Irish Aid Climate Change and Development Learning Platform

Tigray Case Study Final Report

SEPTEMBER 2015

Acknowledgements

IIED would like to gratefully acknowledge the support of the Irish Aid staff in Ethiopia – Leulseged Asfaw and Tesfaye Ejigu. Their stewardship of this case study was central to its success.

The case study was done in partnership with staff at the Tigray Agriculture Research Institute. Director Eyasu Abraha and project manager Hailselassie Amare provided enthusiastic support and guidance for the work. We would like to thank all TARI for being active and insightful partners in the process. The success of the OR project is testament to the good and hard work of TARI and the institute's commitment to agricultural development in Tigray.

Our colleagues in Echnoserve – Meron Awraris and Tibebu Assefu – conducted the case study with energy and rigor and deserve our gratitude.

Diane Guerrier who worked on this assignment as a consultant to IIED showed great dedication to the work and took some wonderful photographs included here. Without her the case study would not have been possible.

The people of the farming households and development agents in Howzein made us feel very welcome and were generous in the ways that they shared information, experiences, insights, opinions and much more with us.

We hope that this case study helps to catalogue the important learning that the OR project has generated.

Table of contents

Acronyms

ARDPLAC: Agricultural Development Partners Linkage Advisor Council
BoARD: Bureau of Agricultural Development
CBA: Cost Benefit Analysis
DA: Development Agent
FGD: Focus Group Discussion Group
FTC: Farming Training Centre
GHG: Green House Gases
IA: Irish Aid
IIED: International Institute for Environment and Development
IRR: Internal Rate of Return
NAPA: National actions Plan of Adaptation
NMA: National Meteorological Agency
NRM: Natural Resources Management
OR: Operational Research
ORTDB: Operational Research Technology Dissemination Project
PSNP: Productive Safety Net Programme
RAAKS: Rapid Appraisal of Agricultural Knowledge Systems
REST: Resilience Society of Tigray
SHF: Smallholder farmers
SNNRP: Southern Nations, Nationalities and Peoples' Region
TAMD: Tracking Adaptation Measuring Development
TARI: Tigray Agricultural Research Institute

List of diagrams

List of tables

List of figures

List of annexes

Executive summary

The Ethiopia programme of Irish Aid has set about integrating climate change into development programming and this experience is a priority for Irish Aid and others to learn from. The Irish Aid support to the work of TARI in Tigray is an important first case of climate integration. Therefore a case study has been developed with colleagues in TARI, Irish Aid, Echnoserve and iied that focuses on key issues of how climate is integrated into agricultural research in support of climate adaptation by smallholder farmers. This case study looks at how effective this integration has been to draw lessons for further integration of climate into development programming.

Following discussions with Irish Aid Ethiopia staff in Addis Ababa and with TARI staff in Mekelle, a proposed design for the case study was generated. It was agreed that the case study should add value to the Irish Aid supported initiative that TARI is implementing. The case study would collate evidence and learning and document this for wider sharing within the Irish Aid Learning Platform, with organisations involved in the implementation of the Agriculture component of Ethiopia's Climate Resilience and Green Economy strategy, and more widely. The case study is not an evaluation – it identified, generated and analysed evidence and is to share learning.

The main objective of the case study was to understand the TARI Operational Research programme and technology adoption process from perspectives of smallholder farmers and the researchers. The case study followed the steps of the TAMD framework.[1]

The way that Irish Aid has integrated climate change into its development programming through the OR project has been insightful. The steps of integration have been followed to varying degrees and in an incremental way.

Having said that there are various ways to improve and take further the integration:

- Better analysis and use of historic weather observation data available from the local weather stations to inform climate risk assessment.
- Access and use of climate projections for the different agro-ecoregions of Tigray again to inform the climate risk assessment.
- Increase the sensitivity of the climate risk assessment at local levels by monitoring climate risk perceptions of adopting and non-adopting SHF.
- Assess how local adaptation strategies diverge from improved crop variety adoption e.g. use of traditional long straw varieties, soil moisture management methods etc.

