions. The complementary manner of a mix method approach was also important for cross-validation and to get a broader understanding of the research questions. For my qualitative methods; unstructured interviews with NGOs and key informants, personal observations and pictures were used. For my quantitative methods; semi-structured interviews and numerical data from the literature were used. Lastly, for the analysis and discussion, the fact that I had different methods available, provided many important aspects of "the truth situation" seen from the villagers, NGOs, the literature and my own experience in the field.

4.3 Semi-structured interviews

The main method used was semi-structured interviews. Semi-structured interview is an interview form that has a list of already prepared questions, and at the same time the participant and researcher have a chance to explore issues they feel are of value, which allows some deviation from the original questions (Longhurst, 2010, p. 103 - 113). This means that the research questions don't need to be followed strict, because there is space to let the interviewer and the interviewee elaborate and to let uncertainties, new information or particular fields of interests be further discussed and explored. In Humla, I had a set of pre-made questions to ask, and where I would see more information was needed, if something was unclear or particular interesting for my research question, a semi-structured format allowed me to go more in depth here. I did however never deviate much from my original questions, because of two reasons: First, I felt my questions to a

large degree was sufficient to answer my research questions. Second, because it was my first greater scientific research, I did not want to overcomplicate the study, thus keep it simple, clear and to the point as much as possible.

4.4 Unstructured interviews

In the unstructured interviews the researcher clearly has aims for the research and a topic of study as well; however, it differs from the semi-structured interview, in the way that the importance of the method is in allowing the interviewee to communicate their perspective, using their own frame of reference, in the form of concepts and experiences, that are accustomed to them (Edwards and Holland, 2013, p. 30). Here more flexibility is possible, because a larger degree of divergence is possible to let the interviewee tell their side of the story. Unstructured interviews were done with my fist key informant Yogi Kayastha - former HDI Coordinator - while we had an afternoon together in the historical city of Bhaktapur; as well as with my second key informant and field assistant, Deepak Phadera, who worked for the NGO Nepal Trust, and who was knowledgeable as well, because of his involvement in different projects in Humla. It was important and helpful to ask Yogi Kayastha question before the field, and in the field, Deepak Phadera, was a great help in evaluating, correct and/or confirm my own observations and understanding under and after the interviews. Three unstructured interviews were done with NGOs as well. Here only a few thoughts were noted down before the interviews, and I allowed myself to deviate more than on the household level, because I felt this was a chance to go more in depth on the different points I was uncertain on, found interesting for my research question or get in to new aspects the interviewee brought forward in the interview, that was relevant for my research questions. Greenhouses was still in the start-up face in Humla, so data about greenhouses were still being collected and worked on by the NGOs, so different aspects became often more discussed than stated in the interviews with the NGOs.

4.5 Observation and participant observation

Observation became a key method, even if the intention was that participant observation should have been a key method as well, although in the field it became problematic. DeWalt and DeWalt (2002, p. 1) defines participant observation as: "*A method in which a researcher takes part in daily activities, rituals, interactions and events of a group of people as one of the means of learning the explicit and tacit aspects of their life routines and culture*". I was able to observe many of the different aspects of life in Humla, however there were many aspects I was not suited to take part in, because I was for example perceived as a guest or a young bachelor man. Domestic work, which was explained to me as "not suitable for guests" or in some cases "not suitable for men". Greenhouses or something related to greenhouse implementation or practise, I was not able to participle in. Observation became more important than participant observation, when it came to greenhouses, because of the limited time and access to participate in life in Humla, especially aspects that would have been relevant for my research question. Many important aspects were observed, thus the most important observations for my research question was the greenhouses themselves (prevalence, quality, style, problems), the vegetables grown inside the greenhouses, villagers working in the greenhouses, villagers harvesting vegetables from the greenhouses and cooking the vegetables from the greenhouses.

4.6 Photography

"*Geographers place great emphasis on the importance of visual imagery to substantiate claims about landscape, place and process – in lectures, in research papers and in coursework*" (Bartram, 2010, p. 131). There is of course a subjective part and agenda of taking and using photographs in this text, however I will make my intentions transparent by following the recommendation of Bartram and making it clear that my sole intention with the photographs were to substantiate claims about landscape, place and process. Photographs was also used to make curtain aspects in the text more understandable for the reader and to be used as examples in this thesis. All the pictures used, were photographed by the author of this thesis in the field.

5 Site selection

Figure 4: map over Humla

5.1 Chhipra village

Chhipra village is approximately a 3-hour hike south-east of Simikot (see figure 4). The village is facing east and is located at an altitude of 2100 m above sea level. The village is Hindu, with most of the inhabitants being of the Chhetri caste (own data). There are 25 households in the village and 10 greenhouses and the growing season was 11 months (own data). The village and its surroundings were experienced as extremely dry and the villagers complained about no rainfall the last 6 months. Chhipra village was as well perceived as a poor village, with bad sanitation and many villagers were complaining about diarrhoea and fever affecting their children (see picture 8). Houses were in most cases small, in a poor condition and placed tightly together; except a very few wealthy looking households, with big houses. Chhipra village has been stated

as highly food insecure (DFSN 2010). This was apparent because the crops they should harvest this summer, were severely damaged after the prolonged drought (see picture 4). There was no school or health facility in the village. To help with the water problem, The Norwegian Development Fund was supporting the building of a water facility in Chhipra village, to help with irrigation. Furthermore, there is a road being constructed from lower Humla to China, and several of the inhabitants in Chhipra village worked on the road, which was a long-term food for work type of project (see picture 9). LI-BIRD is the main NGO in the village, and they had their own office in Chhipra village.

Picture 7: Chhipra village

Picture 8 and 9: left, sick child laying on the ground surrounded by flies, because most families did not have a bed in Chhipra village to put them in; right, manual road construction work next to Chhipra village

5.2 Yalbang village

Yalbang village is approximately a 13-hour hike north-west of Simikot (see figure 4). The village is facing directly south and is located at an altitude of 3100m above sea level. The village is inhabited by the Buddhist Lama people. There are 42 households in the village and 27 greenhouses and the growing season was 5 months (own data). The village was dry, however not as dry and hot as Chhipra village. Yalbang village is stated as moderately food insecure (DFSN 2010). The crops in Yalbang village were perceived as in a much better state compared to Chhipra village, however some damage was also visible here. The village was experienced as much better-off than Chhipra village. The sanitation was good; this was visible because most of the houses were big, in good shape, clean and spread out over the village. Some of the households had a TV or/and a radio. The road that is going from China to lower parts of Humla and connecting China to Nepal, is being built from two sides, and the one side that is going from China to the rest of Nepal, is al-

ready past Yalbang village. Here the road is being built by machines, so here no jobs were available for the normal villagers (see picture 11). In the village, there was a monastery for monks, a school and a health station (see picture 12,13 and 14). ADARA Nepal is the main NGO in Yalbang village, and is operating with their own office there.

Picture 10: Yalbang village (own picture)

Picture 11,12,13 and 14: upper left, road construction; upper right, the Gompa in Yalbang village; down to the left, the school in Yalbang village; down to the right, in the left corner of the picture, the health station in Yalbang village

6 Data analysis

6.1 General information about the interviews

	Number of interviews	Sex		Caste/ethnic group Buddhist		Caste/ethnic group Hindu		
		Male	Female	Lama	Jiril	Brahmin	Chhetri	Dalit
Chhipra village	17	7	10	0	0	4	12	1
Yalbang village	17	8	9	17	0	0	0	0
NGOs	3	3	0	1	1	1	0	0
Key informants	2	2	0	0	0	1	1	0
Total	39	20	19	18	1	6	13	1

Table 1: information about the interviews

The number of interviews in the villages was 34, where the number of interviews was equal between Yalbang village and Chhipra village, which makes a good basis for comparison. Total gender distribution was almost equal, although there were a few more females in the villages and only men from the NGOs and the two key informants were men (see table 1). There is significantly more of the Chhetri caste than of the Brahmin and Dalit caste interviewed in Chhipra village, so to say something particular about Brahmin and Dalit from my own findings alone, is limited; however, that more Hindus are Chhetri in the interviews could be positive as well, because of the social and economic predispositions both Brahmins and Dalits have, where Dalit in general are worse-off, Brahmin in general are better-off and Chhetris are somewhere in between in Humla. That there are four Brahmins and one Dalit interviewed, will have the danger of skewing all the data I collected about Chhipra village artificially in the positive direction. This might however not be the case, because when looking at the social composition in Chhipra VDC and in Lower Humla in general, UNFCO (2013) have mapped Chhetri and Brahmin as the main castes in Chhipra VDC and all the other VDCs of Lower Humla, where Dalits always represent a small fracture of the VDCs population compared to Chhetri and Brahmin. UNFCO (2003) also show that Chhetri is the most dominant caste in Humla, so that they are more represented than Dalits and Brahmins, makes the sample more likely to closer reflect how it actually is in Humla.

6.2 Greenhouse frequency and age

	Number of households	Number of greenhouses	Number of housholds interviewed		Greenhouse age
			With greenhouse	Without greenhouse	Average age in years*
Chhipra village	25	10	9	8	1,7
Yalbang village	42	27	14	3	4,3
Total	67	37	23	11	3,2
*Average because no outliers					

Table 2: greenhouse frequency and greenhouse age

As presented in table 2, there is a medium to high frequency of greenhouses in both villages. In Yalbang the number of households owning a greenhouse is high, with a 64 % coverage for all the households; while this is somewhat lower in Chhipra village, they still have a 40 % coverage of all the households. Together, this is 37 greenhouses in only two villages in Humla. In Chhipra village, 4 of the 9 greenhouse owners interviewed were Brahmin and 5 of 9 where Chhetri. The share of greenhouse owners interviewed was excellent in Chhipra, if we look at coverage, because 90 % of the greenhouse owners were interviewed, however only 53 % of households without greenhouses were interviewed. The coverage was lower in Yalbang, with only 52 % of the greenhouse owners interviewed, with even lower numbers for the households without a greenhouse, were only 20 % were interviewed. In hindsight, it might have been better to conduct more interviews in Yalbang village, to better represent greenhouse owners and non-greenhouse owners; however, the 17 interviews were hard to conduct in itself there, because not all the inhabitants agreed to do an interview and some of the villagers were away at the time of my stay in Yalbang village, so it was not possible to interviews with them. Lastly, it is worth noting that even if the coverage for interviews with greenhouse owners and non-greenhouse owners in Chippra village was higher than in Yalbang village, I was informed by a NGO, that Chhipra village was a particular bad experience for implementing greenhouses. This means that the greenhouse frequency data from Chhipra village might be too low compared to other Hindu villages, and might be problematic to generalize with. Because 7 of the 8 interviewed without a greenhouse was of the Chhetri cast, it means that only 38 % of the Chhetri caste interviewed had a greenhouse in Chhipra village, while 100 % of the Brahmins interviewed had a greenhouse and the one Dalit interviewed had not a greenhouse.

Lastly, when we look at all the greenhouses in the interviews, they are in average young, with an average age of 3,2 years for the 23 greenhouses. We can also observe a bigger difference when we look at Chhipra village and Yalbang village separated (see table 2). Yalbang village implemented their greenhouses earlier than Chhipra village, where the average greenhouse is less than two years old in Chhipra village and over four years old in Yalbang village. In the interview with LI-BIRD, they informed that they started in 2010 with implementing greenhouses, however from 2012 they went in with full force. ADARA Nepal stated that they went in with full force in 2010. SHIP Nepal said that they started 14 years ago, with a few households, and later scaled up. These interviews fit well with my data from 2016 in the villages. ADARA Nepal is the main greenhouse provider in Yalbang village, so the average age of 4.2 years fits well with ADARA Nepal going in with full force in 2010. LI-BIRD is the main provider of greenhouses in Chhipra village and they went in with full force two years later than ADARA Nepal, which fits with a younger average age of the greenhouses in Chhipra village.

6.3 Potential for a greenhouse amongst non-greenhouse owners

		Do you want a greenhouse?		Why do you want a greenhouse?			Why do you not have a greenhouse?			
	Number of non-greenhouse owners interviewed	Yes	no	Family consume	For health	Income	Irrigation problem	No land	Not enough manpower	Financial reasons
Chhipra village	8	8	0	5	7	4	5	6	3	2
Yalbang village	3	3	0	3	3	0	0	3	1	2
Total	11	11	0	8	10	4	5	9	4	4

Table 3: potential for a greenhouse amongst non-greenhouse owners

As we can observe in table 3, all the 11 villagers without a greenhouse in the interviews, wanted a greenhouse. When asked why they wanted one, all the asked villagers in Yalbang village said for family consume and health, while nobody mentioned income. Family consume and health is also the most important reasons in Chippra village, however half of them also mentioned income as a factor. One man from Chhipra village stated: "*greenhouse people have more green vegetables and earns more money, so he wants to imitate*". The informant from LI-BIRD, SHIP

Nepal and ADARA Nepal argued it was difficult to get the villagers to see the benefits of the greenhouse in the beginning and almost nobody cared about getting or wanting a greenhouse then. A few years later, when the villagers could see the benefits of producing, consumption and/or selling vegetables, almost every household wanted one. In addition, the demand was in 2016 so high for greenhouses, that LI-BIRDs informant stated: "*the demand is now overwhelming for us and we do not longer have the funding to meet the demand*".

When it came to limiting factors for being able to acquire a greenhouse; irrigation and land is the most limiting factors for Chhipra village, while Yalbang village don't mention irrigation; land is here the main problem. Financially the interviewees in Chhipra village only to a small degree experience this as a limiting factor, thus in Yalbang this is mention by 2/3. This is interesting because one would think that land and economic reasons would be a problem more related to the Chhipra village, however here we see that land problems and financial problems was an important cause for the non-greenhouse owners in Yalbang village as well. Here a big caveat is that it is highly problematic to generalise from only 8 villagers without a greenhouse in Chhipra village and even more from only 3 villagers in Yalbang village, however it can show some tendencies. It is also a danger that the people without a greenhouse was not informed about how much a greenhouse would cost in Chhipra village where they did not have annual meetings amongst the villagers to discuss greenhouses and investment in one as they did in Yalbang village. Because of the perceived poverty amongst most of the inhabitants in Chhipra village, it did seem like for most of the villagers it would be too much of an investment to acquire a greenhouse. Finally, lack of manpower can also be a problem for implementing a greenhouse and this is mentioned in both Chhipra village and Yalbang village. In some of the interviews it came forward that it was an increasing problem the villages that their children would go to school, migrate to Simikot or out of Humla for higher education or other reasons, because loss of manpower in the villages for agricultural work.

