ADOPTION OF SOIL AND WATER CONSERVATION PRACTICES IN RURAL AGRICULTURE, MUNICIPALITY DARÍO, NICARAGUA

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FOREWORD

As finalization of my studies in environmental management at Hogeschool Gent, I had the opportunity to complete an internship abroad. The organization of my choosing to complete this traineeship with was El Porvenir, an NGO that strives to better the lives of rural Nicaraguans through education, sanitation, providing of clean water and reforestation projects. My work with the organization has mostly been with the reforestation department. The internship stretched from the 5th of March until the 25th of May. Most of this time I've been collecting data for my final report. The goal of the report is to provide more information about the current use of conservation agriculture by the rural population of the municipality of Darío. The run-up to this report has at times been challenging. A large part of communities are very hard to reach which made this at days exhausting and sometimes even impossible. The country of Nicaragua also knew an uprising against the forces currently in power in the period I gathered data for this study. This was very interesting to experience from close by but at times has been shocking and made the work I did here not all that easier.
I would like to thank the entire staff of El Porvenir Managua, Ciudad Darío & Terrabona for their help and kindness. I would also like to thank Wendy in particular, for her help and guidance in a country and language that had for a large part been unknown to me.
Abstract

In this study, we want to get a deeper insight in the rate of development and use of conservation practices in rural agriculture in the municipality of Darío, Nicaragua. The rapport is aimed at providing the reader with a better understanding of the region and its problems and to show at where the rural population could still use help in their progress to a sustainable form of agriculture and the soil and water conservation practices that come with it. As a base for this rapport we made use of field observations, a household survey as well as in-depth interviews with key-figures in the region. We found that although the rural population is making efforts towards soil and water conservation, they could still use a helping and guiding hand in the process. They mostly lack the funds and/or means to make great strides of improvement and lack specific knowledge considering conservation. To improve this situation, efforts could be made to improve education about climate, water and soil. The region would also benefit from larger water projects which could be facilitated by international organisations willing to jump in and assist.
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1 | INTRODUCTION

The Municipality of Darío counts 50,000 inhabitants. About 40,000 of these live in rural areas with no access to the water- or sewage grid and no prospects of change in this situation in the near future (Siasar, 2018). Due to severe droughts, poverty and a low grade of schooling, quality of life for these inhabitants has not seen any significant improvement in the last 30 years. The Municipality is located in central Nicaragua in a region that is called “El Corredor Seco”, or “The Dry Corridor”. A name chosen adequately for the increasingly arid dry-seasons the region gets to endure.

In this region, we will examine through in-depth interviews, household surveys and field research, the origin of the stressing factors on the local agriculture and the attitude and adoption rate of the local population considering soil- and water conservation techniques in rural agriculture. Rural agriculture is with its 500 million small-scale farms worldwide by far the most established type of organisation in the world (Meyer, 2010) and as such should not be overlooked. This study is executed under supervision of the Non-Governmental Organisation “El Porvenir”, which focuses its efforts on water, sanitation, reforestation and education practices. It will contribute to their future projects by supplying information about the region and the current state of conservation practices. With this information, it will be easier for the organisation to imply future strategies and as such contribute to a more efficient conservation approach.
Chapter 1: | Introduction

As Bill Gates said it best: “Helping small, poor farmers achieve better yields for their own consumption and to sell at local markets is the most powerful way of combating hunger and poverty around the world.”

1.1 Conservation agriculture

Conservation agriculture is a sustainable approach of doing agriculture, specifically among small-scale farms. It’s based on three principal factors which have similarities with permaculture principles as well. The first principle is a minimum mechanical disturbance of the soil, keeping the soil life intact. This can be achieved by very low tillage or zero tillage. Secondly it entails the placement of mulch on the soil when the field is not in use, in permaculture this differs slightly, promoting mulching at all times (Mollison, B. 1990). The last important factor is crop rotation, to balance high-demand crops with lower demand crops to give the soil time to regenerate (Dyck B. and Silvestre S. B., 2018). This principle is of conservation agriculture is very important as it is shown to double productivity and at the same time reducing financial input, whilst also being less demanding to soils (Pretty, Toulmin & William, 2011).
2 | GEOGRAPHICAL CONTEXT

2.1 Climate

The country of Nicaragua is situated on the North-American continent, more specifically the Central-American region. Situated several hundred kilometres north of the equator, Nicaragua is divided into three different climate types following the Köppen-Geiger Climate Classification System. It is also influenced by global weather phenomena as ENSO.

2.1.1 Climate type

The Pacific and Caribbean coasts are both dominated by Equatorial climate which boasts tropical rainforests and is characterized by a less pronounced wet- and dry-season (Peel, Finlayson, and McMahon, 2007).

More central the climate is evenly divided in between Tropical savanna at the western side of the country and Monsoon climate in the eastern half, as shown in

Figure 1. Climate map of Nicaragua (Peel, Finlayson, and McMahon, 2007)
Tropical savanna climates have monthly mean temperatures above 18 °C in every month of the year and typically a pronounced dry season, with the driest month having precipitation less than 60 mm and also less than \( \frac{\text{total annual precipitation} \times \text{mm}}{25} \) of precipitation (McKnight & Hess, 2000). It is in this climate type the municipality of Darío is situated. The dry season typically begins at the end of November and lasts until May, when the wet-season sets in. During dry-season rain is very rare with some very strong downpours as exception. The rains during the wet season begin to arrive in the course of the month of May and build up in frequency and amount of precipitation nearing October, which is the month that typically boasts the highest precipitation rates. From August until the end of September the Caribbean knows its hurricane season which, on occasion, influences the weather in Nicaragua as well.
2.1.2 El Corredor Seco

“El Corredor Seco” is a region that is shared with other countries in Central America and stretches from the southern tip of Mexico to Costa Rica. The region earned its name to returning periods of severe droughts which pose a demanding toll on those inhabiting it. The corridor has a history of scarcity and difficult conditions with already many undertaken aid-projects by various organisations such as Wateraid to try to remediate the consequences of the long periods without precipitation. In years where the El Niño weather phenomena returns the conditions worsen even more. As the dry season progresses water supplies start to become scarcer and wells slowly get used up. In Nicaragua, the people living in the rural parts of the region count about 300,000, that’s roughly 5% of the population (INETER, 2018). They depend on agriculture for most of their income and since agriculture in this area is entirely rain-fed this makes them extremely vulnerable. Water supplies are available through efforts of NGO’s in the region but are often not sufficient, as the sustainability of water services in rural areas is influenced by 157 different factors, ranging from government to water system functionality (Walters and Javernick-Will, 2015). Making access to sufficient water “an effort” at best. The map on the right illustrates which area of Nicaragua finds itself in this “Corredor Seco” region. The regions coloured in red are at the highest risk of droughts.
2.1.3 El Niño Southern Oscillation (ENSO)

ENSO is a climate phenomenon which has the ability to change global atmospheric circulation and by doing so influences precipitation and temperature worldwide. As such it is one of the most important climate phenomena on Earth, L’Heureux explains the working of this event perfectly.