In summary the case study found evidence that:

Climate risks and agricultural technology generation and adoption

- Inter-annual climatic variability is increasing and there are demonstrable trends toward warming and drying, particularly in the short rainy period of the year.
- Soil and water conservation measures have been very effective in creating better conditions for agriculture and as a precursor for the adoption of improved varieties of crops and livestock.

[1] Tracking Adaptation Measuring Development see: http://www.iied.org/tracking-adaptation-measuring-development-tamd

- The OR initiative has provided improved crop varieties and livestock breeds that farmers want to adopt. Although these technologies have higher costs of implementation than traditional, returns are greater in terms of yields even in less favourable seasons.
- Widespread adoption of new technologies has contributed to greater productivity and food security for a large proportion of the population during a period of increased climatic variability.
- The longer term effectiveness of climate adaptation through agricultural technology adoption faces challenges of increasing climate risks, uncertainty on the sustainability of groundwater extraction for irrigation, and the compatibility of productivity versus climate resilient technologies.

Integrating climate change into development programming through research support

- Irish Aid's decision to support smallholder farmer climate adaptation through technology generation and dissemination has been vindicated by the success of the OR project.
- Continued support to TARI operational research would contribute to smallholder farmer adaptation to new and emerging climate risks to food security and agricultural productivity.

1. Scope

1.1 Introduction

Background to the study

Irish Aid have partnered with International Institute for Environment and Development (iied) to organise a Learning Platform on Climate Change and Development that will focus on relating country level engagements to international policy frameworks. The Learning Platform includes a training programme to increase Irish Aid staff and partner's capacity to incorporate climate change into development programming and improve tracking and reporting of climate change activities. The longitudinal nature of the learning process requires that the learning platform operates for at least the next four years, 2014 – 2017, with each year building on the previous year's learning. The Learning Platform incorporates workshops, field visits, documentation and publication of case studies, a web-based component for gathering and sharing learning and dissemination of key lessons to inform international climate change dialogue.

Outputs from the learning platform will include documented learning from across Ireland's key partner countries. The platform will produce at least two papers and additional documents each year. The dissemination of these papers and outputs will inform international delegations to the climate negotiations; promote debate on best practice on Climate Change adaptation for local communities among Ireland's partners and others; and incorporate lessons learned into future Irish Aid development programming. In addition, there will be documented Irish Aid case studies to inform partners and the public, of Ireland's Climate Change programmes and to inform public opinion on the importance of addressing Climate Change globally in the run up to the Paris 2015 Climate Summit and beyond.

Objectives

The Ethiopia programme of Irish Aid has been one of the first to set about integrating climate change into development programming. This makes Ethiopia a priority country case for Irish Aid and others to learn from. The Irish Aid support to the work of TARI in Tigray is identified as an important first case of climate integration. Therefore a case study has been developed with colleagues in TARI, Irish Aid and iied that focuses on key questions of how climate has been integrated into the research into use work and how effective this integration has been.