6.4 Potential for a second greenhouse

	Number of greenhouse owners interviewed	Do you want one more greenhouse?		Why do you want one more greenhouse?		Why do you not want one more greenhouse?
		Yes	No	Comercial reasons	Vegetables for relatives and Gompa	No marked access
Chhipra village	9	7	2	5	0	0
Yalbang village	14	11	3	8	4	3
Total	23	18	5	13	4	3

Table 4: potential for a second greenhouse

In table 4, it can be observed that a large share of the villagers that was interviewed with a greenhouse, wanted one more greenhouse; with little differences between Chhipra village and Yalbang village. Commercial reasons are the main explanation for this for both villages, where Chhipra village could sell their products to the market in Simikot; while in Yalbang village, there were several hotels that made them able to sell their products to tourists on the way to Mt. Kailash. Two villagers from Chhipra villages that was interviewed, knew what they had earned from the vegetables they had sold to Simikot market. One of them had earned around 100 000 NPR annually and the other had earned between 80 - 90 000 NPR annually (own data). These numbers might also be too low, because an informant from a NGO argued in the interview that the greenhouse owners often hide exactly how much they earn. If these numbers are possible for the common household, then the demand of a second greenhouse is highly understandable. When these two villagers were asked what they used the money on, education for children was the most important and then household articles. In the interview with LI-BIRDs informant, it came forward that they had seen such a great effect on income and home food production, that they wanted that the villagers and the NGOs should scale up the quantity of greenhouses. In Yalbang village it was also a factor that they could give vegetables to the Gompa and relatives. It came forward in the interviews, that it was considered good karma and important for many villagers to give some of the vegetables to the Gompa. All the households in the interviews had religious articles in their house, which witnessed the importance of religion in their lives and I was informed that for the Buddhists, the practise of generosity is important for accumulating good merit. Here it must be noted that Gompa and relatives cannot be totally separated in Yalbang village, because it was a tradition to send one of their sons to the monastery in Yalbang or one of

their daughters to the nunnery in the neighbouring village, Tumkot. Yalbang monastery was as well taking care of the oldest in the village, in a version of a retirement home above the monastery. so many interviewees had their parents living there and being taken care of by the monastery.

Lastly, it is interesting that all the interviewees that did not want one more greenhouse in Yalbang village, contributed this to no access to a market; while for Chhipra village, the two interviewees that did not say yes, also did not say no; their greenhouse was so recently built, that they had no plan yet to build another one. This might change in Yalbang village when the road from China goes all the way to Simikot and they get access to the market there as well, because some of the villagers that wanted a second greenhouse attributed this exactly to the new road that is being constructed to Simikot and will connect them with the market.

6.5 Implementation of the greenhouse

		Who decided to implement the greenhouse?			Were there any difficulties with the implimentation of the greenhouse?			
	Number of greenhouse owners interviewed	Themselves	NGO	Both NGO and themselvses	Stone	Wood	Labour	No problem
Chhipra village	9	4	3	2	8	8	3	0
Yalbang village	14	1	3	10	7	5	7	4
Total	23	5	6	12	15	13	10	4

Table 5: implementation of the greenhouse

In table 5, we can observe that approximately half of the greenhouses was implemented as a collaboration between the households and the NGOs, while for some the decision was made by the NGO or by the villagers themselves. In Chhipra village it was mostly themselves that decided to implement a greenhouse, while in Yalbang village, the inhabitants perceived that both the NGO and the household decided together in most cases. ADARA Nepal informed that that they had an implementation model where the whole community would gather once a year, and ADARA Nepal informed about the benefits of a greenhouse, what ADARA Nepal would help with and how to invest. LI-BIRD on the other hand, informed that they first implemented a few pilot greenhouses in the villages (Chhipra village being one of them), and when the other

villagers could see all the benefits, they wanted a greenhouse and took initiative themselves to get one. This fits with my data, where three years ago the villagers perceived that the greenhouses built was by the initiative of the NGO, then it was a transition face two years ago where both NGOs and villagers took initiative, and finally one year ago, most of the greenhouses was perceived implemented by the villagers in Chhipra village (see appendix 10.1). It is also interesting that both the two greenhouses that are 3 years old was implemented by Brahmins, on the NGOs initiative. In Yalbang village the implementation seemed to be more in waves. Of the 14 greenhouses, four was five years old, four was four years old and five was three years old (see appendix 10.1). Here there are no trend in what was perceived implemented by the NGO, themselves or both, in the different year of implementation; although in general 71 % perceived it as a cooperation between the villagers and NGO in Yalbang village (see table 5), which fits well with ADARA Nepal implementation strategy. It is important to note here, that this question was open "who decided to implement the greenhouse?" (see appendix 10.4), and this could easily be misunderstood or interpreted differently; so even if some said that they decided themselves, this might have been after a meeting with a NGO or in contact with a NGO.

Furthermore, when it comes to difficulties with implementation, it was observed that especially stone and wood was a significant problem for Chhipra village and a problem for Yalbang village (see table 5). One third in Chhipra had problem with labour for construction, while half in Yalbang had a problem with this. There has been an obvious misconception that villagers could collect the material for the greenhouse themselves cost free and that the only expense was the plastic. Stone must be broken, shaped and carried and that is by no means cost free in Humla. For the wood, there is exceedingly strong restrictions for private households my field informant argued, and wood need as well to be cut, formed, carried and this is expensive as well in Humla, my field assistant further argued. One greenhouse in Chhipra village would cost approximately 80 000 NPR; where stone was approximately 30 000 NPR, wood approximately 30 000 NPR and labour for construction approximately 20 000 NPR. This was also verified by one greenhouse owner and LI-BIRD. The cost of a greenhouse in Yalbang village was a little less, approximately 60 000 NPR. The stone and wood were cheaper, approximately 10 000 NPR for stone and approximately 20 000 NPR for wood; however, labour for construction was more expensive, approximately 30 000 NPR. The numbers were given by two interviewees and ADARA Nepal.

The lower cost might explain why fewer in Yalbang village had problems with stone and wood. The reason that Yalbang village had bigger problems with labour than Chhipra village, might be because it was more expensive in Yalbang village than in Chhipra village, for constructing the greenhouse and two villagers in Yalbang stated that skilled labour was difficult to access when building a greenhouse there. One interviewee stated that because of the high cost of wood and stone, this person had collected wood illegally, however how common this is, is uncertain. All of the people who mentioned they had no problems with construction, came from Yalbang village. If this is because of illegal practises, or that Yalbang village has a better overall better economic status and cheaper access to stone and wood, needs more research to determine. In Simikot, LI-BIRD informed that the price was even higher for a greenhouse, because stone was approximately 30 000 NPR, wood approximately 40 000 NPR and skilled labour approximately 30 000 NPR.

6.6 The biggest changes 10 years ago until now in Humla

		What have changed the most 10 years ago until now?				
	Number of interviews	No vegetables before	Less local grain now	Warmer and less precipitation now	More insects now	More wind now
Chhipra village	17	7	9	17	14	0
Yalbang village	17	6	6	17	14	9
Total	34	13	15	34	28	9

Table 6: what the villagers have perceived has changed the most 10 years ago until now in Humla

What stands out the most in table 6, is that all the 34 interviewees states that there is less precipitation and warmer now. One man in Chhipra village stated: *"Before it used to be up to 0.9 m of snow in the winter in the village, however now there is no snow in the winter in the village"*. Another man in Yalbang village stated: "*Before there was a much higher production of grains, however now it is very dry, with many insects and with a higher frequency of disease amongst the animals*". This links to the answer about less local grains, where almost half of the interviewees have commented this. Some difference can be seen here between the villages, where more people commented on less local grain in Chhipra village than in Yalbang village. From my own observations, the crops in Chhipra village were to a larger degree damaged than in Yalbang village, so the fact that this is more relevant in Chhipra village, was quite clear. LI-BIRDS

informant argued in the interview, that this year the winter crops in some areas in Humla was as low as only 10 % of normal, because of droughts the last two years. My field assistant also informed that the warmer and drier climate is the main reason for such a high increase in insects, which almost all of the interviewees had commented had changed the last 10 years.

Almost half mentioned as well, that before there were no green vegetables. On man stated: "*Before 10 years ago, there was no green vegetables, however now it is plenty*". This was an open question, and what the villagers defined as vegetables could also be quite relative. Later, I was informed by the field assistant that they used to eat some stinging nettle, onions, some other plants from the forest, potatoes and some herbs, however this was quite limited, especially in Upper Humla, and far from adequate for sufficient micro nutrients in the diet, the field assistant argued.

Lastly, wind seems to be more a local factor for Yalbang village, where 9 people comment on increased wind the last 10 years, while for Chhipra village nobody had perceived this as a change. How much this is a local phenomenon or how prevalent this is in Humla is not known and here more research is needed.

6.7 Challenges with the greenhouse

	Number of greenhouse owners interviewed	Do you have any problems with the greenhouse?				
		Irrigation	Equipment	Insects	Plastic	Seed
Chhipra village	9	7	6	7	0	0
Yalbang village	14	11	6	8	7	13
Total	23	18	12	15	7	13

Table 7: difficulties with the greenhouse

Irrigation is the most dominant challenge for the greenhouse owners in the two villages, as 78 % had a problem with this (see table 7). This is linked to table 6, where the reason is mentioned to be drier and warmer conditions the last years. In one interview with a woman from Chhipra

village, she explained that she had to wake up 4 am every morning to get water, so that she could irrigate her greenhouse. Insect is a major challenge as well and Chhipra village was more troubled by this than Yalbang village (see table 7). From my own observations inside the greenhouses in Chhipra village and in Yalbang village, there seemed to be more insects damaging the vegetables in the greenhouses in Chhipra village, than in Yalbang village. My field assistant worked with the insect problem in Humla, and he informed that in the greenhouses, it was mainly caterpillars and aphids that were damaging the vegetables (see pictures 16,17 and 18). In Yalbang village one interviewee informed that there were less insects in the winter, because it was colder, and my field assistant argued that the insects flourish in a warmer climate, thus the smaller problem in Yalbang village than Chhipra village with insects. Some villagers stated their need for insect repellent in the interviews, and one interviewee had already made her own from cow urine. All the NGOs informed in the interviews that they wanted to keep Humla organic, and that is why they were reluctant to use insecticides and pesticides; however, organic insect repellent, was something they were thinking about, to aid the villagers with these problems.

Both Chhipra village and Yalbang village had some problems with equipment, and Chhipra village more than Yalbang village. Many complained during the interviews, that the buckets had holes in them now, or for the ones that had gotten a pipe, that the pipe was leaking. Many of the ones that had only a bucket, where not satisfied with this, and wanted a long pipe that would reach to a water tap, because for the greenhouse owners that are located far from a water tap, it was argued as hard work to carry water to the greenhouse.

Furthermore, only Yalbang village had problems with seed. Seed is something almost all the greenhouse owners in Yalbang village had trouble with. In the interviews, no germination of the seeds received from ADARA Nepal was often mentioned as the reason for the seed problems by the villagers; however, ADARA Nepal mentioned training to be an important factor as well, to be sure that seeds were planted in the right way, at the right time and with the right care by the villagers. Damage to the plastic was also only mentioned in Yalbang village, as it was a problem for half of the greenhouse owners (see table 7) The villagers argued that wind was the problem and with more wind the last years, the plastic got damaged more easily. The plastic was estimated

by the NGOs to last 5 years, however many in Yalbang village informed me, that they had to change after 3 years, because of damage from the wind.

Lastly, it is worth mentioning that in both villages, a few of the greenhouse owners that had a greenhouse for a longer period was complaining that the productivity was falling. In the interview with the representative from LI-BIRD, falling productivity was also noticed by them, and they were in the future planning to learn the villagers to plant common bean among the plants to hinder the soil becoming deficient in nitrogen, as well as teaching them to change the soil inside the greenhouse annually. SHIP Nepal added that they wanted to teach the villagers to use a large amount of cow dung as natural fertilizer, for preventing the productivity from going down. Professor at the University of Bergen, Peter Andersen, argues that the practise of animal manure to ad nutrients to the soil, probably is most important for a higher and more stable production.

Picture 15,16, 17 and 18: upper left, is damaged plastic in Yalbang village; upper right, aphid problem in Chhipra village; down left and right, is caterpillars eating the vegetables in Chhipra village village

6.8 Greenhouse impact on food security

		How has the greenhouse impacted your food security?				How long is the growing season inside and outside the greenhouse ?	
	Number of greenhouse owners interviewed	Increased income	Vegetable production off season	Consumes more vegetables	More diverse diet	11 months outside and 12 months inside	5 months outside and 12 months inside
Chhipra village	9	6	7	6	4	9	0
Yalbang village	14	2	9	14	5	0	14
Total	23	8	16	20	9	9	14

Table 8: greenhouse impact on food security

Four points came out as the most important factors for a better food security. First, most of the greenhouse owners now perceive that they consume more vegetables, because of the implementation of a greenhouse. In Chhipra village, it is possible to grow vegetables outside the greenhouse for a few months, so they did not need the greenhouse all months of the year to consume vegetables; however, in Yalbang village, it is not possible to grow most vegetables outside the greenhouse at most times of the year. This might explain why all in Yalbang village said they consume more vegetables now and 2/3 in Chhipra village. Even if Chhipra village can grow vegetables outside the greenhouse for a few months, most greenhouse owners still use the greenhouse, because as one interviewee stated: "*The vegetables grow much faster in the greenhouse*"; and some vegetables, like tomatoes and cucumbers, could only be grown inside the greenhouse in Chhipra village. Second, vegetable production off-season is important as well for both villages, although it might have been expected to find this to be more prevalent for Yalbang village, because they almost exclusively grew vegetables inside the greenhouse; however, there is still some months in Chhipra village where vegetables cannot be produced outside and many informed in the interviews, that they value to have fresh vegetables year around now. Third, for Chhipra village income is important as well, where 2/3 of the greenhouse owners reported to have gotten more income after implementing a greenhouse, while almost none in Yalbang village mentions this. Chhipra village is only a 3 hour walk from Simikot, so they could easier sell their vegetables in the market there, and as mentioned in chapter 6.4, this can be done with a large profit annually. In Yalbang village some hotel owners could sell their vegetables to guests,

although it is difficult to measure the value, because vegetables often are a part of the meal Dal bhat, which most of the tourist and guests eats. It is not possible to sell vegetables to a market for Yalbang village, because of the distance to Simikot; however this might change in the future, because of the road that is being constructed. Fourth, a more diverse diet is mentioned by 9 villagers. If we look at figure 5, upwards to 16 different crops are being grown inside the greenhouses. This question was difficult to separate from the question of consuming more vegetables, as it somehow includes a more diverse diet; however, as seen in figure 5, the extent of the variation is interesting, and it seems to not be only one or a few vegetable crops, thus many vegetable crops being grown inside the greenhouse, and this is important for both the crops resistance to pest and insects and a more varied diet.