Though ENSO is a single climate phenomenon, it has three states, or phases, it can be in. The two opposite phases, “El Niño” and “La Niña,” require certain changes in both the ocean and the atmosphere because ENSO is a coupled climate phenomenon. “Neutral” is in the middle of the continuum.

El Niño: A warming of the ocean surface, or above-average sea surface temperatures (SST), in the central and eastern tropical Pacific Ocean. Over Indonesia, rainfall tends to become reduced while rainfall increases over the tropical Pacific Ocean. The low-level surface winds, which normally blow from east to west along the equator (“easterly winds”), instead weaken or, in some cases, start blowing the other direction (from west to east or “westerly winds”).

La Niña: A cooling of the ocean surface, or below-average sea surface temperatures (SST), in the central and eastern tropical Pacific Ocean. Over Indonesia, rainfall tends to increase while rainfall decreases over the central tropical Pacific Ocean. The normal easterly winds along the equator become even stronger.

Neutral: Neither El Niño or La Niña. Often tropical Pacific SSTs are generally close to average. However, there are some instances when the ocean can look like it is in an El Niño or La Niña state, but the atmosphere is not playing along (or vice versa) (L’Heureux, 2014).
As shown in the image the El Niño-state of the ENSO climate phenomenon impacts a large part of Central-America and the whole of Nicaragua, in “El Corredor Seco”, where precipitation is already scarcer than in other parts of the country, the effect is more pronounced. In reality, this means that the dry season that generally stretches until May immediately gets followed by lowered precipitation caused by the El Niño phenomenon, further stressing agriculture and causing water shortages, especially in rural regions (Metoffice, 2016).

2.1.4 Future predictions

Climate change worldwide affects Nicaragua significantly as well, prediction models show that by 2030 the mean temperature in Nicaragua’s Corredor Seco region could already rise by as much as 1.4 degrees Celsius, as shown in figure 4. In a region that is already under an enormous amount of pressure regarding temperature and droughts, this increase is immense. Annual precipitation might decline by another 51mm, increasing the already apparent risk of water shortages. Add to this regional deforestation and unsustainable agriculture practices and it
becomes clear the projections are just a modest estimation (CIAT, 2015).

2.2 Geography

2.2.1 Land use

Nicaragua’s land is used for a large part as agriculture. According to a rapport by the World Bank the exact numbers are the following:

Nicaragua’s total agricultural area is estimated at approximately 6 million hectares, or 45% of the country’s total land surface. The majority of agricultural land (54%) is dedicated to grazing areas for dual-purpose cattle, followed distantly by maize (4.5%) and beans (3.4%). Another 40% of Nicaragua’s total land area is dedicated to cropland and pastures. While 27.5% of the country is covered by forests, deforestation rates are around 70,000 ha/year, which, added to natural and anthropogenic degradation, constitutes a serious threat to forest ecosystems. Nicaragua has the second highest rate of deforestation in Central America after Honduras (120,000 ha/year). The main factors that contribute to forest land change are: farmer migration; resettlement of people displaced by war; policies and development programs that prioritize basic grains; and extensive livestock systems. Protected areas account for National context: Key facts on agriculture and climate change approximately 2 million hectares, of which 50% is devoid of forests and threatened by the expansion of the agricultural frontier. Land and income distribution, particularly in the agricultural sector, is very unequal in Nicaragua: in 2009, the Gini index was 45.7. More than half of the country’s farmers (55%) cultivate on less than 7 hectares of land, and yet they own just 5.6% of the country’s total farmland. Small-scale farmers owning less than 1.75 hectares make up approximately 33% of all farmers, while subsistence farmers with 0.7 hectares or less account for 18.5%. The disparity between small- and large-scale farming operations largely accounts for discrepancies between, on the one hand, the high commercial importance, and on the other hand, the low productivity of the agricultural sector (World Bank, 2015). The map in appendix C shows the land use in the region of Darío Municipality. Illustrating that a large part of the land is used for agriculture. It’s
worthy to note that field observations have showed that the areas marked on this map as forest mostly have been converted to pasture lands for cattle. Very little true forest remains.

2.2.2 Soil profile

Central Nicaragua is dominated by Andosol and Cambisol soils. The region of Darío Municipality is home to soils that range from 88 to 100% Ando- & Cambisol. Both of these soils are well suited for agricultural use and as such are intensively used for this purpose around the globe.

2.2.2.1 Andosol

The name Andosol is derived from the Japanese words “an”, black and “do” meaning soil. According to the European Soil Data Center (ESDAC) they’re defined as follows:

Andosols develop from materials rich in volcanic glass, such as ash, pumice or cinder. The weathering of the glass produces specific clay minerals, called allophanes and imogolites. In more humid or more acid conditions, large amounts of organic substances can accumulate to build up compounds with the aluminium released by weathering. Andosols have a very low bulk density and a high plant-water and phosphate retention capacity. Although Andosols can be among the most productive soils on our planet, many of them need phosphate fertilisation (ESDAC, 2012).
2.2.2.2 Cambisol

Cambisol’s name is rooted in Spanish, where the word “cambiar” means to change. The ESDAC describes this type of soil as follows:

Cambisols encompass a broad variety of soils. They show at least some soil genesis in a subsurface horizon (formation of soil structure and of some oxides or clay minerals). However, they lack the horizons that are typical for advanced soil formation such as the redeposition of clay, organic matter or oxides. Cambisols cover large surfaces across a broad range of landscapes (level ground to mountainous terrain), climates and vegetation types. Depending on organic matter content and pH, many of them can be fertile (ESDAC, 2012).