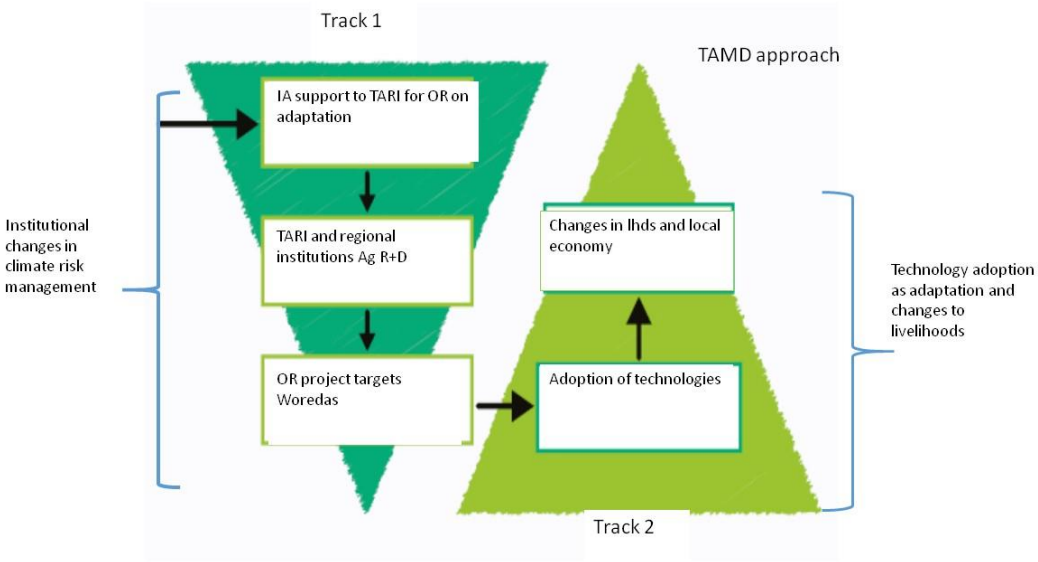
Following discussions with Irish Aid Ethiopia staff in Addis Ababa and with TARI staff in Mekelle, a design for the case study was generated. It was agreed that the case study should add value to the Irish Aid supported initiative that TARI is implementing. The case study would collate evidence and learning and document this for wider sharing within the Irish Aid Learning Platform, with organisations involved in the implementation of the Agriculture component of the Climate Resilience and Green Economy strategy, and more widely. The case study is not an evaluation. Rather in an appreciative inquiry way it identified, generated and analysed evidence and is to share learning.

The main objective of the case study was to understand the TARI Operational Research programme and technology adoption process from perspectives of smallholder farmers and the researchers. The process studied is encapsulated in the diagram below that uses the TAMD framework to map out the process – see below.

1.2 TAMD framework – methods and steps of the case study

TAMD[2] is a twin-track approach that assesses institutional CRM on the one hand (Track 1) and measures outcomes in terms of adaptation and development performance on the other (Track 2)[3]. In this case study, TAMD was applied to the TARI OR programme to understand the processes within Track 1 and Track 2 and their potential linkages. The entry point was the need to evaluate the impacts of the OR programme technologies dissemination for smallholders farmers in terms of development outcomes. Track1 aimed at capturing how relevant institutions in the region e.g. the Agricultural Bureau, Meteorology Agency, TARI, are managing climate risk in general as well as in the OR programme funded by Irish Aid. In the Track 2, linkages between technology adoption and adaptation to climate change among smallholder farmers were examined. Changes within livelihoods have also been studied in Track 2. The diagram below depicts the logic of the two tracks and their linkages for the operational programme case study.

Diagram 1: TAMD Framework applied to TARI OR programme
The process of the TARI Operational research programme mapped out according to the TAMD framework



The different steps of the application of TAMD in analysing the OR programme are:

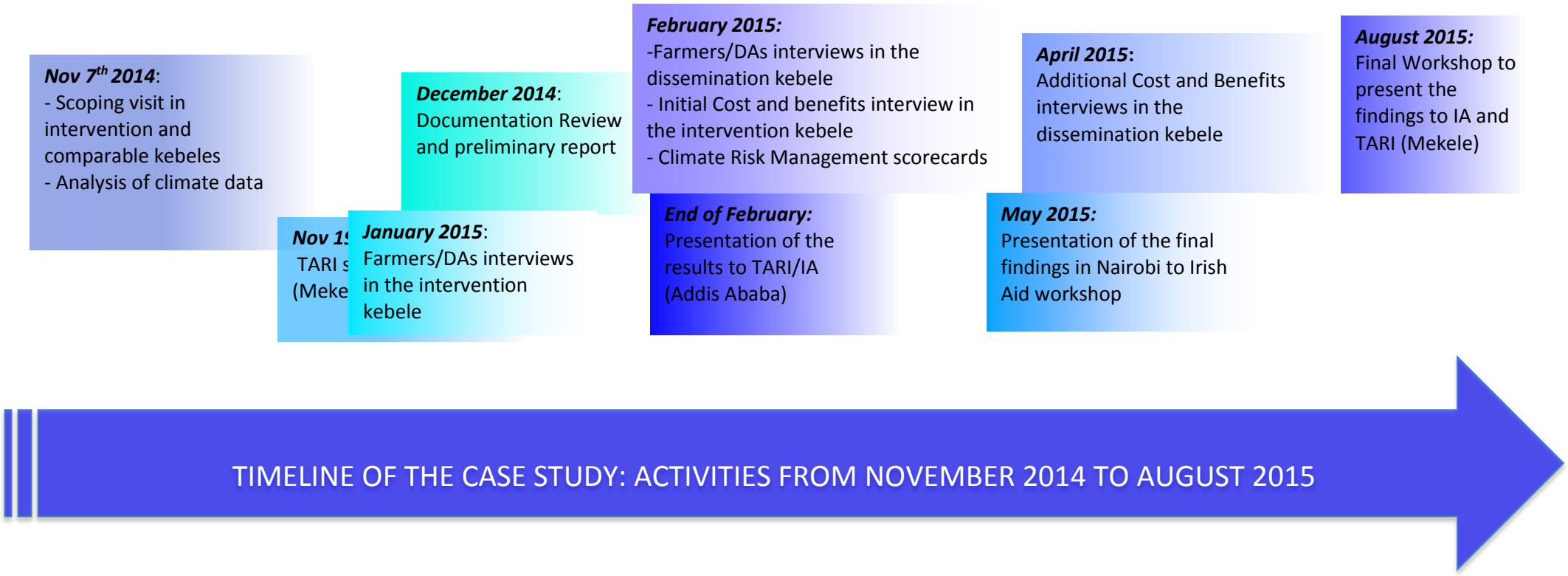
1- Defining the scope
2- Understand the theory of change
3- Defining and constructing indicators
4- Measuring indicators
5- Analysing and interpreting results
6- Learning

This case study report presents how these several steps have been achieved, explaining the methodology, the results and what we have learned.

[2] http://www.iied.org/tracking-adaptation-measuring-development-tamd
[3] Tracking Adaptation and Measuring Development : a step-by step guide, December 2014, p.5

The diagram below presents the timeline of the main activities carried out for the Irish Aid Tigray case study from November 2014 to August 2015:

Diagram 2: Case study workplan



The case study was carried out from November 2014 to April 2015 and included various activities including scoping visits, information gathering, analysis, consultation and report writing.

- **Scoping visit in the kebeles (Debrebirhan and Degum) and analysis of climate data-** ***November 2014***

A first scoping field trip was organized on the 7th of November 2014 in Hawzen woreda in the operational research kebele (Debrebirhan) and in its comparable kebele [4] (Degum) to enable the research team to have a first contact with the farmers. These two kebeles were chosen to apply a with and without approach through Focus Group Discussion, looking at how climate change is affecting the communities and how are they coping with the different hazards in a kebele beneficiating from the OR project and a kebele which is not. These FGD were used to understand how the Tigray farmers perceive and are impacted by climate change but also how they deal with it. It gave a first picture of the climate change challenges faced by the farmers in terms of hazards (droughts, hailstorm and strong wind) and impacts on livelihoods especially on five important capitals: natural, physical, financial, human and social. The results of this scoping visit are presented in the part 4 presenting of this report.

Picture n° 1: Focus group discussion in the intervention

Temperature and rainfall data for Hawzen woreda area were also collected in November 2014 to start understanding the climate profile of the project area. Detailed analyses of these climate data are given in part 3.

- **TARI Scoping workshop-** ***November 2014***

On the 17th of November 2014, a one-day workshop was organized in Mekelle by iied and Echnoserve[5] for the researchers of TARI (Tigray Agricultural Research Institute) involved in the Irish-Aid Food security Operational Research and capacity building programme for sustainable livelihoods in the Tigray region. This workshop was one of the first steps –with the documentation review- to build the Theory of Change (ToC) that needed to be established for the case study. It aimed at understanding the process of the project, the different linkages between the stakeholders using the RAAKS methodology[6] in order to build up the 'researchers' theory of change. The overall goal was to start understanding from the TARI researchers perspective; how research is supporting development to have more options to adapt in the climate change context. The main findings of this workshop are presented in the part 4 of this report.