Furthermore, if examine the growing season for Yalbang village, it is outside only a five months growing season for grains, while it is for 12 months possible to grow vegetables inside the greenhouse. This means that with the greenhouse, the growing season for food can be extended with seven months. For Chhipra village, the general growing season for food can only be extended for one months, however as mentioned above, some vegetables can only be grown inside the greenhouse and some for only a limited period outside. For both Yalbang village and Chhipra village it is now possible to grow vegetables year-round, which especially for Yalbang village is a major change, because they have such a limited climate for growing vegetables outside at any time of the year. It must also be mentioned that not all vegetables can be grown year around, and my key informant informed that for the winter months - here duration varies from village to village, because of altitude differences –, only green vegetables were produced inside the greenhouses, because the temperature got too cold for other varieties. Lastly, it is important to note that before there was a practise in Humla of fermentation and drying of vegetables, to extend the season of consumption of vegetables, so at least for fresh vegetables consumption and growing season, the numbers here are valid, however for consumption of dried and fermented vegetables, it is unknown how prevalent and extensive this was in the past. As 7 interviewees in Chhipra village and 6 interviewees in Yalbang village argued that there were no vegetables before, this might have been very limited, at least for the two villages in this study.

6.9 Greenhouse impact on health and nutrition

		How has the greenhouse impacted your health and nutrition?		
	Number of greenhouse owners interviewed	Better health	Better eyesight	Off-season consume of vegetables
Chhipra village	9	6	4	8
Yalbang village	14	13	3	12
Total	23	19	7	20

Table 9: impact on health and nutrition

In table 9, it can first be observed that almost everybody perceived that their health is now better after acquiring a greenhouse. This would be expected, when going from a very limited intake of vegetables in their diet, to consuming a large variety during the whole year. One woman in Yalbang village argued in the interview, that especially for her children and the older man in the family, the health had become much better. A man in Yalbang village explained that he used to have bad lungs, however after starting to consume more vegetables with the implementation of a greenhouse, he experienced no problems anymore. It is also interesting to see that the villagers now consume vegetables off-season as well as producing it off-season (see table 8), which for Yalbang village is an exceedingly long extension of time. I was informed by my field assistant that a well-running greenhouse produce vegetables in waves, so that there are vegetables available through the whole year for consumption. Better eyesight is a part of better health, and especially in Chhipra village this was mentioned by close to half of the greenhouse owners. This was somewhat expected when they go from a diet of mostly imported white rice and local grains, to be able to consume food rich in vitamin A, C and K. In Chhipra village the greenhouses were implemented recently (see table 2), so the number presented here can be expected to be even higher, because some only had the greenhouse for one year or less in Chhipra village, and had only recently started to produce vegetables, so it is expected to be some time before they can notice possible health benefits.

Here it is a big caveat. The NGOs might have informed the villagers about the better health effects, better eyesight and other health benefits from the greenhouse. The villagers then believe

it, without experiencing it, so there might be that they simply think that this is what they "should" think. However, my own experience was that this was at least not always the case, because many had their complete own and personal story about direct effects. Examples was better health for the child, better immune system for the family, child mortality lower in the family, better eyesight, better lungs, more strength and better health for the elderly in the family. This might of course also be placebo or because of other changes; correlation does not necessarily imply causation. However, some also mentioned more vitamin A in the diet, more nutrients in the diet and a more balanced diet, and this sounded more like they passed on information they had learned from the NGOs, so called "received wisdom".

6.10 Production of vegetables in the greenhouses and usage.

	Number of greenhouse owners interviewed	How much do you produce annualy?		
		Median in kg*	Average in kg**	Production range in kg
Chhipra village	9	350	532	250 - 1000
Yalbang village	14	250	232	50 - 450
Total	23	250	367	50 - 1000
* Median because of outliers **For comparison reasons with NGO data				

Table 10: production of vegetables and usage

If we examine table 10, we can observe that the total estimated production by the greenhouse owners is 250kg per household, while for Chhipra village alone, this is 100kg higher. Because, when HDI and Candy et al. measured production, they used average, so I included the average as well for comparison reasons later, however median is in this study a better means of measure, because of outliers effecting the numbers greatly. LI-BIRDs informant argued that he was sceptical to the average number I had gotten, and believed that 200-300 kg would be more correct for whole of Humla. This fits with the median number of total of 250kg in average between the villages. The production number in Chhipra village is, no matter if we look at median or average, higher than in Yalbang village. The total for all the findings in table 10 are skewed, as Chhipra

village is represented by 9 greenhouses and Yalbang village is represented by 14 villages. This unfortunately gives an overrepresentation of Yalbang village on the data for the total.

The reason for a larger production in the greenhouse in Chhipra village compared to Yalbang village, seems to be based on three factors. First, the seeds in Yalbang village have problems germinating (see chapter 6.7). Second, lower Humla has a warmer climate and land that is more suited for agriculture (Nagoda, 2015, p. 37). Third, Yalbang village had a longer time in the winter where leafy greens were produced mainly in the greenhouses, because of the cold. In Chhipra village this period was shorter, and this left more time for heavier vegetables to be produces in the greenhouse, for example pumpkin, cucumber and potato. While green leafed vegetables will have a low weight to volume, the heavier vegetables would have a bigger weight for volume.

In the interview with LI-BIRD, it was also mentioned that it is not easy for the villagers to estimate themselves how much in kg they produce, so most likely are these data not exact. This is of course a valid point, however some more reliability is added to the number, because LI-BIRDs informant had the same experience of 200-300kg to be what could be expected of the average greenhouse, with some more production in Lower Humla, because of a warmer climate. In addition to the fact that many in Chhipra village argued that they had a quite correct number, because they had to measure everything when they sold the vegetables to the market. As seen in the production range in table 10, the kg produced varies highly from greenhouse to greenhouse. This can witness of as well that training is not complete, and my field assistant informed that their practise and maintaining of the vegetables, varied greatly from greenhouse to greenhouse.

Picture 19 and 20: example of a well-kept greenhouse with different sections for different varieties; on the right is a cauliflower section in the same greenhouse as on the picture to the left

6.11 Varieties grown inside the greenhouses

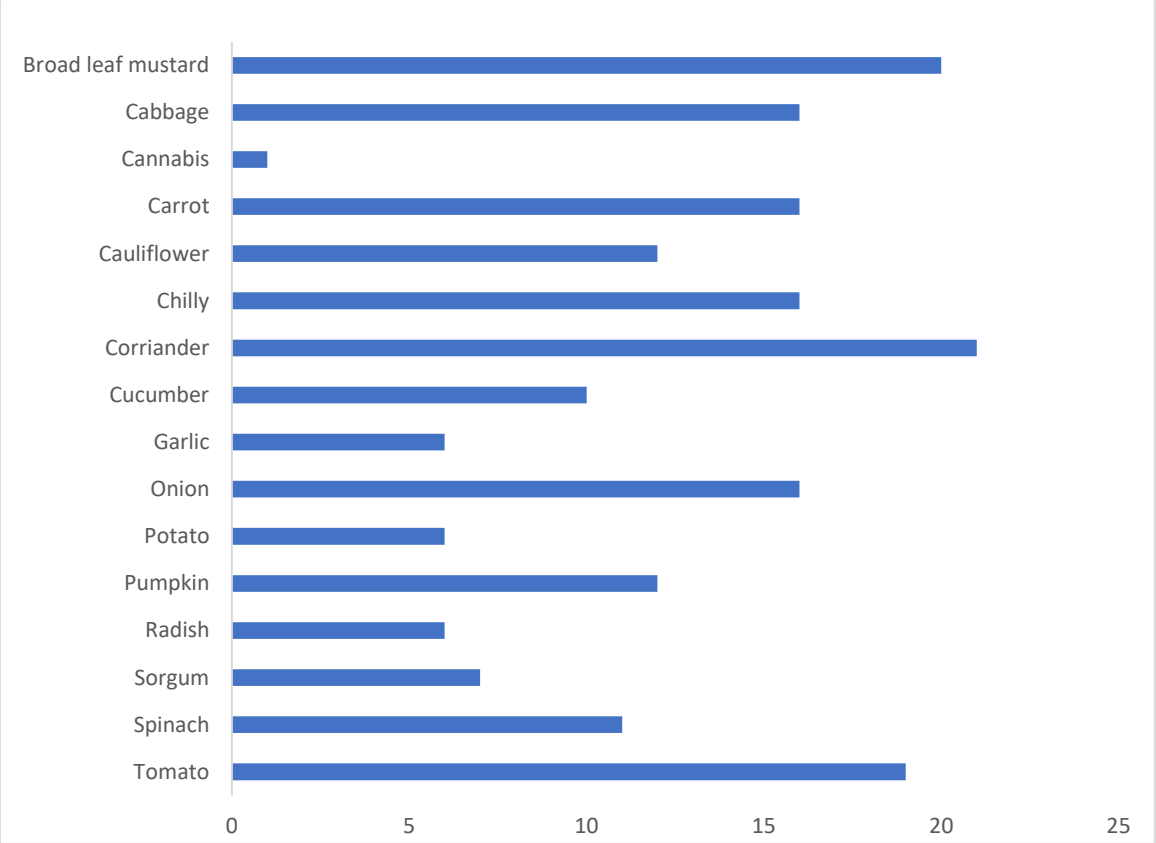

Figure 5: type of vegetable crop and their frequency grown inside the greenhouses.

In figure 5, it shows clearly that there is a great variety of vegetables being grown inside the greenhouses. The three most popular are: coriander, broad leaf mustard and tomato; which are all vegetables high in important nutrients like vitamin A, K and C. Cabbage, onion, carrot and chilly are popular as well, with 16 of 23 greenhouse owners growing them and this is an important sourced for micro-nutrients as well. Some of the products produced can be seen in picture 21 and 22. There were only minor differences between what the villagers in Yalbang village and Chhipra village, and that is why only the total number is mentioned here and not the villages by themselves. Sorgum is also produced in the greenhouse, and that is interesting because it is not a vegetable. When asked, it came forward that the greenhouse for some also were used as a nursery for some grains and potato, and that is most likely why Sorgum is mentioned here.

It is important to note here that these numbers are slightly unbalanced, because 9 greenhouse owners were interviewed in Chhipra village and 14 in Yalbang village, so Chhipra village is represented 39 % by these numbers vs 61 % representation from Yalbang village. Furthermore, most likely did not the greenhouse owners mention all of the vegetable crops produced, because they had to think for a long time when this question was asked and my field assistant gave suggestions quite often and then the interviewee often would remember some more. Another question is also what they would normally would grow and what they are only "testing" out. It is of course a difficult question when upwards to 16 varieties was grown and needed to be remembered, so this would be an approximate number and not an exact number for the two villages. Finally, what was written here of names of the different vegetable crops might have been lost in translation, especially for the different green leafed vegetables. This is because of some language/communication problems. It seems more specific that spinach might be wrong, because Professor Peter Andersen at the UiB argues that it most likely is another type of broad leaved mustard.

Picture 21 and 22: on the left picture is carrot, tomato, cucumber, potato and chilly; on the right picture is cauliflower, cabbage, onion and ginger.

6.12 Access to seeds for the greenhouses

	Number of greenhouse owners interviewed	From where do you get access to seeds?		
		NGO	Marked	NGO and marked
Chhipra village	9	5	2	2
Yalbang village	14	6	0	8
Total	23	11	2	10

Table 11: access to seeds

In table 11, there seems to be a trend in both Chhipra village and Yalbang village to buy some of the seeds on their own, especially for Yalbang village. Yalbang village is far from Simikot market, still did 8 of 14 get access to seeds from NGO and market. The explanation for this, when asked in the interviews, was that Yalbang village is thus not so far away from the Chinese market, and many of the villagers did trade there, also for seeds. The reason for buying some seeds themselves, was that even though ADARA Nepal distributed seeds for free, the villagers had problems with the seeds germinating (see table 7). Chhipra village on the other hand did not have particular problems with seeds and that is why most would get the seeds only from LI-BIRD. This was in the form of a seed cooperative, where all payed a smaller amount and then LI-BIRD would provide them with seeds. Some also got seeds from the market in Chhipra village, and the explanation for this turned out to be twofold: First, some villagers argued that they were curious about trying new varieties, both for consume and for sale possibilities. Second, even if seeds were not a general problem for the households in Chhipra village, some would mention problems with germination for one or two varieties provided by the cooperative, so then they would rather buy those varieties in the market.