2.2.3 Erosion & soil degradation

Soil degradation is best defined as an unwanted reduction in the land’s actual or potential use (Blaikie and Brookfield, 1987). Many agricultural practices contribute to this degradation, exposing soil to erosion by wind and water by tilling repeatedly, weakening soil structure. As such crop productivity is reduced and nutrients are being removed (Lutz E, Pagiola S. and Reiche C., 1994). Erosion is one of the key contributors to the loss of productivity of Nicaragua’s soils. One of the culprits is deforestation. Deforestation rate, at about 70.000 ha/year is among the highest in Central America, second only to Honduras where forests disappear at the rate of 120.000 ha yearly (World bank, 2015). Leaving the soil exposed it is even more vulnerable for the other major contributor to the erosion of Nicaragua’s soils, heavy rainfalls in the wet-season. Due to the poor soil structure, badly engineered roads and steep slopes, the country’s soils disappear through its rivers in as well the Pacific-
as Atlantic Ocean at an astonishing speed. Further conflicting damage not only to farmers losing the best of their topsoil’s but also to marine life at the mound of the rivers transporting the runoff. The map reveals how central Nicaragua consists of hills and slopes and flattens towards the coasts. This profile supports soil erosion on a larger scale. On a smaller scale, the hills in the municipality of Darío facilitate soil erosion through runoff from heavy rain showers. Although farmers try to mitigate this with small efforts, the impact is still devastating and further worsened by other factors that come in to play such as bad road designs and deforestation.
Rural agriculture in Nicaragua has mostly been passed on from generation to generation. For the population in rural areas this is the main source of income and often the only significant one. Innovations in rural agriculture have often been limited by poverty and limited education available. This poverty is often strongly correlated with the degree of rurality of a community, it is this availability (or lack thereof) of financial, human and technical resources that influences the development of conservation efforts (Larson. M.A., 2002). NGO’s have undertaken efforts to assist farmers with improving their conservational efforts in the last 40 years but not always with equal success. This is because many of the conservation programs designed to address the problems have fallen short of expectations and/or often farmers have not adopted the recommended conservation practices or have abandoned them once the project ended (Lutz E, Pagiola S. and Reiche C., 1994). Motivations are often economically oriented on individual as communal level ecological awareness is perceived rather low. So are municipalities who carry the responsibility over forest management often reticent to take these up and are their primary actions and interventions often economically motivated (Larson M. A., 2002). Another influential factor is the revolution the country has known throughout the eighties. This revolution brought with it the seizure of large amounts of agricultural land and redistributing it to members of the reigning party, poisoning relations between farmers and making the sharing of knowledge and cooperation almost inexistent.
This quarrel between both parties dragged on into the nineties and made for some unusual and often contradictory initiatives. Adding more difficulties to a proper and streamlined soil and water conservation policy that had already been meagre (Ortega, 1997). Only recently this redistribution of agricultural lands has been more or less undone, restoring relationships that had been sour before slightly and making way for a more close-knit community cooperation in many places.
4 | Methodology

To set the boundaries of this study we looked at what would be the most fertile for the organisation as well as what subjects would be the most valuable in regards to future projects. This led us to the study of adoption of soil and water conservation practices in rural agriculture. It was decided to focus specifically on these two practices since both are often closely knit together in as well the origin of the problems as the mitigation therefore. The research done for this dissertation was divided in different forms. The reason for this was to assure the most suited methods were used for each part of the analysis, ensuring the most representative result possible. Background information on the country of Nicaragua, and more specifically the municipality of Darío, their respective climates and general geographic information were mostly collected through desk research. Various sources of information are available, mostly internationally operating universities or study bureaus and as such were expected to provide all information necessary. For the actual obtaining of results we opted to combine qualitative and quantitative methods.

Quantitative methods would allow us to form conclusions that would be representative for a large group of people divided over a larger area. Qualitative methods were added to fill in the gaps of information that a solely quantitative approach would unavoidably produce. By combining these two we ensured an analysis that covered all aspects without missing any important information.
4.1 Quantitative methods

For quantitative research a household survey (See Appendix B) was produced. The survey consists of questions to test the knowledge of practices and behavioural trends towards soil- and water conservation. The surveys have been conducted over a timespan of one and a half month and were done in person on location. This to guarantee a maximal response rate as contact information of potential respondents was unavailable and as such it was not an option to conduct surveys through any channel of communication other than in-person interviews. The survey has been produced using the application “Magpi”, which allows the creation of a survey that can be conducted using a smartphone equipped with the application and is easily exportable afterwards. To calculate the sample size there was chosen for a confidence interval of 95% and a standard deviation of 5%. A dataset (See Appendix A) listing the inhabitants of the communities and provided by the Nicaraguan government was used for the actual calculation. This led to a projection of 266 surveys to be conducted, in line with the number of inhabitants in each community.

4.2 Qualitative methods

Qualitative data was gathered using a combination of field observations and in-depth interviews. The interviews were based on a loose baseline structure to ensure answers that wouldn’t deviate to far from the subject. Other than used solitary, often these interviews were also used in combination with the field survey. This combined use of methods ensured a complete understanding of current practices and behaviour towards soil and water conservation when collecting information on location. Where possible a field observation was also done to filter out possible malicious answers and to uncover possible discrepancies between actual practices and those stated by the interviewees. These data gathered in the field was gathered in the form of detailed field notes and voice-memos.
4.3 Statistical representativity of results

It must be mentioned that the intended number of surveys has not been attained and as such the results in this analysis cannot be considered statistically representative. In total 144 surveys have been conducted out of the intended 231 necessary for a statistical representative result. The reason therefore was the limited amount of time available to conduct the surveys as well as the remote location of some communities and their difficult accessibility. This does not at all imply the obtained results are useless. The municipality of Darío has geographical traits that are fairly similar throughout. As such, a sufficient variety of communities and locations have been studied to draw conclusions that are worthwhile and accurately represent these different traits and accompanying problems. Furthermore, in-depth interviews have been used to gather more information about more distant and difficult accessible communities from inhabitants of close by communities to mitigate this loss of information as much as possible.
5 | RESULTS

5.1 Introduction

The communities of the municipality of Darío live in difficult conditions. Poverty is widespread and is strongly influenced by the success of the annual harvests and thus by climate as well. The region knows a 6 month-lasting dry period which has gradually become more severe, especially in recent years. Farmers and their families are experiencing an increasing pressure from drought-related problems ranging from water shortages to asthma, chronic coughs and other respiratory illnesses. As global climate change cannot be halted and definitely not short term, it is beneficial to both farmer and local environment to study what can be done to adapt to this changing climate and how to mitigate the risks it brings with. In this chapter, the collected data on farmers’ practices considering soil and water conservation will be elucidated. The chapter will be divided into different parts to make a distinction between current conservation practices and their origins, motivation behind these practices, external factors influencing the behaviour of farmers in regards to “good practice” and the room for improvement.
5.2 Current agricultural practices

Field research and observations provided a clear insight in the variety of agricultural practices presently used in the region and the motivation behind these. The usage of techniques has been similar throughout the visited communities with minor deviations in some areas. Agricultural landscapes often provide very valuable ecosystem services, especially when it comes to conservation, they provide biodiversity and as well affect downstream water supplies. For farmers though, these functions often are externalities and as such are not actively pursued (Pagiola S., et al., 2007). They are beneficial to their surroundings however and can help restore harmed environments. In the following paragraphs will elaborate further on practices found to be used within the municipality.