- **Literature review and preliminary report-** ***December 2014***

The documentation review was an essential step to have a good understanding of the OR project from its beginning and of its implications for farmers. It is based on the documents that have been made available by Irish Aid and the TARI researchers (annual reports, evaluation reports, field days reports,

[4] The term « comparable kebele » refers to a similar kebele than the project one but not benefiting from it.
[5] An ethiopian research consulting company based in Addis Ababa
[6] RAAKS has three *operational objectives*[6]: to identify opportunities for intervention, to create awareness among actors of the constraints and opportunities which affect their performance as innovators, to identify actors who can overcome specific constraints or act on specific opportunities (http://www.fao.org/ag/againfo/programmes/en/lead/toolbox/refer/RAAKS.htm)

baseline report). Only the main documents were studied in order to understand what was planned by the OR programme in terms of activities, what was done so far with a special focus on the dissemination phase and what was assessed referring to the different evaluation reports produced since the project exists. The second part of the report is presenting the main findings of the literature review. This literature review informed the case study team for the organization and planning of the field trips and interviews organized early 2015. It resulted in the writing of a preliminary report, also compiling the results of the TARI workshop and the scoping visits in the intervention and comparable kebele. This preliminary report was shared with Irish Aid and the TARI team for comments and discussion.

- **Field trip in in Debrebirhan and Megab** – ***January/Febraury 2015***

Picture n°2: Farmer's Interview

Individual interviews with farmers (original beneficiaries, technology-adopters and non-adopters) as well as Focus Group Discussions (FGD) were carried out in January and February 2015 both in the intervention kebele Debrebirhan and the dissemination kebele Megab, as well as interviews with the Development Agents (DA). The farmers' interviews were based on questionnaires (see annex n°1) focusing on the way the OR programme technologies were adopted, how they impacted their livelihoods and how they influenced adaptation to climate change effects (technology adopters from both intervention and dissemination kebeles). For the non-adopters (both from dissemination and intervention kebeles), the interviews aimed at understanding the reasons of non-adoption and how they were impacting and coping with climate change challenges. Focus Group Discussions also helped to understand the process of dissemination. In addition, a two-way ranking FGD was applied with women and men to understand what are the main challenges for the crops which are important for their livelihoods (wheat, tomoato, potato, teff). Costs and Benefits Analysis were also used to interview adopters farmers from the dissemination kebele in order to identify and value the use of OR improved technologies, comparing with local seeds, looking at parameters like the price, the labour required, the production etc.

Picture n°3: Women farmer interviewed

The DAs were also interviewed to better understand their role in the dissemination process as well as their views on several issues related to agricultural development in a climate change context (water access, fertilizer, PSNP etc.).

In addition to the kebeles interviews focusing on the OR project and its dissemination phase, some TAMD track 1 scorecards with appropriate indicators were distributed to different agencies, ministries, governmental bodies identified with TARI as relevant stakeholders in agricultural development (Regional Agricultural Bureau, Woreda Agricultural Bureau, Regional Meteorology agency, Seed Enterprise Bureau etc..). These scorecards aimed at assessing the extent and quality of institutional processed and mechanisms for addressing climate-related risks through several types of indicators (climate change integration into planning, institutional coordination for integration, climate

information, participation etc.). For the case study, these scorecards indicated the level of climate risk management among relevant agricultural development stakeholders in Tigray and gave us the institutional background.

- **Workshop with IA and TARI team-** ***End of February 2015***

At the end of February, the case study team organized a meeting with TARI and IA representatives to present the results gathered and collected since November and to initiate discussions and comments on the work done so far. This meeting was the opportunity for IA to see what was achieved and discover preliminary analyses of the interviews findings but also to decide together what should be the next steps to finalize the case study.