6.13 Gender and greenhouses

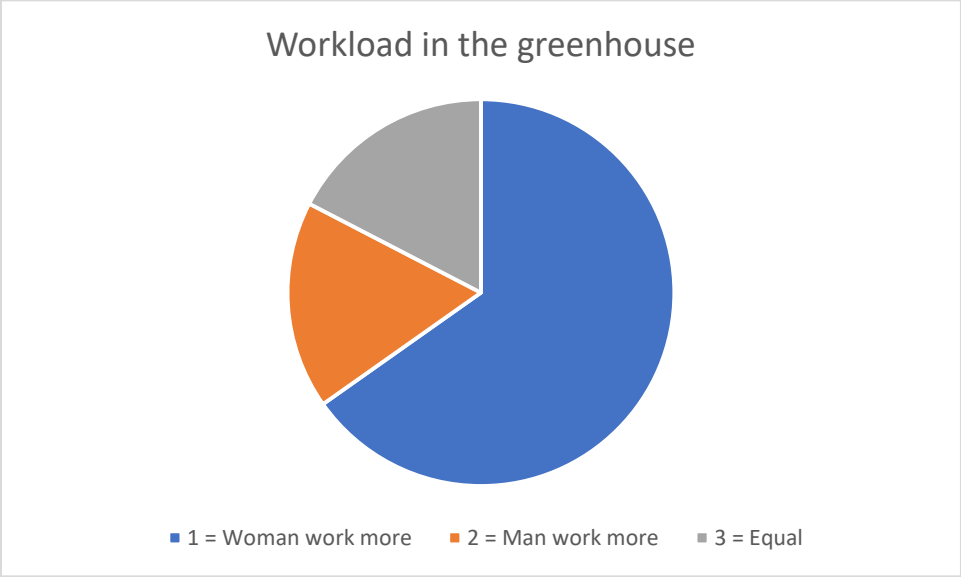

Figure 6: gender distribution of workload inside the greenhouse

Mostly women work in the greenhouses in the two villages (see figure 6). This was the case for both Yalbang village and Chhipra village. Although it was not mainly a women's job, since the interviewees in most cases stated that both men and women would work in the greenhouse at some time, although the women quite more frequent. The reason for this came forward in the interviews to be that it was more convenient that the women would work in the greenhouse, because the men often had some work further away from the household and the women closer, because she would as well take more care of the house and children. It did not appear to be based upon social norms that women would work more in the greenhouse than the men, it seemed simply to be based upon convenience. Some of the interviewees described this as hard work, especially the ones that had not gotten a pipe and had to carry water from the water tap to the greenhouse to irrigate it. It is interesting that the women have to work the most with the greenhouses, because when asked about who implemented the greenhouse, of the 18 greenhouses that was not perceived implemented by the NGO alone, 67 % was perceived implemented by a man in the family, 6 % by a woman and 28 % by both, where this was more decided by both in

Yalbang village then in Chhipra village where the man decided to a large degree (see appendix 10.2). It is important to mention that the data are skewed here to large degree, as the data represents 6 greenhouses in Chhipra village and 12 greenhouses in Yalbang village.

6.14 Data analysis

The way the data was encoded from two notebooks to tables and figures was done accordingly: First, the interviews were duplicated from two notebooks to excel. Second, the answers were coded in to numbers representing a particular category of answers; here there was some subjective judgment, because many of the questions were open (see appendix 10.4) and people would answer different from each other in some ways, as well as some answers were given so infrequent or were of so little relevance for the research questions, that they were not included in the results. Third, the numbers were structured in to mostly tables, to show the difference between the Lama village and the Hindu village and the total. For gender distribution and varieties grown in the villages, the differences were so small between the villages, that figures were used instead to better highlight the findings. The data processing and coding gives a possibility for human error to impact the data on each step of the prosses; however, to counter this, the numbers have been double checked.

6.15 Critique of data

Critique have been made that qualitative data might easily become affected by biases or ambivalences of the researcher (Johnson and Onwuegbuzie, 2004). This was a problem in the field, because I asked many open-ended questions and there were interpretable answers to them, as well as some observations were interpretable. Most of the questions I had to interpret immediately, because I was in a middle of a conversation or interview, and the next sentence would come two seconds after; and with the observations I am sure many were judged sub-consciously as well.

My positionality as a clear outsider in an extremely foreign culture enhanced these possible weaknesses, at the same time as language went from Nepali dialects, to an English that was not perfect by my field assistant or myself, to Norwegian in my head or in my notes, and finally written on a computer in English. My field assistants experience, knowledge and work for Nepal trust might most likely have affected the answers even before I could interpret them as well, because as an expert on the questions I asked, it seemed often like he and the interviewee would together find the "right answer" to the questions. As I could not speak the language, there was some loss of control under the interview situation. Therefore, the best efforts were made to make the research transparent, to be honest about my positionality and about possible uncertainties and weaknesses; not only in the field, however for the analysis and the discussion part as well. As mentioned above, this was mainly a comparative study, where I went in depth with interviews and observations in two villages and compare them to each other; however, information and observations in other villages, from literature, from key informants and from NGOs were important to limit bias and ambivalence, as they were applied to support or contradict my own findings, test generalization possibilities and for having a larger base of information to be able to answer the research questions with more certainty.

It might also seem that the data from Chhipra village, can be particular troublesome to generalize to all the Hindu villages in Humla, for a reason that was discovered after the fieldwork in Chhipra village was conducted. As one NGOs informant stated that "*Chhipra village was a particular challenging experience for implementing greenhouses*". Fieldwork in another Hindu village might then have been more accurate to represent a *more* general Hindu village in Humla.

My quantitative data were as well based on only a few individuals in two villages, where these again often were divided either in to groups of people with greenhouse or without greenhouse. These interviews were at the same time not possible to conduct random or systematic, because of so few interviewees available in the villages, so the ones that were home and willing to do the interview were asked; a form of convenience method of sampling. This made the data somewhat clustered, especially in Chhipra village there were two parts of the village where most people accepted to do an interview. In one area, the the Chhetris lived and they would live in small and

squeezed together houses. In another area, the Brahmins were located, and they had significantly bigger houses, that was more spread out. Most of the questions were as well not simple yes and no questions (see appendix 10.4), so the line between quantitative data and qualitative data from the interviews was sometimes difficult, because at the same question someone would give exact numbers and others would tell long stories. In retrospect, to be a little more precise and narrow with the questions, might have given less space for questions I had to interpret and then limit biases and ambivalence; however, on the other hand, then I might have missed out on some information that was given to me under the more open-ended questions and that later proved valuable; the case of falling productivity inside the greenhouse is a good example here.

Furthermore, positionality is an important discussion to take here. An outsider is somebody that does not belong to a group that is being studied (Mullings 1999). I came to Humla as a Norwegian male, in the beginning of my twenties and always walking around with a pen and notebook. I was as much as an outsider as I could be; although for me, this was experienced as good in most cases, because Norway supported different projects in Humla trough the Norwegian Development Fund (Utviklingsfondet), so most people seemed happy and eager to do interviews, show the greenhouse and to share information. Furthermore, Fonow and Cook (1991) argues that an outsiders are more likely to be perceived as neutral, because they don't belong to the group that is being studied, and I can in this way have been given information that would not be given to an insider. There can also be a larger degree of objectivity in the observations from the researcher, because he or her is not part of that social group (Mullings 1999). However, this is not to say the outsider position I had was without challenges or difficulties. First, I might miss many factors that only an insider could get access to or can be able to observe (Mullings 1999). Second, I felt it was difficult experiencing a so foreign system and a way of living, with a western perception of what "is" and how it is "supposed to be". Here my field assistant was of great use, as I could ask about every matter I did not fully understand. Furthermore, I was most likely perceived by the villagers as someone that might give them something, because of the many projects that have been successfully implemented in Humla (HDI, 2014; McKay et al., 2007). The villagers connected me to these projects, because the Norwegian development fund (Utviklingsfondet) was a great contributor to many of the projects in Humla, and I was Norwegian myself. The information I got, was most likely in most cases, coloured by me being perceived as a "walking bag of

money". This I felt in particular had an impact on how people responded to me Chhipra village, because the Norwegian Development Fond was at the moment supporting a large and popular water project there, as well as they founded HDI, that was the main NGO working in Chhipra village. Here, often 10-15 people gathered around me and in the interviews, they would often tell about how thankful they were for the support, thus how much they needed even more support. One woman stated in Chhipra village: "*Thank you, thank you for the water project and greenhouse project*" and many interviews involved statements like this. Although this was not so strongly felt in Yalbang, it still was experienced here. One woman for example stated: "*We are poor, please support, water huge problem, need pipe, you should help Yalbang people!*". This was enhanced by the fact that my field assistant was part of many of the projects, as an agriculture specialist for the NGO, Nepal Trust, because villagers seemed to know that he was implementing different projects in Humla and that funding came from people "like myself".

My field assistant was from Lower Humla and worked for Nepal Trust, and even if he had no formal education in the agriculture field, he had a lot of experience and seemed quite knowledgeable about the subject. He also mastered both the Nepali dialect in Humla, which was spoken by the Hindus, and the Lama people's language, which is linguistically closer to Tibetan then Nepali (Nagoda, 2015, p. 38). He was helpful in entering "insider" information, since he was from Lower Humla and a Hindu from the Chhetri cast, as well as known in the area amongst the people, because of his work for Nepal Trust. In Chhipra village this was maybe most evident, because most of the villagers were mainly from the Chhetri caste and they knew each other from before. In Yalbang village my field assistant had an uncle working in the medical outpost there and he knew everybody in the village, so even if my field assistant and his uncle were Hindu, they knew the village and the people well, which made us come more on the "inside". On the other hand, he was a representative from the NGO, Nepal Trust, and was involved in different agricultural projects in Humla. He was by no means neutral, and was regarded as an expert on agriculture, as well as a source for new projects that might aid families or their village, as many projects had done previously. Still my field assistant fitted good with Kapborg and Berterö (2002) recommendation that: "*The interpreter should not only have the required linguistic abilities, but also be trained in research field, and furthermore, the validity will be strengthened if the interpreter is part of the culture arena*". As my field assistant worked with agriculture and NGO

work, was from the research area and had good linguistic abilities in both the Humli dialect and the Lama people's dialect, he fitted quite well to this recommendation.

Mullings (1999) argues that insider/outsider is not always either or. In the field, my field assistant and me together I experienced as not a clear insider or a clear outsider, however me and him together I felt affected the interviews. The villagers had to at the same time relate to my field assistant and to me, to both insider/outsider, so the classic stereotype of insider/outsider was not clear. Mullings (1999) is right in arguing that it is always possible to strike the right balance of insider/outsider in a situation; however, if we did, would I know? The interviews were in a language I could not understand, and how would this possible positionality we were given affect the validity of my claims? I can only be transparent about my perception of me and my field assistants' positionality in the field, however how we were perceived together is difficult to know and this again is only my perception of how others might have perceived us and not how they "actually" perceived us.

It is also important to mentioned that there are almost no "objective" sources about greenhouses in Humla specifically, and most of the data in the literature are anecdotal data. The articles that are used in this thesis are often from a NGO or in cooperation with a NGO, so their results - which I often compare my finding to -, are then a reflection of the different NGOs normative view. The NGOs I interviewed were as well not objective, as they represented and presented their NGO; however, they provided valuable information, based on years of experience about greenhouses in Humla; although, concrete facts they were often still researching.

I tried to combat these weaknesses with a mixed method approach. The interviews with the villagers, the two key informants, NGOs and the literature, together with observations and photographs; represents a range of methods and perspectives, that hopefully together can throw light on the research questions, despite the limitations presented in this chapter.

7 Discussion

7.1 Greenhouses impact on food security

This thesis follows the definition of FAO (1996) for adequate food security: "*when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life"*. Important aspects here are availability, access, utilization and stability, and these aspects will be profoundly discussed in the light of greenhouses in Humla.

7.1.1 Availability – a vegetable revolution in Humla

Availability is when supply is the focus and is based on stock levels, food aid, level of production and net trade (FAO 2006). Vegetable availability used to be low in Humla (see chapter 3.3); however, per 2016, the availability situation has changed significantly to the positive. HDI (SHIP Nepal and LI-BIRD together) had built approximately 500 greenhouses in Humla (Subedi and Shrestha, 2016), Nepal Trust approximately 50 greenhouses and ADARA Nepal reported they had built more than 1000 greenhouses (own data). This gives a total of a minimum of 1550 greenhouses in Humla. There are also four larger commercial greenhouses built in Simikot by LI-BIRD and nine by ADARA Nepal, which both LI-BIRD and ADARA Nepal argues sell a large quantity of vegetables. This list is not complete, since more NGOs are distributing greenhouses in Humla as well as DADO (governmental organization) and this data I was not able to acquire. In addition, local villagers might have built them privately, as two interviewees in this thesis had done, however the extent is not known. There are 9479 households in Humla (Central Bureau of Statistics, 2012, p. 40). If 1550 greenhouses are divided by 9479, we get a minimum of a 16 % coverage of greenhouses per household in the whole of Humla, although this is expected to be higher, especially in the villages in Upper Humla, where ADARA Nepal has built over 1000

greenhouses alone. The only comparison data for greenhouse prevalence is from 2012, when Fuller and Zahnd (2012) reported that 62 greenhouses were built in Humla. If these data are somewhat accurate, it fits with greenhouses being in average 3,2 years old in Yalbang village and Chhipra village together (see table 2), and this means that most of the minimum 1550 greenhouses in Humla were built after 2012, and most of them in Upper Humla. The natural conclusion from this, is that the availability of vegetables has increased significantly and especially in Upper Humla.

	Own data *	Candy et al. **	HDI ***	LI-BIRD ****
Upper Humla	232kg			
Lower Humla	532kg		567kg	
Humla	367kg	156kg		200-300kg
	* average	**(Candy et al., 2012)	***(HDI, 2014, p. 7)	****(own data)

Table 12: comparison of production of vegetables inside a greenhouse in Humla

However, that more vegetables are available in Upper Humla might not be case, because as observed in table 12, it seems that more vegetables can be produced inside a greenhouse in Lower Humla than Upper Humla. For Lower Humla, HDIs number might be more correct, where the number in Chhipra village of 532kg average annually (own data), was almost identical with HDIs number of 567 kg average annually. The informant from LI-BIRD was critical towards this number from HDI being generalizable to the whole of Humla and argued that from their observations and experiences, it is most likely between 200-300kg annually for the whole of Humla, which fits well with the median from the data in this master thesis (see table 10). The number from Candy et al. (2012) was lower, however this was only measured in the winter months, so 156 kg is expected to be higher when the whole year is measured. As there were no comparison data with the data from one village in Upper Humla, it is only expected that production in Upper Humla is somewhat lower than in total for Humla, because of the temperature differences with the increased altitude; however, to which extent must be determined by more research. The difference between Upper Humla and Lower Humla when it comes to availability is then uncertain, because while Upper Humla has a higher frequency of greenhouses, Lower Humla seems to have a higher production of vegetables per greenhouse. Furthermore,

Fuller and Zahnd (2012) argues that 52 % of the greenhouses that had been built prior to 2012, were in 2012 not operating as intended. All of the greenhouses in Humla are expected to be producing vegetables in 2016, because the NGOs and key informants had not experienced anyone that had stopped using their greenhouse as intended.