5.2.1 Gender roles

Gender roles can be seen as traditional as in almost all cases encountered, men were out on the field working and women were performing household tasks in and around the house. When asked how daily tasks were divided it was confirmed that in dry season, the men generally provided income through labour while women took care of cooking, cleaning and other maintenance tasks. In wet-season however, women often help with agriculture, especially in times when intensive care of crops is necessary, such as seeding and harvesting.

5.2.2 Origins

In our study, the respondents were asked who thought them how to farm. Multiple answers were possible. As the chart in figure 6 shows, the vast majority of those farmers got their knowledge from someone within their family, in almost all cases this was their father. Some farmers got some additional
information from other sources as NGO's. It has to be noted as well that in some exceptions farmers indicated that they were part of a cooperation supplying one specific supermarket chain in particular. This cooperation organised workshops to educate their members on new methods and better practices. This was only a very slight minority though. The majority of schooling about farming originates in a father to son transfer of knowledge relation. These results clarify two things, first of all they show that most current farming practices are the practices that have been used since a very long time, as they originate mostly from within the community the farmer lives in and only little outside input plays a role. This explains for a part the low adoption rate of more climate-smart practises. As a farmer-to-farmer learning process can often provide benefits (Taweekul, Caldwell, Yamada, and Fujimoto, 2009). This demands the information that is passed to be innovative and up to date, which in this case, it is not. Secondly, the results show the minimal presence of agricultural orientated NGO’s in the region. An enthousiast readiness to implement changes has been noted as well though, as interviewees where always eager to know about techniques they indicated not knowing. Backe with a strong community cohesion and organisation (Walters P.J. and Chinowsky S.P., 2015). this would make for a high potential of quick adaption.

5.2.3 Use of pesticides and fertilizers

The majority of farmers use chemicals on their lands. Mostly these are pesticides that get sprayed on by hand-pump. The motivation behind their usage is the combatting of plagues that threaten their crops. Urea has also been seen to be added to the soil. Further details about the use of either pesticides or fertilizers have not been collected since they were not relevant for the study. None of the farmers have been known to use compost as natural fertilizer for their crops although all the ingredients to make a basic organic compost where found to be readily at hand.
5.2.4 Land preparation

All fields observed where seen to use tillage to prepare the land for seeding and be seen to do so using the means there are at hands. In most cases this means ploughing by the means of cows and with a very basic, hand-made wooden plough. Figure 7 shows the most common used technique in action. Observation showed that in some cases machine-powered ploughing systems were also used but these cases occurred only very rarely and were situated in less remote areas. For this reason, they can be neglected in the results of this study as they are a very small minority of the studied subjects.

When preparing a newly acquired piece of land for agricultural purposes, the commonly used technique is ‘slash-and-burn’. A method where the natural vegetation occupying the land up to that point is cut down and these cuttings are burned. Slash-and-burn is a technique that is used very often due to the ease with which it is executed. Unfortunately, often the fire spreads beyond the intended limits, burning down whole hillsides. Furthermore, burning all organic matter available on the field takes away the nutrients otherwise fed back to the soil and leaves it exposed to the sun. Figure 8 depicts a plot of land that has been cleared during the dry-season. After the boulders will have been removed it’s ready to be cultivated when the rain season starts.
5.2.5 Irrigation

Irrigation of crops knows more deviation throughout the results. Where there was sufficient water to irrigate crops in the dry season, drip-irrigation was used by 76% of farmers. The main reason for this was the efficiency of water usage. A large chunk of the interviewees indicated however that there was not enough water to practice agriculture in the dry season. Since the wet season doesn’t require any irrigation because of the sufficiency of rainwater alone, people who only cultivated their fields in the wet season did not use any kind of irrigation techniques. Furthermore, some farmers indicated that sometimes they suffered a production loss due to too heavy rainfalls which would “drown” their crops. Further highlighting the immense difference in season these farmers have to cope with.

Figure 9: Usage of drip irrigation
5.3 Crop variety

The study showed that agriculture is largely dictated by the wet- and dry season. In wet season, all farmers are able to cultivate crops with a high demand for water such as wheat, rice and maize and as such do so. In dry season only very little farmers grow these basic grains. The majority of farmers cultivate basic grains in wet season, when there is sufficient rainwater available. They store their harvest for own consumption and if the harvest is sufficient, sell of what they don’t need. This implies that when the season’s harvest is disappointing, this has an immediate impact on the farmers in a loss of income. It also has to be noted that that little number of farmers found to be cultivating these water intensive crops were all situated close to rivers and in valleys. Figure 10 reflects these findings, affirming that the prevailing crops are maize and red beans, especially in wet season. It also shows that remarkably, tomatoes are cultivated by a higher number of farmers in dry season than in wet season. This is due to the fact that in wet season a large part of the available land gets used to cultivate more water intensive crops such as basic grains.

5.4 Soil conservation practices

For current practices, we differentiate between practices that are directly aimed at conservation of water or soil and practices that contribute to conservation but are not especially implemented because of this reason. Their contribution to conservation efforts rather is a by-product of measures taken out of other motives. Both approaches are further explained in the following paragraphs.
In our survey, we wanted to obtain information about the usage or lack of different soil- and water conservation techniques. To test this, we looked at practices that would be suited for a climate as the one in Dario and considering the crops that are locally grown. Based on this information we drafted a list of questions adapted to local circumstances to form an image of the conservation practices in use. A conservation technique that has been found common practice is the construction of retention dams on hillsides. Farmers would either with stones or live plants construct barriers to prevent soil erosion in case of heavy rainfall. The plants used for these barriers often is bamboo. Figure 11 shows an example of a soil retention barrier constructed with live plants and stones as base. When asked why this was their preferable technique, motives knew some variation. 50% of respondents indicated that it was the cheapest method with success. Another 36% indicated it was the simplest way. 23.6% answered that they did not know of any other method to combat soil erosion.

5.5 Water conservation practices

As depicted in Figure 12, only 61% of farmers have sufficient water to cultivate their fields year-round. Others have to rely on labour provided by more productive farmers for their income in that period. Thus, it goes without saying that water conservation practices are very important. However, the use of water conservation practices was found to be very limited. Although drip
irrigation is used, this often was found to be the only technique in use directly aimed at conserving water.