- **Additional Cost and Benefits Analysis-** ***April 2015***

These cost and benefits analysis enabled the research team to interview 9 additional farmers in the dissemination kebele (Megab) and analysed in what extent the improved varieties compared to the local ones have supported the farmers in their livelihood improvement.

The main research methods and approaches used during the case study are the following:

- With and without approach
- RAKKS methods
- Focus Group Discussion
- Two way ranking Focus Group Discussion
- Individual Farmers Interview
- Cost and Benefits Analysis

1.3 ORP – secondary information review

The secondary information review was a first step to define the scope and understand the agricultural development system promoted by the OR programme as well as to set the basis to establish the theory of change of project.

In December 2014, key document reviews were carried out base on the documentation made available by TARI and Irish Aid for the case study. The documents used to carry out this secondary information review are the following:

- Evaluation Report, H.J.W.Mutsaers/Siseraw Dinku, June 2005
- 2007 Annual report of Food Security Operational Research and Capacity Building for Sustainable Livelihoods in Tigray, Gebrehiwot Hailmariam and Hagos Dory, July 2008
- Final Evaluation report, Roman Moges Asefaha, Ray Purcell, January 2011
- Tigray Agricultural Institute Operational Research for Technology Dissemination Project progress Report, October 2012
- Operational research technology dissemination project (ORTDP), Baseline survey, April 2013
- Irish Aid Operational Research Technology Dissemination Project in Tigray Annual Report (Technical and Financial) for the Period 2013/2014, July 2014
- Irish Aid Funded project Operational Research and Capacity Building for Food Security and Sustainable Livelihoods in Tigray, Ethiopia, Field day reports of 2007,2008,2009 and 2010

Some documents reported activities both in Tigray and the SNNRP (e.g. baseline survey, 2005

evaluation report): in this case, the review only focused on the Tigray project.

In 2003, the regional government of Tigray in partnership with Irish Aid, started watershed rehabilitation project in the degraded eastern part of the region. It successfully achieved its initial aim of physical conservation work. The watershed rehabilitation project changed the history of the area, reduced women burden and for the first time created green environment. The project has identified that watershed focused intervention was not enough to bring sustainable livelihood change and reduce poverty and food insecurity in the region. As a result, Irish Aid has started supporting the food security programs of the region through capacity building program.

In mid-2003 the Operational Research and Capacity Building Programme began its work in collaboration with University College Cork of Ireland, Mekelle University, Tigray Regional Bureau of Agriculture, Tigray Agriculture Research Institute (TARI) and REST (local NGO). Combined these institutions are referred as Mekelle Consortium and up until 2005 they were chaired by Mekelle University. One of the challenges identified in earlier study was that, the Consortium was initially weak as the frequency of meeting of the consortium were really low but this deficiency was filled by the dynamism of the technical committee formed by staff member of the consortium institutes, who were directly involved in the fieldwork. The consortium role was then to have conceptual discussion based on the technical committee reports. TARI has been involved in the project starting from 2007, replacing the coordination and supervision role of Mekelle University (2003-2006). TARI had the responsibility to coordinate the project and bring technical support. DAs (Development Agents) also played a role in selecting the farmers to participate to the project, based on their motivation, interest and ability to take risk to try new technologies. Final project evaluation report prepared in 2011 indicated that a significant improvement was made in the Consortium and working arraignment. The report also indicated that at the woreda level, there were good regional-woreda linkages that were a key to the effectiveness of the project at the operational level: the woreda teams were well responding to the challenge and opportunities provided by OR[7].

For the purpose of OR project two highly vulnerable kebeles Debrebirhan from Hawzen woreda and Begasheka were selected from Kola Tembien woreda which is found in the Eastern part of the region. After carrying out watershed rehabilitation in those woreda, the Ireland team in consultation with Mekelle University started to support researchers in Mekelle University to sustain the profound effect of the rehabilitation project. The OR project mainly focused on introducing new and improved agricultural technologies by the researcher in TARI.