Vegetable availability seems to be in expansion as well, because the NGOs interviewed argued that demand for greenhouses became higher every year and if Fuller and Zahnd (2012) are correct in that only 62 greenhouses were built in Humla in 2012, then most of the minimum 1550 greenhouses were built between 2012 and 2016. The greenhouse projects in Humla then follows the principle of sustaining a steady expansion of foodstuff for increased availability (United Nations 1975). This was also verified in the field, as all villages interviewed without a greenhouse, wanted a greenhouse, and most of the villagers with a greenhouse, wanted another greenhouse (see table 3 and 4). To secure a steady expansion, there seems to be a great potential to increase the production from the greenhouses that are already operating in Humla as well. Summarized, the challenges with the greenhouses were irrigation problems, insects, equipment problems, seed problems, wind problem and a decrease in productivity inside the greenhouse (see chapter 6.7). If these challenges are dealt with and new challenges are continuously identified and improved, then the practise in Humla would follow the recommendations from World Bank (2006, p. viii and ix); that innovations should include both bigger and smaller improvements in an continuous progression of improvements.

The time of the year in which food is available, is an important factor as well. For Chhipra village, food outside the greenhouse could be produced 11 of 12 months of the year (see table 8); however, some varieties of vegetables could only be produced inside the greenhouse, for example tomatoes and cucumbers. For Yalbang village, the greenhouses had a significant impact on the growing season, because food outside the greenhouse could only be produced 5 months of the year, while food inside the greenhouse could be produced 12 months of the year (see table 8). There most of the vegetables had to be produced inside the greenhouse, because of low temperatures at night, also in the summer months. This should not be any different in other villages at same altitude as Yalbang village or higher, where greenhouses are estimated to have a

large impact on the growing season. Limi is the VDC in Humla highest above sea level (villages located at 3700m – 4100m above sea level), with an even shorter growing season than Yalbang village – being 700-1000m higher in altitude - and here my field assistant informed he knew about 4 greenhouses that were constructed by SHIP Nepal and were producing vegetables. In Muchu VDC, which is located in the west of Upper Humla, at the border to Tiber, HDI (2014, p. 63) reports that fresh vegetables were only possible to produce two months of the year previously, because of the cold climate; however now with greenhouses, fresh vegetables can be produced throughout the whole year. In general, in Humla, months of food deficiency were experienced from mid-February to mid-June and from mid-August to mid-October (see figure 2). Greenhouses produces food regularly the whole year, and can help securing food availability in the months of food deficiency, providing increased food volume, micronutrients and some calories. As observed in table 9, off-season consume of vegetables was mentioned by almost all the greenhouse owners, so fresh vegetables are not only being produced off-season, they are as well consumed. A well-kept greenhouse has different sections for different types of vegetables (see pictures 19 and 20), which ensures that some types of vegetables would be available every month of the year.

Lastly, food aid is an important aspect of availability (FAO 2006). Nagoda (2015, p. 15) argued that WFP distributed approximately 7 980 metric tons of foodstuff in Humla from 2004 to 2011 (Nagoda, 2015, p. 15) to help against food shortage. However, because this is mostly rice (Nagoda, 2015, p. 39) it does not increase the availability of vegetables, and while white polished rice provides calories, it still does not increase availability of food rich in micronutrients. At the same time, Humla is extremely isolated when it comes to trade with the rest of Nepal, because of the lack of roads to transport foodstuff. Outside contact to provide availability of vegetables is thus minimal and greenhouses can in this way be argued to be of further importance for availability, because of Humla's isolation.

In this thesis, it will be argued that greenhouses have led to a significant increase of availability of vegetables in Humla. Furthermore, for Upper Humla, the increased in availability seems to

specifically be caused by a major increase in the duration of the growing season and a larger frequency of greenhouses; while for Lower Humla, an important factor is that the climate is in general more suitable for agriculture (Nagoda, 2015, p. 37), so even if the greenhouses are fewer here, the production is higher of vegetables per greenhouse compared to Upper Humla. World Bank (2006, p. viii and ix) argued that considerable value should be added to the non-traditional agricultural sectors, and this seems to have been the key in Humla to make availability of vegetables improve significantly, because of the implementation of the non-traditional innovation of greenhouses.

7.1.2 Access – not the same for everyone

This thesis has argued that different access factors still hinder food security, even if availability is adequate and that these factors are based on entitlements. 'Entitlements' was defined as: "*The set of all commodity bundles over which a person can establish command given the legal, political, economic and social arrangements of the community in which they live*" (FAO 1996). Nagoda (2015, p. 10 (paper 2)) argues that in Humla; poor, women and low castes are the most social and political marginalized.

The households that own a greenhouse in Humla have access to the vegetables produced from the greenhouse. As seen in Yalbang village (see table 10) vegetables are being shared out amongst relatives, with the monks in the monastery in Yalbang village and the nuns in the monastery in the neighbouring village Tumkot. The villagers in Yalbang village, without a greenhouse, then seem to have a certain access to vegetables as well. The Dalit that was interviewed in Chhipra village also mentioned that higher castes sometimes share vegetables with the Dalits for free or in exchange for work, and HDI (2014, p. 5 and 45) reports similar incidents from a Hindu village in Lower Humla. Thus HDI (2014, p. 5) argues that because of a better economic status for the households that can sell vegetables from their greenhouse; successful greenhouse owners could now afford to hire Dalits for labour. This might be especially important because Onta and Resurreccion (2011) reports that Lama respondents informed that they can no longer hire Dalits, be-

cause of the frequent droughts they had not enough grains to pay them with. To build a greenhouse, one need workers as well to transport the materials, to break and shape the stones and cut and shape wooden beams, and the field assistant informed that this "type of work" was often done by the Dalits or the poorer households. As there have been built a minimum of 1550 greenhouses in Humla and more are expected to be built in the future, this is not insubstantial as a potential source of work for the Dalits and the poor. If greenhouses can be a part of creating surplus that will continue making jobs available for Dalits or the poor, it would strengthen their access to foodstuff as well with being paid in money or food. As these data are anecdotal, the frequency or magnitude of this is not known, only indicators that others than the greenhouse owner experience some trickle-down effects from the greenhouse projects.

There is also a market for selling vegetables in Simikot and villagers close to Simikot can access the market here for buying or/and selling vegetables, Chhipra village being one of them. When the road is finished, accessing the market will be easier for villages further away from Simikot as well, if they live somewhat close to the road. The field assistant informed that there are also smaller markets in other parts of Humla, where vegetables can be sold and bought as well. Furthermore, HDI (2014, p. 6) sees that in Simikot the demand is so high for vegetables now, because of international trekking groups, local employees, police, retailers, hotel owners and the military; that some villagers regularly get costumers directly to their greenhouse, so they have a direct access to vegetables. In Yalbang village trekking groups also demanded vegetables, so tourists traveling through Yalbang village can now easily access vegetables here because of the greenhouses, and the greenhouse owners in Yalbang village have an extra income source from selling vegetables to the tourists (own data). It should be noted here that there were in 2013 only 1603 tourist in Humla (Ministry of Culture, Tourism & Civil Aviation 2013, p. 3); so, the number of tourists are still quite limited. However together with the local employees, police, retailers, hotel owners and the military, the numbers still add up and provides for some greenhouse owners indirect access to other food items through sales of vegetables. In the interviews, there were some greenhouse owners complaining about falling prices of vegetables in the market, due to more people wanting to sell their vegetables now; however, this is good for consumers, who now can access a larger quantity of vegetables for a falling price. It thus seems like the market is

becoming more saturated, so on the other hand, falling prices might be a problem for the villagers who wants to earn a living from a greenhouse.

The greenhouses in some cases, also have an indirect effect on food access in Humla. Especially in Chhipra village, it was observed that local grain was failing and not available anymore to sustain the village, so income from inter alia greenhouses was crucial to be able to access rice. As seen in chapter 6.4, earnings in the case of two of the interviews in Chhipra village was as high as 80 000 – 100 000 NPR annually. In the interview with LI-BIRD, they had experienced earnings up to 150 000 NPR annually from a family greenhouse, and HDI (2014, p. 63) could shed some light in Upper Humla with greenhouses and hotels, because they observed in Muchu VDC (same VDC as Yalbang village is located), that when combining greenhouse and hotel, one man would earn 70 000 NPR annually. This is a substantial amount of money for the inhabitants of Humla, which have an average GDP of US$ 72, or approximately 7700 NPR (in March 2017) (McKay et al. 2007). Rice is expensive in Chhipra village, because of transport, first with airplane to Simikot and then with animals down to Chhipra VDC and for 1kg white rice the price was 200 NPR in Chhipra VDC in May 2016 (own data). In Yalbang the dependency on imported rice seemed less profound, although they still wanted access to white rice for tourists, guests and own consume. White rice could be sold to tourist at a higher price than from what they bought it. The income from the greenhouses could also be used to make other things available. Examples from the interviews included kitchenware, hygienic products, clothes and education for the children in the family. Rosengrant and Cline (2003) argued that especially investment in education for agriculture technology is important for food production and income. This seems to have been vital in Humla for both increased production of vegetables and as an income source for the households closer to a market, to be able to access other commodities and services to improve livelihoods. HDI (2014, p. 7) reported that for material, plastic, training and technical support, their expense as an NGO was around 50 000NPR for a greenhouse, and this was only possible because of funding from different agents, so that the NGOs could invest in agriculture technology and educate the villagers in Humla about it.

Lastly, some local practises in Humla are documented, and they affect the entitlement of villagers and particular women to vegetables, because of the beliefs and traditions in the community in which they live. First, *Chhaupadi* is a Hinduistic practise and it revolves around the concept that menstruating women and those about to give birth are unclean. The female should stay away from their families and they often had to stay in unsanitary conditions like a buffalo shed or in a small hut, called a "chhaupadi goth" (United Nations 2011). In this period, women should only eat salted flatbread (United Nations 2011). Nutrients from milk, meat, vegetables and fruit is essential in this period to keep strong and healthy, and with this practise, there is no access. This contributes to many life-threatening health problems in this period (United Nations 2011). Even though the Nepali government introduced regulations against this practice in 2007, these have had limited impact in remote areas, where Chhaupadi has influential defenders like traditional healers and priests and the government agencies are not that prominent (PHASE 2013). Data from 2010, shows that 58 % of women in Humla had experienced staying in an animal shed during menstruation (Central Bureau of Statistics and UNICEF, 2010, p. 109). This can make the access for Hindu women to vegetables inaccessible at certain vulnerable times, even when otherwise available. Some NGOs are working with female empowerment in Humla and my field assistant argued that the women groups have been especially important for creating awareness of the dangers with Chhaupadi. It was informed to me further by my field assistant, that Chhaupadi is slowly coming to an end, much because of these women groups, who creates awareness about it among the villagers; however, it takes time in the remote villages to change this tradition. Second, in Chhipra village there was a traditional view of vegetables called *Hariyo khaye hariyo farkinchha*. This means that some vegetables are thought to be indigestible and that especially green vegetables should not be fed to children or pregnant women (Subedi and Shrestha 2016). It is unknown how many villages follows these traditions or similar traditions in Humla, however NGOs are doing an important job in changing these misconceptions, so that villagers, and women in particular, can be able to access sufficient nutrients from vegetables, in all times of their life.

7.1.3 Utilization – a large step towards a more adequate diet

FAO (2006) defined utilization as: "*Adequate diet, clean water, sanitation and health care to reach a state of nutritional well-being where all physiological needs are met*". As argued for in chapter 3.3, the inhabitants of Humla did previously not have an adequate diet. This was because the diet contained too little calories, proteins and micro-nutrients, which led to a high frequency of macro-nutrient and micro-nutrient related deficiencies in Humla. Greenhouses seems to positively influence the diet in both Yalbang village and Chhipra village. In almost all the interviews the villagers with a greenhouse stated that they now consume more vegetables, which the interviewees felt improved their health (see table 9). Based on this limited study it is difficult to conclude that their health has improved; however, the fact that many villagers now are consuming fresh vegetables regularly, should improve their resistance to micro-nutrient deficiencies in the long run, especially vitamin A and C deficiencies, as the most popular vegetable crops were green leafy vegetables, coriander and tomato, which in most cases were supplemented with other crops that gives a more diverse and healthy diet (see figure 5). This is especially important, because Bhandari and Banjara (2015) identified Nepal in the risk zone for vitamin A deficiency.

The increased intake of a diversity of vegetables is important, because now significantly more of the inhabitants of Humla have fresh vegetables being utilized year-round that supply valuable micronutrients in a traditionally largely grain based diet. Grains are rich in phytate as well. Phytate is an acid that limits absorption of both iron and zinc (Hunt 2003). To reach "*a state of nutritional well-being where all physiological needs are met"* a diverse diet including more vegetables is important for providing valuable micronutrients to strengthen resistance to nutrient deficiencies and meet the physical needs of the human body.

In 2016, greenhouses can be argued to be even more important for households in Humla, because LI-BIRDs informant stated in the interview that up to 90 % of the winter crops have failed in some parts of Humla. Most of this local and nutritious grains will be replaced by less nutrient

rich, white polished rice. If this will be the future trend as well, the greenhouses will be a key-stone for a diverse diet rich in vegetables in Humla. LI-BIRDs informant stated that the Lama people are in general healthier than the Hindu, because they have better food habits and a more varied diet. Hindus in Humla mostly eat white rice now, some local grains and drink black tea with a substantial amount of sugar; while the Lama people eat more vegetables, some white rice, more dairy products, more local grains and drink Tibetan tea - which is made of black tea, milk, salt and butter (this is based on observations and anecdotal data from the interviews). My first key informant also argued in the interview that Lama people have a better and more diverse diet with more animal source foods, while Hindu people in Humla have a simpler, more insufficient diet. If this is correct, it is important to especially make the Hindu communities in Humla consume additional vegetables, so they will have a more varied and healthier diet to shield against micro-nutrient deficiencies.