Considering agriculture in general, conservation practices were scarce. Almost none of the respondents used, or even knew about for example, pit-planting. A technique that can increase crop yields significantly and is highly effective in drier climates. The African Development Bank describes it as follows. “Planting pits are used as a precipitation harvesting method preventing water runoff and thereby increasing infiltration and reducing soil erosion. Basically, holes are dug 50-100 cm apart from each other with a depth of 5-15 cm in order to prevent water runoff. Planting pits are most suitable on soil with low permeability, such as silt and clay. They are applicable for semi-arid areas for annual and perennial crops (such as sorghum, maize, sweet potato, bananas, etc.). One main advantage is their simple implementation and maintenance.” (ADB, 2008).

We observed some cases where farmers did construct larger dams on hillsides to collect rainwater and store this for the dry season as depicted in Figure 13. However, most of these would dry up halfway the dry season. We also noted that these were farmers that had more means than average, as other farmers who were asked why they did not construct the same type of water harvesting ponds answered this was too large of an investment for them. Although we observed that all fields on slopes were orientated at a 90-degree angle in regards to that same slope, we never found farmers that used infiltration swales to let water set and infiltrate in the ground. The usage of such swales could heavily increase the amount of water that gets captured in events of heavy rainfall and attribute to the replenishing of water in the soil. Some of the farmers with larger water retention dams used a swale to lead more water to their dam. Yet,
this was rather to collect more water, not to let it infiltrate.

5.6 Agricultural extension services

Of all respondents asked, 62.5% answered that there were no agricultural extension services present in Nicaragua. Although there definitely are, indicating that the people were not frequently visited by such organisations. Younger farmers often were corrected by an elder as well when they answered they never had an extension service visiting them, since this was in cases before they were born or before they could remember. The average time since the last visit of one of those services was 7 years. The majority of the respondents indicated that they do not feel supported in any way by organisations providing them with insightful knowledge considering farming or soil and water conservation techniques. As already mentioned a minority of farmers of the north-western region of the municipality indicated that they were part of a cooperation of farmers. This however is not exactly an extension service but nevertheless should be mentioned as this cooperation is a good example of own initiative some farmers took to educate themselves on new techniques and exchange knowledge.

Figure 14 shows the range of themes that has been discussed with the farmers on the last visit they got from an organisation aimed to aid them. It’s clear that fertilizer usage and plague control were the hottest topic. This affirms one of the expectations we had commencing this study, that farmers get some help but that information about soil and water conservation isn’t widespread by organisations active in the region.
5.7 Influential factors in implementing conservation practices

One of the main goals of this study was to try to find out what exactly makes the rural population want to implement certain sustainable agriculture techniques or what halts them from doing so. Based on field observations, interviews and our survey we observed following factors.

5.7.1 Funds

The results of the survey show that when respondents were asked why they did not use, or consider to use, certain mitigation measures, 37% of the time, the respondents indicated that the cost to implement these was too high for them. This was by far the most common reason why was chosen not to use certain practices. The rural population depends for almost their entire income on agriculture. Since this can fluctuate immensely every other season it is difficult to plan ahead and make larger investments that do not guarantee immediate return or in their opinion seem not to contribute in an immediate way to their wellbeing, an increase in productivity or bring any other immediate benefits.

5.7.2 Knowledge

Another reason was found to be the lack of knowledge about soil and water conservation. The techniques seen in use were rather basic, if those would even already be there. When asked why respondents did not consider to try another technique they often replied that the technique they’re using is the most effective for the problem. This makes us assume that the knowledge about more effective ways to aid soil- or water conservation is not widespread under the respondents.
5.7.3 Seasonal differences

As mentioned before, the lack of funds to make investments plays a large role in the decision-making process of the rural population. This gets strengthened by the seasonal differences the region knows. It’s hard to think of measures to use when one half of the year almost doesn’t get any rain, and the other half way too much. Techniques that are effective for one season almost never work for the other. So is only 34.7% of the respondents collecting rainwater. The given motivation behind this is that there is no rain to collect in the dry season and there’s plenty of water available in the wet season which would make collecting rainwater pointless. Other water conservation practices that were brought up were also quickly put down by respondents as they mostly indicated that they had no need for water collection in wet season and there just wasn’t any in dry season.
6 | DISCUSSION AND CONCLUSION

In this report, we wanted to examine the use of soil and water conservation techniques in rural agriculture in the municipality of Darío in Nicaragua. The region and its inhabitants are under great stress due to droughts and climate change and so conservation practices are very important to guarantee productive agriculture in the future. The goal of the rapport is to provide the reader with a deeper insight of the conservation practices currently in use (or not in use) and the underlying motives therefore, as well as make advicements to El Porvenir to improve their current undertakings.

In our study, we found first and foremost that neither the rate of adoption, nor the level of conservation practices was very high. Practices specifically aimed at conservation (e.g. reforestation, infiltration swales) are almost only implemented by NGO’s active in the region and conservation practices in rural agriculture are scarce. Transfer of knowledge about farming gets transferred from father to son. As a result, in the last 30 years, no significant improvements have been made in regards to farming. To tackle this problem, it is necessary educate the population on sustainable and more advanced farming practices. As we experienced the difficulty of teaching new methods and seen the problems with keeping these in use long term, this process has to be thought through. It’s important that new techniques are realistically implementable with the materials at hand and that their success can be shown. This can help contribute to their acceptance by local farmers. Education wise as well, it might be helpful to work with “test-plots”
which can be visited by farmers and show through example that proposed modifications work. Thereby removing any reticence to try new techniques.

Because of their full dependency on farming as an income the population is extremely vulnerable to climate change as this directly influences their only source of income. Because of this, a large part of the rural population lacks the funds to make larger, long term investments that could help them getting out of this spiral of poverty. The only solution to help rural families fight this is to make their fields more productive year-round, thus providing a more reliable source of income.