What was observed in every household meals were served in the field work, was that the preparation of the vegetables was mostly not problematic for utilization. The vegetables would be heated in oil and later water would be added, to keep the pan from overheating. When it comes to vitamin A, D, E and K, they are vitamins that needs oil for optimal nutrient uptake, being fat-soluble vitamins (EUFIC 2010). However, there might be a problem with the duration of heating, because exposure to heat can deteriorate the vitamins in the vegetables for both fat-soluble and especially all the water-soluble B vitamins and for vitamin C (EUFIC 2010). It was observed in the field that in the preparation of most meals, vegetables were prepared under higher temperatures for around half an hour. This was also verified by ADARA Nepal informant, who argued that this is the common practise for most of the vegetable preparation in the whole of Humla and that they had some concerns about this as well.

It is difficult to argue that the people of Humla have gotten a more adequate diet after implementing greenhouses. This is because more white nutrient-poor rice is consumed and less nutrient-rich local grains are consumed, especially in lower Humla. However, if we look at households with greenhouses isolated, it is now the current situation that vegetables are being consumed from the greenhouse throughout the whole year, which led to a more adequate diet for

many households in Humla. It is not possible to say anything about improved health from this limited study directly from the greenhouses, other than that the villagers themselves in Chhipra village and Yalbang village perceived that their health had become better after starting to regularly consume vegetables. This seemed to be both "received wisdom" from the NGOs, because some argued about more technical matters, like more vitamin A in the diet; and actual health improvements, because of a large extent of individual and unique stories about particular health improvements (see chapter 6.9 for a further discussion). Pandey et al. (2016) argues in a meta-study, that evidence linking the agricultural interventions and their impact on the nutritional status is scarce in South Asia, because linking agriculture and nutrition is a difficult and complex matter. At the same time, their findings indicate that home production of nutrient-rich food crops, is central in the process of improving the nutritional outcomes for individuals. The sharp increase of vegetable consumption in Humla, it is - even if it is hard to quantify - expected to improve nutritional outcomes, especially because the diet has been so grain based and malnutrition has been documented to be so severe in Humla (Central Bureau of Statistics, 2006, p. 43 - 54).

7.1.4 Stability – drought resistance and NGO dependency

To be food secure, it has previously been argued in this thesis, that a population, household or individual must have available and be able to access adequate food, and that different shocks and instabilities should not affect food security negatively (FAO 2006). Rainfed and snowfed agriculture is the most prevalent form of agriculture in Humla, and as little as 11% of the agriculture land is irrigated (UNFCO 2013). Years with droughts, will then led to less harvests than years with more precipitation. As argued in chapter 3.4, Humla is now experiencing frequent and severe droughts, and this problem is expected to become more extensive as the climate is warming, and the monsoon patterns in the Himalayas are changing (Eriksson et al., 2009). For both villages in this study, greenhouses have proven to be an exceedingly useful tool for a stable food security. Firstly, the greenhouse is not depending on precipitation alone, because it can be irrigated with a pipe or bucket from a water tap. The field assistant informed, that almost all the villages now have water taps created by the NGOs. This is not without some problems, since

almost all interviewees in this thesis had problems with irrigation (see table 7), although they still manage to keep a high production of vegetables, even under the droughts the last years in Humla. Greenhouses have a higher water use efficiency - as the greenhouse is a controlled environment where moisture stays longer in the soil because the greenhouse reduces evaporation - compared to an open field that is exposed directly to the sun. SHIP Nepal's informant argued that the water use efficiency could be improved if the villagers would be trained in adding straw and leaf on top of the soil in the greenhouse to conserve even more water. In Yalbang village it was observed that one water tap had stopped producing water because of the drought (see picture 3), which can be fatal if a greenhouse depends on it. Secondly, indirectly, the greenhouse can be a source of income to combat other instabilities as FAO (2006) argues that both direct and indirect stability is important. In Chhipra village they used the extra income they earned from selling vegetables on inter alia imported rice, to compensate for the loss of local grains. In Yalbang village, some of the hotel owners with greenhouses could sell vegetables to tourists, to compensate for the lower production of local grain there as well.

While the greenhouse is more stable than rainfed agriculture, there are some challenges still that needs to be addressed in addition to irrigation, to keep a stable production of vegetables in the greenhouse. These factors are increasing insect problems, seed problems, plastic problems, equipment problem, insufficient training and a fall in productivity in the greenhouse (see chapter 6.7). These are all leading to an instable production of vegetables and need to be dealt with to make sure greenhouses will provide a stable nutrient-rich food source (and in some cases an income source) for a future where more severe climate changes in the Himalayas are expected. SHIP Nepal informed that they wanted to hire one expert in each related field, to give advice on how to deal with problems and enhance positive experiences. LI-BIRD wanted to start a coordination community, where the different NGOs can share benefits and challenges with their program, and together help each other towards optimal greenhouse implementation, training and follow-up. These are all important step towards dealing with instabilities and making sure that the villagers will have access to adequate food at all times, both in the long run and in the short run.

Lastly, dependency on NGOs is important to discuss for future stability in Humla, because if there is a large dependency on the NGOs for a stable production of vegetables, then it betrays the principle that sudden shocks should not hinder food security (FAO 1996). If something happens that cuts funding to the NGOs or hinder transportation to Humla of greenhouse material, then new greenhouses would be hard to build and the current ones would face problems with access to new seeds, plastic and equipment. By now there seem to be a strong dependency on the NGOs in Humla as NGOs brings the plastic and equipment to Humla and they provide training in usage of the greenhouse. To run the greenhouse the two things that are needed to grow vegetables are seeds and new plastic if the old one gets broken. On the other hand, it was observed in Chhipra village and Yalbang village that people are starting to acquire seeds themselves now, especially in Yalbang village (see table 11). There was also one interviewee who argued that she had started to sell seeds she had produce herself inside the greenhouse to the market in Simikot, because she argued that they were of such good quality. This is an important indicator for a growing independency from the NGOs. ADARA Nepal was aware of this, and they wanted to make the villagers less dependent in the future, and therefore they had training and coordinators in the villages, to teach the villagers how to use and manage a greenhouse by themselves; however, this was difficult and took a long time, the informant from ADARA Nepal argued. HDI (2014) reports that some successful greenhouse owners they interviewed, now teach others who are starting with a greenhouse themselves, how to successfully run a greenhouse. This is as well an important indicator for a beginning independency from the NGOs in Humla.

This chapter reflects the view of Neufeldt et al. (2003), that adaptations are not only a “win-win” situations. While Humla have managed to increase food security when it comes to vegetable production, there seem at the same time to be increased dependency on the NGOs amongst the villagers in Humla, even if some tendencies of independency were observed.

7.2 Are greenhouses climate-smart?

In this thesis, the definition by FAO (2013, p. 548) was used to define something as climate-smart agriculture: "*Agriculture that sustainably increases productivity, resilience (adaptation), reduces/removes greenhouse gases (mitigation), and enhances the achievement of national food security and development goals*". The discussion of exposure, sensitivity, adaptive capability and vulnerability, will be central topics here.

7.2.1 Exposure – a question of interregional differences

Exposure refers to the degree of exposure to a risk of climate variation, where both intensity and duration of the climate variation determines the risk (FAO, 2013, p. 84 – 92 and 550). NAPA (2010) concluded that Humla is highly exposed to drought, and UNFCO (2013) reports that lower Humla is more exposed to drought then Upper Humla. In my data, all the interviewees stated that warmer temperatures and lower precipitation were occurring the last years in Humla (see table 6). Chhipra village was already exposed to high temperatures and low precipitation, so the frequent droughts the last years had hit Chhipra village hard, as the area within and around the village had become exceedingly dry (see picture 4). Yalbang village was also exposed to lower precipitation, although not as low as Chhipra village and not so exposed to high temperatures, being 1000m above Chhipra village in altitude. As the meteorological data from Humla is missing, the only evidence available was based on villagers own experience, and they experience that temperatures had continually risen the last years, and snow and rain were decreasing, both in frequency and amount, leading to droughts the least years (see chapter 3.4). On the other hand, it seems that the inhabitants of Yalbang village are more exposed to what was experience as stronger winds the last years than Chhipra village was (see table 6). How prevalent this is in other villages in Upper Humla or Lower Humla, is not known. While more research is needed on this for the whole of Humla, it appears - in this limited study - that because drought is the biggest challenge in Humla, that the already warmer Lower Humla is even more exposed to the occurring warming and less snow and rain than Upper Humla. This came forward in the interviews in the fieldwork for this

thesis, in UNFCO (2013), as well as by Himalayan News Service (2016), who reported just days after the fieldwork for this thesis was conducted, that villagers from Maila VDC, Madena VDC, Shreenagar VDC, Kalika VDC and Jayar VDC had to migrate away from their homes because of the food crisis following the heavy drought that had lasted from winter to May 2016. All the VDCs mentioned here are located in Lower Humla. Furthermore, with more heavy rain in shorter periods, flash floods are expected to become more frequent in Humla in the future (see chapter 3.4). Lower Humla seems to be exposed to a larger degree then Upper Humla (UNFCO 2013). Lastly, exposure to heavy snowfall seemed to have gone down in Humla. Onta and Resurreccion (2011) conclude that in Humla, villagers own experience is that snowfall had decreased dramatically in both intensity and frequency during the winter times. Also, one interviewee in this thesis argued that before it used to be 0,9 m of snow in the winters, however in the recent years, there was hardly any snow in the winters. That exposure to heavy snowfall has gone down in Humla is positive for constructions that can be damaged by it, like a greenhouse.

7.2.2 Sensitivity – rate of sensitivity within and between villages

Sensitivity has been defined as the extent to which a system is altered or transformed by disturbances (Adger, 2006). NAPA (2010, p. 9) concludes in their report, that Humla has an overall very low sensitivity to climate change; however, this is only based on protected area coverage, forest area coverage and population density, and this report fails to include the large regional differences in Humla. LAPA concludes differently with a regional study of sensitivity in Humla. Out of 27 VDCs, 15 are rated as highly sensitive or very highly sensitive to climate change, while only two VDCs have low sensitivity to climate change (HTSPE 2012). Here it is important to note that 12 out of the 15 VDCs with high or very high sensitivity to climate change, were located in Lower Humla. As previously argued in chapter 5.1, Chhipra village was experienced as worse-off compared to Yalbang village and more impacted by the drought. Muchu district (where Yalbang village is located) had a medium sensitivity and Chhipra district (where Chhipra village

is located) had a very high sensitivity to climate change according to HTSPE (2012). This corresponds with the data and observations from fieldwork in the two villages, that Chhipra village in general was highly sensitive to droughts, then seems accurate; at the same time as Yalbang village had a more resilient system that was much less sensitive to droughts, because of less exposure to drought and more diverse occupations than in Chhipra village, that did not make the villagers so dependent on agriculture alone as in Chhipra village (see appendix 10.3). Some of the inhabitants in Chhipra village that were interviewed, had as well another job in addition to agriculture, however all except a tailor, one skilled labourer and LI-BIRDs employee in Chhipra village, had a job in a food for work type of program. Thus, Chhipra village seemed to be sensitive to drought to a much higher degree then Yalbang village.

As previously argued, a greenhouse will make a household less sensitive to drought, because of increased availability, access, utilization and stability in terms of food security. Furthermore, because of the water taps now in most villages, still providing irrigation to the greenhouses in times of drought, greenhouses are much more resistant to drought than the mostly rain- and snowfed agricultural land. Greenhouses (as argued for in chapter 7.1.4) are resistant to drought and seem to be able to still produce a large amount of vegetables, even if the area is exposed to heavy drought. The greenhouses have been mentioned as sensitive to heavy snowfall in Humla (Fuller and Zahnd 2012); however, the exposure to this has gone down the last years as the interviews in this thesis and in (Onta and Resureccion 2011) revealed that there is hardly snow anymore in the winter. This makes the greenhouses less sensitive to heavy snowfall, as the exposure has gone down. In Yalbang village there were reports of the greenhouse being exposed to progressively stronger winds (see table 6.7), and that these winds would tear the plastic; however, the extent of this is not known or whether it is a problem for Lower Humla as well.

Following the previous section, it will be argued that a household with a greenhouse will become less sensitive to climate change. Even if Yalbang village has a larger number of greenhouses per household, with a 64 % coverage vs 40 % coverage in Chhipra village, the production in Yalbang village is lower than in Chhipra village with a median of 250kg vs 350kg for Chhipra village. Also, many greenhouse owners in Chhipra village were able to sell vegetables to a market for a large revenue. Thus, in Chhipra village, a few of the villagers are getting to a high degree less

sensitive to climate change, because of a large production of vegetables for consumption and the possibility of high income from sales, while most are getting more sensitive, because of the increased exposure to droughts the last years. A greenhouse also leads to risk spreading, because if the villagers only have their fields and they fail they have nothing, however, if they have other sources of food and possible income, it will limit the strong dependency on rain- and snowfed crops and reduce the sensitivity of the household to droughts. This reflects the view of IUCN (2013), that where social justice is weak, this often creates sensitive groups of people with a high risk of food insecurity. This was evident in the greenhouse implementation in Chhipra village, where all the Brahmins interviewed had implemented a greenhouse and had a great revenue from this, while most other households were suffering immensely from the drought and many were afraid of starvation.

Now, let us examine generalization possibilities. The fact is that 18 % of the population in Humla are of the Buddhist Lama people (UNFCO 2013). This at the same time as over a 1000 greenhouses have been built for Upper Humla, which is mainly inhabited by the Buddhist Lama people (UNFCO 2013). Furthermore, it was reported by LI-BIRD that HDI (both LI-BIRD and SHIP Nepal) have tried to target Dalits, so 20 % of all their greenhouses have been built for Dalits. This is interesting because only 12 % of the Hindus in Humla belongs to the Dalit cast, so they are in fact overrepresented when it comes to greenhouses built in Humla for Hindus (UNFCO 2013). This was not only a positive experience, as a NGO informant argued in the interview that: "*All the help made the Dalit more passive, because they got too much without working for it*". Also, another NGO informant, warned against a stronger passive attitude amongst the Dalits and because of the help, they expected more help and started to take less initiative themselves to change their situation. On the other hand, HDI (2014, p. 1-3) sees how a greenhouse can both benefit the diet of the Dalits and their financial status (if in an area, they can sell the vegetables) and in chapter 7.1.2 it was discussed how there is some trickle-down to the Dalits as well from the greenhouse project. Another vulnerable group in Humla that has been prioritised by HDI, is single women. Here HDI support with 14 000 NPR and they help with construction, tools, plastic and training (own data). There was no data about this in general in Humla, however it seems that two vulnerable groups, Dalits and single women, are being targeted, at least by HDI. Furthermore, there were no data on greenhouses for Chhetris or Brahmins for the whole of Humla. While there

was no strong evidence for Brahmins being overrepresented in adapting a greenhouse in this thesis, there was observed a tendency of this in Chhipra village, where 100 % of the interviewed Brahmins had a greenhouse (own data). It is expected that Brahmins have a larger share of the greenhouses, compared to them only representing 6 % of the Hindus in Humla (UNFCO 2013), however more research is needed on this.

It has been argued that while interventions help with food security in Humla, it does at the same time widen or risk widening the gap between the worse-off and better-off in Humla, giving less to the worse-off and more to the already better-off (Nagoda, 2015, p. 77; Gautam and Andersen 2017). The greenhouses have mostly been built in Upper Humla, and as 12 out of the 15 VDCs with high or very high sensitivity to climate change, were located in Lower Humla (HTSPE 2012); it seems that the less sensitive Lama people in Upper Humla are getting much more from the greenhouse projects, than the more sensitive Hindus in Lower Humla. This is although not necessarily negative, it can be argued that there is a greater need of greenhouses for the Lama people, and as greenhouses have such a large effect on the growing season, and as it's colder in Upper Humla and Lower Humla can grow vegetables outside for a significantly longer period than most of Upper Humla. Although there can be argued to be a great need for Lower Humla as well, as greenhouses were water-efficient and a possible source of improving the financial statues and indirectly provide access to other foodstuff if they could sell the vegetables to a marked when local grain was failing in times of drought (see chapter 7.1.2)

O'Brien et al. (2015) warns against adaptation to climate change without confronting the societal context, because it does not account for the underlying sources of vulnerability that are often determined by social, economic and political relations. They see that too much technical focus has had its negative effects. This seems to be the case with the greenhouse project as well, that to prioritise Dalits and single women in projects are of course good, however it fails to see the frames that created this situation, and will most likely continue to determine the entitlements for the worse-off, no matter if they have been prioritised in one project or not. As well as it can build dependency, as one NGO informant argued had become a common attitude in Humla: "*why work for something, when you can wait for it to be handed to you*". So, while the greenhouse projects are highly beneficial, it does not change the underlying factors for sensitivity in Humla, and in

general helps the most the ones that are already less sensitive to drought and food insecurity in Humla. As Gautam and Andersen (2017) argues with food interventions in Humla; the greenhouse projects might as well be at risk for widening the gap between the less sensitive and most sensitive in Humla, even if some NGOs have targeted the most sensitive groups with some success.

7.2.3 Adaptive capacity – limitations and drivers for adopting a greenhouse

Adaptive capacity is the capability to successfully adapt to a new climate. Adaptive capacity is dependent on socio-economic factors of the inhabitants in the affected area and the areas biophysical factors, as well as knowledge on how to adapt, technology, skills, current infrastructure and the innovations for the adaption itself (Parry et al., 2007, p. 21; Fellmann, 2012, p. 40). It has been said that necessity is the mother of invention. At the same time ADARA Nepal's informant argued that the riskier the environment in Humla, the higher was the demand for a greenhouse. However, on one side, it seems that McKay et al. (2007) is right in arguing that from their experience in Humla: "*People living in environments that are inherently riskier will be less likely to adopt a change than people living in less risky places"*; because the Lama people in Upper Humla that lives in areas less exposed to climate change and especially drought (see chapter 7.2.1), have adopted greenhouses to a much larger degree than the Hindus in Lower-Humla, an area that this thesis argues is inherently riskier and more exposed to climate change than Upper Humla (see chapter 7.2.1).

What was discovered in the interviews, was that the inhabitants without a greenhouse in Chhipra village and Yalbang village all wanted a greenhouse. However, there were strong limiting factors that made it difficult for them to build a greenhouse even if they wanted one. For the limiting factors, there were a few clear trends (see table 3). For social factors, some villagers in both Chhipra village and Yalbang village mentioned lack of manpower as a problem. Some of the villagers without a greenhouse were complaining that the young were leaving to Simikot or to a bigger city outside Humla, in addition to their children often being too busy at school to help the family at home. They already found it hard to manage their fields now with less help, so some villagers

perceived that they did not have enough manpower to implement and run a greenhouse, in addition to other responsibilities. Furthermore, limitations when it came to land and the economic situation, where other social factors that the villagers argued limiting them from building a greenhouse, in both Yalbang village and Chhipra village. That this was as evident in Yalbang village was somewhat surprising as the Lama people are often described as a better-off homogenous group in Humla. Nagoda (2015, p. 38) argues that the Lama people in Humla are not just one homogenous group, because among both the Hindus and the Lama people, there are worse-off and better-off households. This was also the impression in this paper, however, the poor in Chhipra village were experienced to be poorer compared to Yalbang village and a greater number of inhabitants were experienced to be poor in Chhipra village compared to Yalbang village; because, as it came forward in the observations and the interviews, that poorer households in Yalbang village would still have a bigger house, access food and relatives helping them, while in Chhipra village they would live in a very small house that often did not have a bed and they would be afraid of starvation (see chapter 5.1 – 5.2). One explanation for the economic factors in Chhipra village being relatively low for building a greenhouse, could have been that they could acquire a tunnel at a much lower cost than a greenhouse. Some interviewees also argued that it was no problem constructing a greenhouse (see table 5), and this might partly be because of illegal collection of wood. One villager stated: "*Wood is very expensive here, so I collected wood illegally*" (own data). HDI (2014, p. 13) sees this as well, and reports that one person would everyday see young villagers doing illegal collection of wood in the forests, having bribed the forest chairperson, so that they could do it without legal problems. This demonstrates that that some have adapted to the high cost of a greenhouse, with avoiding paying for the full cost of constructing a greenhouse legally. The extent of this is not known and more research on this is needed. In addition to this, another economical factor may be limiting the implementation; LI-BIRD had observed that greenhouse cost was dependent on periphery, so the closer to Simikot, the more expensive it was to build a greenhouse because construction costs became higher. This fit well with the data from this thesis, that a greenhouse in Simikot was approximately 100 000 NPR, in Chhipra village approximately 80 000 NPR and that a greenhouse in Yalbang village was approximately 60 000 NPR (see chapter 6.5). This might as well be a part of why more greenhouses had been built in Yalbang village, a 13 hours' hike from Simikot, compared to Chhipra village, a three hours' hike from Simikot. Lastly, while no inhabitants in Yalbang village argued that they

would have any natural factors limiting the implementation of a greenhouse, the villagers without a greenhouse in Chhipra village would mention natural factor as an important reason for not having a greenhouse, and especially lack of irrigation possibilities was mentioned here and this is directly linked to the land situation of a household, because only the households with land in the village could irrigate their greenhouse; if they had land outside the village, there was no possibility to irrigate the greenhouse and therefore it could not be built there. That the more sensitive Chhipra village is adopting greenhouses to a lesser degree than the less sensitive Yalbang village, reflects the argument of McKay et al. (2007) that: "*people living in environments that are inherently riskier will be less likely to adopt a change than people living in less risky places"*

Now the limitations for acquiring a greenhouse is stated; however, there are also drivers for implementing a greenhouse in Humla. The drivers for innovation seems to be different in the two villages. If we look at table 5, most greenhouse owners in Chhipra village decided themselves to acquire a greenhouse, while for almost all the greenhouse owners in Yalbang village, this was a cooperation between them and the NGO. LI-BIRD told in the interview, that their method is to first establish a few pilot greenhouses. This fits good in Chhipra village where the oldest greenhouses were decided almost exclusively by LI-BIRD to build and the younger greenhouses to a much larger degree by themselves (see chapter 6.5). The villagers would later see the benefits from the pilot greenhouses and then started to demand greenhouses themselves. In Yalbang village, ADARA Nepal informed that they had another model. They would gather everyone in the village for a meeting annually and then inform them about the benefits of a greenhouse and how to invest. This likely explains why so many in Yalbang village experienced the decision to be a cooperation between them and ADARA Nepal.

The question now is whether the greater adaptive capacity of Yalbang village (64% greenhouse coverage) vs Chhipra village (40% greenhouse coverage) is dependent on different NGO practises or limiting social, economic or/and natural factors. In this thesis, it will be argued that more limiting factors are the reasons for a higher adaptive capacity for implementing greenhouses in Chhipra village and not the NGO practise, because if you have not enough manpower for running a greenhouse, no access to land or land without irrigation possibilities and/or no financial surplus to invest; then the practise of the NGO matters only to a very limited degree.

Then there is a question of generalization possibilities. It has been argued that agriculturalists are inherently conservative (McKay et al. 2007). It was also being argued in an interview with a NGO, that Hindus are more conservative and more reluctant to innovate, than the Lama people in Humla. World Bank (2006, p. viii and ix) argues furthermore that attitudes and practises are a major obstacle for innovation. In this thesis, it was found that in the first phase of greenhouse implementation in Humla, it was the NGOs that was the drivers in both the Buddhist and Hindu villages. This was observed by ADARA Nepal`s informant, who stated: "*It was hard in the beginning of the project, then people would see the importance of a greenhouse*"; as well as my first key informant (who used to work from HDI) who stated: "*It was difficult to implement greenhouses in the start, however after the villagers could see vegetables being grown in winter time, all wanted one*". All the NGOs interviewed had the same experience. Thus, it looks like there has been a shift from the NGOs trying to advocate this for the villagers, who seemed to have a reluctance in their attitude towards an innovation like a greenhouse in the beginning, to the villagers themselves wanting and pushing for more greenhouses when they could see the benefits of the investment. This was experienced in the interviews from this thesis, where all who did not have a greenhouse wanted one and that almost all who already had a greenhouse, wanted another (see table 3 and 4). Fuller and Zahnd (2012) found the same to be the case in one village in Humla, where enthusiasm was low in the beginning; however, after successfully growing vegetables in the winter, enthusiasm rose and the number of greenhouses shortly increased by 400 %. This reflects the point of Smit and Wandel (2006), who argued that climate change is not the single reason for adaptation in most cases, and especially not when it is only important for decision makers. This was also argued by my first key informant, that especially when the villagers saw they could make money from a greenhouse, the interest grew rapidly. Furthermore, this was experienced in Humla by NGOs as well. They were finding it difficult to implement greenhouses amongst the villagers in the beginning, because the villagers could not see and experience the benefits of such a large investment at that time; however, when the villagers could experience how greenhouses would benefit them as well, then it also became something they sought after and demand sharply rose from the villager's side. The drivers for innovation are thus shown to be similar for Lama villages and Hindu villages and a more inherent reluctant attitude amongst the Hindu people was not found in in this thesis. However, the limitations are not similar, and Lower

Humla are more sensitive to especially drought. Hindu people are less likely to adopt to greenhouses because in addition to possible social and economic limitations, they are also strongly limited by natural factors in Lower Humla. Sanders (2010) is therefore not correct in her conclusion, that the better-off people are in Humla, the bigger their chance is to be *open* to new innovations. After villagers in Humla could see the positive effects, most likely all the inhabitants are open to the innovation, however limiting social, financial and/or natural factors determines who will be able to adopt a greenhouse and who will not.

Furthermore, it has been argued that networking and communication is central for successfully implementing new innovations (World Bank, 2006, p. viii and ix). Rogers (1995, p. 286 - 288) argues that in a homophilous system, better networking occur because people are to a larger degree similar, and this enhances communication amongst the people in that system. Furthermore, Rogers (1995, p. 286 - 288) argues that inside a heterophilous system, there are more isolated social groups, so networking and communication is more difficult, than in a homophilous system. This might be important for innovation in Humla as well, because we have argued that Hindu villages are more strongly heterophilous systems in Humla and Lama villages are more Homophilous systems in general, although worse-off and better-off households exists here as well. ADARA Nepal's approach to introduce greenhouses in Upper Humla and SHIP Nepal and LI-BIRDs approach in mainly lower Humla, seems to fit with Rogers. ADARA Nepal's approach was meetings with the whole village, where opinion leaders could be convinced that greenhouses would fit with pre-existing norms, and this did not only work in Yalbang village, thus most likely in most of Upper Humla, because if we look at the data, ADARA Nepal have implemented themselves over a 1000 greenhouses in Upper Humla in a few years. At the same time, LI-BIRD's and SHIP Nepal's approach in mainly Lower Humla, fits well with Rogers heterophilous system, as Hindu villages are argued to be strongly heterophilous in Humla. The elite (upper castes) first get access to the greenhouses, because as Rogers (1995, p. 128) argues: "*Development agencies tend to provide assistance especially to their innovative, wealthy, educated, and information-seeking clients*". As those households successfully implement it, others will follow their example; and as seen in table 3, everybody wants a greenhouse in Chhipra village. Sanders (2010) on the other hand, saw that NGOs failed to implement greenhouses in non-homogenous locations in Humla, because the implementation plan was based on similarity in the area and not the divergent need

and situation of each household, and this is a valid argument. It might be especially important because ADARA Nepal's informant argued that the riskier the environment is in Humla, the higher was the demand for a greenhouse. In this thesis, there was shown a clear difference between wanting to adapt an innovation and being able to do it, because of limiting factors. It seems then that the NGOs fails to see the different needs and situation of each household; based on individual social, economic and natural limiting factors, that still limits many from adapting, even if they *want* to imitate the ones who have adopted. This results in that the better-off ends up with more means than before, while many others cannot follow, because their individual limitations will vary strongly. As by now, the greenhouse model of implementation seems to be based mostly on a similarity that does not exist in Humla as Sanders (2010) almost rightfully argues; because, in this thesis it will be argued that this is more the case specifically for Lower Humla, and to a lesser degree in Upper Humla, which has a more heterophilous system, with less limiting factors for implementation.