To accomplish this, the most important issue is education. We observed that the majority of the farmers simply do not have the understanding of basic conservation practices that could help reduce their costs and increase their yields long term. Educating farmers in a form of workshops seems to be the most cost-effective way to make a difference. It’s important however not to lean towards a centrist/instructionist approach of setting standards and trying to make subjects meet these using incentives and penalties. However this might be a good approach for more globally orientated players, it is debatable whether this approach is the most successful for small-scale farms. A more local innovation approach is preferred here, focusing on local, smaller players and their mutual distribution of knowledge (Dyck B. and Silvestre S. B., 2018). El Porvenir already organises workshops in other fields so it would be only a matter of changing the subject for them to start this up. There are also other NGO’s active in the region that are more agriculture-oriented that could definitely help contribute to such efforts, with the consideration mentioned before in mind. To successfully accomplish full adoption of innovative techniques the organisation could as well make use of the TCOS framework (Hall, Matos, Silvestre, & Martin, 2011). A framework thought out to help increase adoption rates of innovation and is built on the idea that four different factors leading to uncertainty in innovation should be addressed collectively by NGO’s and local players. These four components are the following:
1. Technological feasibility, which refers to the uncertainty associated with the existence (or not) and possibility of developing the required technology. To address this uncertainty, innovations must be demonstrably technologically feasible, based on existing capabilities.

2. Commercial viability, which refers to the uncertainty associated with the existence (or not) and possibility of creating a market for an innovation. To address this uncertainty, innovations must be demonstrably commercially viable.

3. Organizational appropriability, which refers to the uncertainty associated with the potential to appropriate the benefits of the innovation and how easily it could be imitated. To address this uncertainty, the development and exploitation of the innovations must be demonstrably congruent with organization strategy.

4. Societal acceptability, which refers to the uncertainty associated with the potentially detrimental societal side effects (including environmental, social, cultural, or political). To address this uncertainty, these potential side effects must be recognized and addressed.

The second issue is water, because of the extreme dry season the region knows, fields are just not productive year-round. However it would be impossible to achieve an even balance of productivity in wet- and dry season, there are ways to mitigate the low supply of water half of the year. First of all, water services should be guaranteed year-round. The best way to do this is to ensure sufficient funds to operate and maintain these water services, ensure viable water sources and external support to help with the initial stages of water service development (Walters P.J. and Chinowsky S.P., 2015). Secondly, we look at different permaculture principles. One of these principles that is almost not seen in use is infiltration. An enormous amount of rainwater washes down hillsides without any chance to infiltrate in the soil. Farmers either did not see this as an opportunity or indicated they did not have the money to finance costly earthworks, necessary for infiltration-assisting constructions. We think that a combination of several measures could be incredibly beneficial to the productivity of rural agriculture in the region. Small-scaled projects aimed at
infiltrating water in the soil executed mostly by the farmers themselves could be a first step. These would, for example, consist of earthworks such as swales and infiltration ponds that farmers could build on their own fields and with their own capacity. Larger scale projects such as strategically placed water reservoirs that could harvest the enormous amount of rain that is available during wet season and store this for irrigation in dry periods could be a solution communitywide.

Although this requires more extensive research on placement, soil and surroundings in general, with community and government support, slightly larger projects like these could book immense progress, bettering the lives of hundreds of people at once.

The third issue we found is soil. The soil is under significant stress due to droughts, poor agriculture practices and erosion, this means it gets exhausted. Much of the soil additives used in agriculture are chemical and provide only short-term benefits. Almost none of the farmers used biological alternatives. We think that one of the the simplest and most easily applicable solutions to the general problem is the improvement of the soil. Very little techniques that can be seen as conservation-supporting in regards to soil are used in the region. The good thing is that only slight adaptations are necessary to make improvements here. First of all, farmers should be motivated to practice low or no-till agriculture, as this would be beneficial to soil organisms, disturbing them minimally. (Mollison, 1990) Mulching soils and fields would be the next step, as to implement one of the three most important conservation agriculture principles. (Dyck B. and Silvestre S. B., 2018) At this moment, whole hillsides are left barren and exposed to the sun, not giving it the time to heal in between cultivating. A third step is to produce organic compost, An incredibly easy way to improve soil life. None of the farmers have been seen to use this technique although all the materials needed are ready at hand. Combining all these techniques would only require minimum efforts and slight changes in agriculture practices but would be very efficient to improve soil structure. This in return would also improve water holding capacity of the soil and as such help solve erosion problems as well.
7 | REFERENCES


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Chapter 9: Appendices

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## Communities Dataset

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**Comunidades**

**Ciudad Darío**

**Situción de Agua y Saneamiento del Municipio**

**UNIDOS EN GRANDES**

**2018**
Comunicaciones

Población de Vientos del 15-02-2016 AL 330-0217

Edificio Municipal

Situación de Água y Saneamiento del Municipio
### Comunidades

**Ciudad Darío**

*Periodo de levantamiento del: 15-02-2016 al: 27-07-2017*

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*Willem Keuppens - May 2018*
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## Comunidades

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### Hermanos Retidos y compromiso en informacion agro comunitaria

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**Comparados**

**Período de Levantamiento del: 15-02-2016 al: 27-07-2017**

**Situación de Agua y Saneamiento del Municipio**

2018
APPENDIX B | HOUSEHOLD SURVEY

1. ¿Cuál es el nombre de tu comunidad?

Question Type= dropdown
Data Field Name : Community
Choose one response:

- Apacorral (Apacorral)
- Apompua (Apompua)
- Asiento Viejo (Asiento_Viejo)
- Bacacan La Planta (Bacacan_La_Planta)
- Buena Vista (Buena_Vista)
- Candelaria (Candelaria)
- Casas Viejas (Casas_Viejas)
- Cerro Colorado (Cerro_Colorado)
- Cerro Grande (Cerro_Grande)
- Chagüite Belén (Chagite_Beln)
- Chagüite Santa María (Chagite_Santa_Mara)
- Dos Montes (Dos_Montes)
- Dos Quebradas (Dos_Quebradas)
- Dulce Nombre de Jesús (Dulce_Nombre_de_Jess)
- El Bejuco (El_Bejuco)
- El Bijao (El_Bijao)
- El Cacao de Los Suarez (El_Cacao_de_Los_Suarez)
- El Carbonal (El_Carbonal)
- El Chote (El_Chote)
- El Coyolito (El_Coyolito)
- El Cristal (El_Cristal)
- El Delirio (El_Delirio)
- El Guineo (El_Guineo)
- El Hato (El_Hato)
- El Horno (El_Horno)
- El Nancital (El_Nancital)
- El Papayal (El_Papayal)
- El Pital (El_Pital)
- El Prado (El_Prado)
- El Regadillo (El_Regadillo)
- El Roble (El_Roble)
- El Sesteo (El_Sesteo)
- El Tempisque N°1 (El_Tempisque_N1)
- El Tempisque N°2 (El_Tempisque_N2)
- El Terrero (El_Terrero)
- El Zarsal (El_Zarsal)
- Escobillo (INPRU) (Escobillo_INPRU)
- Hato Nuevo (Hato_Nuevo)
- La Ceibita Valle San Juan (La_Ceibita_Valle_San_Juan)
- La China (La_China)
- La Cruz del Jicaro (La_Cruz_del_Jcaro)
- La Flor (La_Flor)
- La Joya (La_Joya)
- La Montañita (La_Montaita)
- La Picota (La_Picota)
- La Pita (La_Pita)
- La Quesera (La_Quesera)
- La Rauda (La_Rauda)
- La Remonta (La_Remonta)
- Las Alvellanas (Las_Alvellanas)
- Las Cañas (Las_Caas)
- Las Delicias (Las_Delicias)
- Las Mezas (Las_Mezas)
- Las Naranjitas (Las_Naranjitas)
- Las Nubes (Las_Nubes)
- Las Pencas Puertas Viejas (Las_Pencas_Puertas_Viejas)
- Las Pilas (Las_Pilas)
- Las Pozas Santa Bárbara (Las_Pozas_Santa_Bárbara)
- Las Tunas (Las_Tunas)
- Llanos de Tamalapa (Llanos_de_Tamalapa)
- Llano Verde (Llano Verde)
- Los Calpules (Los_Calpules)
- Los Cerritos (Los_Cerritos)
- Los Cocos (Los_Cocos)
- Los Encuentros (Los_Encuentros)
- Los Limones (Los_Limones)
- Los Pedernales (Los_Pedernales)
- Los Ramírez (Los_Ramrez)
- Los Rostranes (Los_Rostranes)
- Maunica (Maunica)
- Monte Sinaí (Monte_Sina)
- Ojo de Agua Ispangual (Ojo_de_Agua_Ispangual)
- Ojo de Agua Tamalapa (Ojo_de_Agua_Tamalapa)
- Palo de Agua (Palo_de_Agua)
- Palos Verdes (Palos_Verdes)
- Piedra Rajada (Piedra_Rajada)
- Plan de Monte (Plan_de_Monte)
- Playas de Moyua (Playas_de_Moyua)
- Potrerio (Potrerio)
- Pueblo Nuevo (PuebloNuevo)
- Puertas Viejas (Puertas_Viejas)
- Rincón de Santa Teresa (Rincn_de_Santa_Teresa)
- Sabana Verde (Sabana Verde)
- San Agustín (San_Agustn)
- San Antonio del Jobo (San_Antonio_del_Jobo)
- San Cristóbal (San Cristbal)
- San Esteban N°1 (San_Esteban_N1)
- San Esteban N°2 (San_Esteban_N2)
- San Juanillo (San Juanillo)
- San Pedro (San Pedro)
- San Rafael Del Jobo (San Rafael Del Jobo)
- Santa Lucia de Las Jaguas (Santa Lucia de Las Jaguas)
- Sonzapote (Sonzapote)
- Tamalapa (Tamalapa)
- Totumblita (Totumblita)
- Trujillo (Trujillo)
- Valle San Juan (Valle San Juan)
- Veracruz (Veracruz)
2. Cuál cultivos cultivas en invierno?

Question Type= checkbox

Data Field Name : CropsInvierno

Choose all that apply:

- maíz (maiz)
- caña de azucar (cana)
- sorgo (sorgo)
- tomates (tomates)
- yuca (yuca)
- frijoles (frijoles)
- banano (banano)
- cebolla (cebolla)
- pepino (pepino)
- papaya (papaya)
- chiltoma (chiltoma)
- arroz (arroz)
- ceniciento (ceniciento)
3. ¿Cuáles cultivos cultivas en verano?

Question Type= checkbox

Data Field Name : CropVerano

Choose all that apply:

- maíz (maiz)
- caña de azúcar (cana)
- sorgo (sorgo)
- tomates (tomates)
- yuca (yuca)
- frijoles (frijoles)
- banano (banano)
- cebolla (cebolla)
- pepino (pepino)
- papaya (papaya)
- chiltoma (chiltoma)
- arroz (arroz)
4. Conoces el método de hoyos de plantación?

Question Type= radio

Data Field Name : PlantingPits

Choose one response:

- Sí (Sí)
- No (No) If this response, jump to 12

5. Quién te informaste de ese método?

Question Type= checkbox

Data Field Name : InformationSourcePits

Choose all that apply:

- Un otro agricultor (un_otro_agricultor)
- ONG (ONG)
6. Alguna vez usaste hoyos de plantación en un campo de cultivos?

Question Type= radio

Data Field Name : TriedPlantingPits

Choose one response:

- No (No)  If this response, jump to 12
- Si (Si)

7. Cuándo fue la primera vez que probaste hoyos de plantación

Question Type= checkbox

Data Field Name : FirstTimePlantingPits

Choose all that apply:
8. ¿Qué tan profundos eran los hoyos? en centímetros

Question Type= numeric

Data Field Name : DepthPlantingPits

9. ¿Qué tan amplios eran los hoyos? en centímetros

Question Type= numeric

Data Field Name : WidthPlantingPits

10. ¿Qué tan largos eran los hoyos? en centímetros

Question Type= numeric

Data Field Name : LengthPlantingPits
11. Hay una razón por que no?

Question Type= checkbox

Data Field Name: ReasonWhyNotPits

Choose all that apply:

- faltaba información (faltaba_información)
- faltaba tiempo (faltaba_tiempo)
- faltaba materiales (faltaba_materiales)
- pienso que no es efectivo (pienso_que_no_es_efectivo)
- no me interesa (no_me_interesa)
- otro (otro)

12. Aquí en Nicaragua hay organizaciones de extensión agrícola?

Question Type= radio

Data Field Name: ExtensionServices

Choose one response:

- Si (Sí)
13. ¿Qué organizaciones?

Question Type= dropdown

Data Field Name : WhichServices

Choose one response:

- UCA (UCA)
- CEPAD (CEPAD)
- CRS (CRS)
- CATIE (CATIE)
- otro (otro)

14. Otra organización

Question Type= Text

Data Field Name : Other_organisation

15. ¿Cuándo fue la última vez que alguien de un organización como estos te visitó?
16. ¿Qué temas ellos discutieron contigo?