The drivers and limitations are important to continuously study and identify, because challenges are evolutionary, continuous, always changing (World Bank, 2006, p. viii and ix). This seems to be done in Humla as all the NGOs stated that they are doing research and continually evaluating and improving their greenhouse project (own data). On the other hand, it seems that World Banks innovative systems fails to encompass that such an important component as natural factors can be a large part of drivers and limitations for innovation, as observed in Humla. Aase et al. (2013) argue that natural factors are needed in the framework for researching innovation in agriculture, and this is highly relevant in this study. If drought, land, insects, natural resources, snow, water and wind would not be included in this analysis together with social and economic factors, then it would not have been possible to fully comprehend the different factors at play when answering the research questions in this thesis. Criticism should then be made towards innovative systems as a fully covering theoretical framework for innovation in agriculture, when they fail to include natural factors, which are an important factor for innovation in agriculture, both for drivers and limitations for innovation and implementation, at least for greenhouses in Humla.

7.2.4 Vulnerability and further discussions on greenhouses as climate-smart

Exposure, sensitivity and adaptive capacities together determines if an area is vulnerable to risk, however not as independent factors, thus as interdependent factors where all are linked and changing related to each other (Smit and Wandel 2006). In this thesis, I have argued that Chhipra village in Lower Humla is more exposed to drought than Yalbang village in Upper Humla, and this seems to be the general trend between Lower Humla and Upper Humla. Furthermore, because of a higher level of poverty and fewer greenhouses in Chhipra village, than in Yalbang village, they also seem to be more sensitive to the exposure of more droughts in Chhipra village, and this as well seems to be the general trend in Lower Humla compared to Upper Humla, because of better-off Lama people with more greenhouses in the Upper Humla and the in general worse-off Hindu people in Lower Humla with fewer greenhouses. It was argued that the adaptive capacity of Chhipra village was lower than in Yalbang village for adapting greenhouses, because of general stronger natural, social and economic limitations in Chhipra village; however, this is hard to generalise for the whole of Humla, because of larger differences in social, economic and natural factors on the village level, although the fact that many more greenhouses have been built in Upper Humla is an indicator that the adaptive capacity is bigger in Upper Humla, compared to Lower Humla for greenhouses. Furthermore, it seems like O'Brien et al. (2015) are right in that underlying sources of vulnerability are often determined by social and economic factors, and this have been argued in this thesis to limit adaptive capacity in Humla. At the same time as Aase, et al. (2012) are right in arguing that these vulnerabilities can be determined by natural factors as well. The degree of influence will vary from village to village in Humla, as was seen between Yalbang village and Chhipra village, and further recommendations is to include a framework of both social, economic and natural methods of approach to determine limitations and drivers for adaptive capacity. This is important, because Smit and Wandel (2006) argues that adaptation is the expression of adaptive capacity. In Humla both natural, economic and social factors come in to expression when greenhouses are being implemented and these factors are needed in the framework for successful adaptation for all groups in Humla.

Neufeld et al. (2003) argues that for something to be called climate-smart it must have as well a measurable positive effect both in the long and short run; the aspects of vulnerability and its sub-

categories are not enough. In this paper, it is being argued that greenhouses have a measurable positive effect on food security, both in the long run and short run in Humla. In the short run by the directly affect of producing more vegetables and indirectly - for the households close to a market or to the tourist route to Mt Kailash - by providing money from sales that can be used to buy foodstuff, kitchenware, household articles etc. In the long run, it will provide a more sufficient diet, that will combat micronutrient-related diseases and it will make the population of Humla become less sensitive to future climate change, with greenhouses being able to produce a large quantity of food even during droughts and greenhouses can stand against climate changes in the future. Lipper et al. (2014) argue that to be able to call something climate-smart, it should also increase adaptation or/and build resilience to climate change from the farm to the national level. In fact, the first key informant argues that now, there are greenhouse projects going on in Dolpa region and Khumbu region as well. Fuller and Zahnd (2012) reports as well about a greenhouse project in Jumla region, as well as Dolma (2016) reports of greenhouse projects in Mustang district, Baglung district and Langtang district. Greenhouses was in the Himalaya originally projects that was started in Tibet, China and Ladakh, India and now it seems to spread over most of the mountainous regions in Nepal. Greenhous projects like this, thus seem to have a high degree of transferability and seems to have the potential to quickly reduce vulnerability from the farm to the national level in Nepal.

This thesis argues that IUCN (2013) are correct in that both technical, social, economic and natural factors are important when considering policies for food security. The greenhouses in Humla are an exceedingly useful technical climate-smart solution for fighting vulnerability through increased food security and reducing sensitivity to climatic risks; however, the local social, economic and natural contexts must be included to optimise the adaptation of the projects and to counter the fact that the less vulnerable are the ones that continue to get the most and that the more vulnerable are the ones that continue to get the least from outside interventions.

7.3 Gender perspectives – a blessing and a burden

Nagoda (2015, p. 10 (paper 2)) argues that marginalisation of women is important to explain food insecurity and vulnerability in Humla. This is because women, amongst others, have a limited access to agricultural resources, land and networks and in local decision-making processes. Both in Chhipra village and in Yalbang village, the women worked more in the greenhouse than the men (see figure 6). Subedi and Shrestha (2016) reports that women farmers in Humla are more involved in vegetable production than men as well. A trend of a general large female workload was observed in Humla by Sigrid Nagoda, and she argues that: "*Women tend also to be overloaded by work, and when the men migrate during winter or engage in trade, women typically stay in the village taking care of the children, livestock and lands*" (Nagoda 2015, p. 11 (Paper 2)). From the fieldwork for this thesis, women were always observed caring water or fuelwood, cleaning, taking care of children, preparing or serving food or working in the greenhouse or garden with vegetables. The work in the greenhouse is hard and difficult work for the women, and especially carrying water to the greenhouse was perceived as hard work in the interviews for the ones who had not gotten a pipe. HDI (2014, p. 7) experienced, that to get good results in Humla, the greenhouses need a high amount of work and time to be successful. It thus seems like the already overburdened women are getting a larger workload with the greenhouses. This is interesting because of the 18 greenhouses that was not decided exclusively by the NGOs to implement; 68 % was implemented by a man in the family, 5 % by a woman and 28 % by both (see chapter 7.5). In most cases the men makes the decision to implement a greenhouse and the women are the ones that do most of the work when it is implemented.

On the other hand, the greenhouses seem to affect positively the financial status of women, if they are able to use the greenhouse for commercial reasons. One woman informed in an interview, that she now earns 80 – 90 000 NPR annually from vegetable sales, which has greatly improved her economic status and made her no more financially dependent on a man. In Yalbang village, another woman interviewed was positive to the fact that she was able to sell vegetables to tourist, because of the financial surplus it would bring her. Subedi and Shrestha (2016) and HDI (2014) tells other successful stories from women in Humla. Some of these women have been able

to open bank accounts, because they earned such a large revenue from the sales and to send their children to school. This financial empowerment seemed to be interlinked with women groups in Humla, the field assistant informed. These groups in Humla have been teaching and empowering women to combat social, economic and cultural discriminatory behaviours and give them literacy and vocational training and given them access to credit funds, which will improve income and employment opportunities for women involved in these projects (Mission Øst, undated). With the greenhouses, some women get income to improve their economic status (own data) (HDI 2014). How great the magnitude is for improving the economic status of women is however still unknown in Humla, and more research on this is needed.

8 Conclusion

Greenhouses in Humla seems to be highly important for food security, especially because they are providing a more adequate diet, that includes more vegetables for a larger part of the year. It is now estimated that a minimum of 1550 greenhouses have been built in Humla, where a minimum of 1000 of these have been built in Upper Humla. The greenhouses produced approximately 250kg vegetables annually, with this number being higher in Lower Humla and lower in Upper Humla. It also creates a longer growing season for vegetables, especially for areas in Upper Humla. Indirectly, the greenhouses have given the opportunity for villagers close to a market or on the trekking route to Mt. Kailash, to sell their products and buy foodstuff, which indirectly increases food security, especially because it helps protect against malnutrition and hunger in times of drought. Previously, in Hindu communities, women seemed to have had less access to vegetables, because of local practises and believes, however this seems now to fall away with the help of NGOs in Humla.

Even if greenhouses have positively influenced food security in Humla, there was found many challenges and limitations for an optimal production. First, measures must be taken to make the greenhouse model as inexpensive as possible, to include the largest range of possible adaptors to

the greenhouse project. Second, the villagers perceived irrigation problems and insects, to be the most dominant challenge for optimal production, so these fields can be argued should be given the most attention for future improvements. Training of the villagers, equipment maintenance, seed quality, cultivation practise, maintenance of soil fertility and wind destroying the plastic of the greenhouse, is challenges that needs attention as well; however, non-germinating seeds and strong winds destroying the plastic, seems to be more local challenges for certain areas in Humla, and more research is needed to be able to evaluate the magnitude and prevalence of these challenges. To deal with these problems are important for the optimization and stability of the vegetable production in Humla.

It was furthermore found that the greenhouses were an expensive innovation and that the villagers could not "just use local materials". Stone and wood to be shaped and transported, as well as hired labour was necessarily for excavation and masonry. The total price seems to vary from approximately 60 000 – 100 000 NPR for a normal greenhouse, depending on the periphery. The closer to the district headquarters, it seems the higher the cost. Tunnels seems to be a promising solution for the high cost in Lower Humla, as the temperatures are higher here.

Greenhouses are arguably climate-smart in Humla, because they are highly important in making the villages less sensitive to climate change, especially when it comes to the exposure to drought. Because of large inter-regional differences, the magnitude and extent of this varies highly in Humla, thus in Upper Humla greenhouses seems most important to prolong the growing season and making fresh vegetables accessible for a significantly longer period of the year and for Lower Humla, greenhouses seems to be more important to counter droughts, with being water effective and at the same time enhance food security indirect when local crops fail.

For adaptive capacity, there was found no difference in the Lama- and Hindu population regarding their attitudes towards acquiring a greenhouse. However, three limiting factors for implementing greenhouses were identified: natural factors, social factors and economic factors. The Lama people had an easier access to greenhouses than Hindus, because of less limiting factors and that is highly influential in why more greenhouses have been built in Upper Humla

than in Lower Humla. While natural, economic and social factors are limiting the access for some worse-off Lama people as well, the Hindus seems in general to be worse-off by all these factors. The reason for the uneven distribution, is that the NGOs have not adequately taken in to consideration the different social, natural and economic factors, and this cannot be excluded if the worse-off should be included on the same level as the better-off in this project. If the projects continuous without these aspects in mind, then it risks to further enhance the difference between the better-off and the worse-off in Humla. However, there was found one exceptions to this, as HDI had successfully targeted Dalits in Lower Humla.

The drivers for greenhouses in Humla were both NGOs and the villagers. In the beginning, it was mainly driven by the NGOs and they had to work hard to get the villagers to see the benefits a greenhouse would bring and for them to implement one. After the villagers, could see the benefits, this changed, and in 2016 the demand by the villagers was so large, that the NGOs had problems meeting the large demand.

The greenhouses seem to be mainly operated by women in Humla, and it will be argued to both benefit women and to make women life's harder. To be able to make a greenhouse run successfully with a high production, it demands a high amount of work and women are already in general exposed to a very high workload in Humla. On the other hand, if it is a possibility to sell some of the vegetables, this seems to empower women and boost their economic status.

While a substantial number of farmers take up greenhouses, especially in Upper Humla; the better-off are the ones that continue to get the most out of NGO interventions in Humla, also when it comes to greenhouses; however, some trickle-down effects due to increased availability of vegetables gives greater surplus locally.

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10 Appendix

10.1 Implementation date compared to who decided to implement the greenhouse for each year

Implimentation date	Decided the implimenta-tion	Chhipra village	Yalbang village
1 year ago	NGO		
	Self	3	
	Both NGO and themself	1	
2 year ago	NGO	1	
	Self	1	
	Both NGO and themself	1	
3 year ago	NGO	2	
	Self		
	Both NGO and themself		4
4 year ago	NGO		1
	Self		
	Both NGO and themself		3
5 year ago	NGO		1
	Self		
	Both NGO and themself		3
6 year ago	NGO		
	Self		
	Both NGO and themself		1
7 year ago	NGO		
	Self		1
	Both NGO and themself		

10.2 The decision maker for the greenhouse implementation

Decided the implementation of the greenhouse	Chhipra village	Yalbang village
Man	5	7
Woman	1	
Both		5

10.3 The occupation of the interviewees

Occupation	Chhipra village	Yalbang village
Agriculture and/or livestock	11	8
Job	1	0
Both	4	9

10.4 The semi-structured survey used on the household level

Question 1

How long is the growing season for this village, inside and outside the greenhouse?

Question 2

What is your occupation?

Question 3

What have changed the most the last 10 years in Humla?

Question 4 (If they have a greenhouse)

When did you get the greenhouse?

Question 5 (If they have a greenhouse)

Was the construction process easy or difficult?

Question 6 (If they have a greenhouse)

Did you buy the plastic or did you get it subsidised?

Question 7

Which crops do you produce inside the greenhouse?

Question 8 (If they have a greenhouse)

How much do you produce annually in the greenhouse?

Question 9 (If they have a greenhouse)

How do you get access to seeds?

Question 10 (If they have a greenhouse)

Do you want one more greenhouse?

Question 11 (if yes or no on question 10)

Why?

Question 12 (If they have a greenhouse)

Do you use the vegetables produces for own consumption or other things?

Question 13 (If they have a greenhouse)

What are the benefits with the greenhouse?

Question 14 (If they have a greenhouse)

Do you consume more vegetables now?

Question 15 (If they have a greenhouse)

Has the greenhouse impacted your health?

Question 16 (If they have a greenhouse)

Do you have any challenges with the greenhouse?

Question 17 (if they don't have a greenhouse)

Do you want a greenhouse?

Question 18 (if yes on question 17)

Why?

Question 19 (if no on question 17)

Why?

Question 20 (If they don't have a greenhouse)

What are the limiting factors for acquiring a greenhouse?

Question 21 (if they have a greenhouse that is not in use anymore)

Why is the greenhouse not in use anymore?

Question 22

Do or did you have any contact with a NGO?

Question 23 (if they have a greenhouse)

How did or do the NGO support you with the greenhouse?

Question 24 (if they have a greenhouse)

Who decided to implement the greenhouse?

Question 25 (if they have a greenhouse)

Is the workload in the greenhouse equal?

Question 26

Is there something more you like to add that is relevant to what we have been talking about?