Question Type= checkbox

Data Field Name : ThemesDiscussed

Choose all that apply:

- variedades de semillas (variedades_de_semillas)
- fecha de plantación (fecha_de_plantación)
- control de plagas (control_de_plagas)
- uso de fertilizantes (uso_de_fertilizantes)
- preparación del suelo (preparación_del_suelo)
- manejo después cosecha (manejo_después_cosecha)
- ventas y marketing (ventas_y_marketing)
- otro (otro)
- conservación del suelo (conservación_del_suelo)

17. Observaciones
Question Type= Text
Data Field Name : Observations

18. De qué manera riegas tu cultivos en verano?

Question Type= checkbox
Data Field Name : Watering
Choose all that apply:

- con el mano/regadera (con_el_mano)
- riego de por goteo (riego_de_por_goteo)
- aspersor (sprinklers)

19. Por qué usas este método?

Question Type= checkbox
Data Field Name : WhyThisMethod
Choose all that apply:

- es el mas barrato (es_el_mas_barrato) If this response, jump to 21
- es el mas simple (es_el_mas_simple) If this response, jump to 21
- no tienes herramientas para hacer diferente (no_tienes_herramientas_para_hacer_diferente) If this response, jump to 21
- es el más eficiente (es_el_más_eficiente) If this response, jump to 21
- otro (otro)

20. Otro

Question Type= Text

Data Field Name : Otrrro

21. Quién te enseñó cultivar?

Question Type= checkbox

Data Field Name : WhoTaught

Choose all that apply:

- un otro agricultor (un_otro_agricultor)
- ONG (ONG)
- vendedor de semillas (vendedor_de_semillas)
- una persona de la familia (una_persona_de_la_familia)
- el radio (el_radio)
- el gobierno (el_gobierno)
22. Haces algo para coleccionar el agua de lluvia?

Question Type: radio

Data Field Name: CollectRainwater

Choose one response:

- sí (si)
- no (no)  If this response, jump to 26

23. Que haces para cosechar el agua de lluvia?

Question Type: Text

Data Field Name: RainWaterTechniques

24. Por qué estos métodos?

Question Type: checkbox

Data Field Name: WhyTheseMethods

Choose all that apply:
- es el mas barrato (es_el_mas_barrato)
- es el mas simple (es_el_mas_simple)
- no tiennes herramientas para hacer diferente (no_tienes_herramientas_para_hacer_diferente)
- es el mas eficiente (es_el_mas_eficiente)
- No conoces otras maneras (no_conoces_otra)
- otro (otro)

25. Otro

Question Type= Text
Data Field Name : Otro

26. Haces algo para detener el erosión del suelo?

Question Type= radio
Data Field Name : SoilRetention
Choose one response:

- si (si)
- no (no) If this response, jump to 30
27. Que haces para detener el erosión del suelo?

Question Type= Text

Data Field Name : WhatSoilRet

28. Por que estes métodos?

Question Type= checkbox

Data Field Name : WhyThese

Choose all that apply:

- es el mas barrato (es_el_mas_barrato)
- es el mas simple (es_el_mas_simple)
- no tiennes herramientas para hacer diferente (no_tienes_herramientas_para_hacer_diferente)
- es el mas eficiente (es_el_mas_eficiente)
- no conoces otros metodos (no_conoces_otros_metodos)
- otro (otro)

29. Otro
30. En los 5 años pasados, tu cosecha:

Question Type= checkbox

Data Field Name : YearFiveHarvest

Choose all that apply:

- aumentado (aumentado)
- se mantuvo igual (se_mantuv__igual)
- reducido (reducido)

31. Alguna vez has pensado de instalar un tanque para almacenar agua de lluvia?

Question Type= radio

Data Field Name : WaterTank

Choose one response:

- si (si)  If this response, jump to 34
- no (no)
32. Por qué no?

Question Type= checkbox

Data Field Name : WhyNoTank

Choose all that apply:

- es demasiado caro (es_demasiado_caro)
- no puedes encontrar un tanque (no_puedes_encontrar_un_tanque)
- no quieres un tanque (no_quieres_un_tanque)
- no es útil (no_es__til)
- es demasiado trabajo de hacerlo (es_demasiado_trabajo_de_hacerlo)
- otro (otro)

33. Otro

Question Type= Text

Data Field Name : Other

34. Alguna vez has pensado de hacer estanques/hueco en tu propiedad o cerca de tu campo de cultivos para coleccionar el agua de lluvia?
Appendices

Willem Keuppens - May 2018

Question Type= radio

Data Field Name: Ponds

Choose one response:

- si (si)  If this response, jump to 37
- no (no)

35. Por que no?

Question Type= checkbox

Data Field Name: WhyNotPond

Choose all that apply:

- es demasiado caro (es_demasiado_caro)
- no puedes encontrar un tanque (no_puedes_encontrar_un_tanque)
- no quieres un tanque (no_quieres_un_tanque)
- no es útil (no_es__til)
- es demasiado trabajo de hacerlo (es_demasiado_trabajo_de_hacerlo)
- otro (otro)

36. Otro
37. Conoces riego por goteo?

Question Type= radio

Data Field Name : DripIrrigation

Choose one response:

- si (si)
- no (no)  If this response, jump to 39

38. Usas esto método de regar?

Question Type= radio

Data Field Name : UsingDripIrrigation

Choose one response:

- si (si)  If this response, jump to 40
- no (no)
39. Por qué no?

Question Type= dropdown

Data Field Name : Por_que_no_

Choose one response:

- es demasiado caro (es_demasiado_carro)
- no puedes encontrar un tanque (no_puedes_encontrar_un_tanque)
- no quieres un tanque (no_quieres_un_tanque)
- no es útil (no_es__til)
- es demasiado trabajo de hacerlo (es_demasiado_trabajo_de_hacerlo)
- otro (otro)

40. Conoces el uso de zanjas/canales para almacenar agua de lluvia?

Question Type= radio

Data Field Name : Swales

Choose one response:

- si (si)
41. Alguna vez usaste estas?

Question Type= radio

Data Field Name : UsingSwales

Choose one response:

- sí (si) If this response, jump to 43

- no (no)

42. Por qué no?

Question Type= dropdown

Data Field Name : Por_que_no_2

Choose one response:

- es demasiado caro (es_demasiado_caro)

- no es útil (no_es_util)

- es demasiado trabajo de hacerlo (es_demasiado_trabajo_de_hacerlo)

- no sabes como (no_sabes_como)
43. Alguna vez has replantado árboles en la comunidad?

Question Type= radio

Data Field Name : ReplantingTrees

Choose one response:

- sí (si)
- no (no)

44. Por dónde obtuviste las semillas?

Question Type= dropdown

Data Field Name : WhereGotSeeds

Choose one response:

- un otro agricultor (un_otro_agricultor)
- ONG (ONG)
- vendedor de semillas (vendedor_de_semillas)
- una persona de la familia (una_persona_de_la_familia)
- el radio (el_radio)

- el gobierno (el_gobierno)

- otro (otro)

45. Por que no?

Question Type= Text

Data Field Name : WhyNoPlanting
APPENDIX C | LAND USE MAP