The TARI OR project has been concentrated on crops and livestock research, NRM technologies and socio-economic analysis. Irish Aid supported OR Project in Tigray and SNNPR in two phases. The project started by providing support to farming inputs for the farmers and by creating farmers research groups who participated in selection of variety of inputs, agricultural interventions and technology evaluation. Some of the technologies introduced through OR are local innovations and others are introduced from some other area where the agro ecosystems are similar. Farmers also get training to practice and adopt new technologies from the project and share their knowledge to other farmer through FRG (Farmer Research group).

The project started in 2003 and it was implemented in two phases. Phase I focused on rehabilitation of watershed and Phase II on evaluation of agriculture technologies (trials of different technologies in crop and livestock production within the 2 selected woredas). Phase III of the project started in 2010 and it is currently undergoing. This phase of the project focuses on promoting a wider dissemination and adoption of tried and tested agricultural technologies. The technologies that have been chosen

[7] Final Evaluation report, Roman Moges Asefaha, Ray Purcell, January 2011, p.4

for dissemination were the most promising ones as well as the prioritized according to their capacity to make positive contributions on the following IA focal themes (dissemination criteria):

- Food security
- Nutrition
- Gender/social exclusion/poverty
- Climate resilience

The project beneficiaries were selected based on the pre-defined criteria in such a manner that disadvantaged groups (OR technology dissemination will target women and other marginalized groups, such as the landless, those living with HIV, and households with disabled people) of the farming community would be targeted by the project. The major selection criteria of beneficiaries were [8]:

- Household resource endowment (access to land, oxen ownership, availability of farm labour)
- Food security and nutritional status of the household
- Female headed household

Though the project started with an aim of benefiting 2,547 households directly by the dissemination program of both crops and livestock technologies in the first year of 2012, more than 4,146 households were reached by 2012. Out of these, 3,806 have received crop technologies and 340 are beneficiaries of the livestock technologies[9].

The key interventions from livestock were feed encasement, breed improvement of goat and sheep, modern beekeeping techniques, as well as introduction and evaluation of improved poultry breeds. Wheat, Maize, Teff, Sorghum, Finger millet, and Chickpea were the crop technologies selected for dissemination program. The technologies have been collected from different sources including regional and federal BoA and research organizations. Almost all crop varieties were obtained from regional sources mainly BoARD and TARI. Some crops such as Mekelle-1 and Gibie-1 were also purchased from farmers of the previous OR project sites and other farmers who were engaged in seed multiplication activities. ***There were also efforts to get additional seed.*** There was critical seed shortage for some of the crop technologies such as Natoli variety of chickpea, Mekelle-1 and 2 wheat varieties and Melkassa-6 and Gibie-1 maize varieties. As an example: 284.5qt of the above mentioned crops purchased and distribute to target beneficiaries and 70qt of Teff, Wheat, obtained from TARI[10].
Capacity building, trainings and awareness creation were key part of initial activities and In 2012 technical trainings of trainer were given to researchers, BoA staffs from the selected woredas and target farmers who received the OR technologies. Moreover, special training was given to farmers who are interested to work on seed multiplication activities. In addition to the formal training, some orientations and awareness creation activities have been performed to participating farmers on pre-extension popularization and PVS of crop technologies. As a result of TOT (Training of Trainers) the knowledge and skill of stakeholders enhance their knowledge on techniques of beekeeping and poultry production and management thereby transfer the skill to the beneficiary farmers.
The dissemination process is implemented through three different ways: Participatory Variety Selection (PVS), Popularisation and Scaling-out. One of the challenges of the project has been linking research and extension. The core rationale of the project is that it cannot be assumed that the promising outputs of OR research project activities will automatically be disseminated to farmers.

[8] Tigray Agricultural Institute Operational Research Technology Dissemination Project Tigray Annual Report 2012, October2012 p.8
[9] Tigray Agricultural Institute Operational Research Technology Dissemination Project Tigray Annual Report 2012, October2012 p.9
[10] Tigray Agricultural Institute Operational Research Technology Dissemination Project Tigray Annual Report 2012, October, 2012 P,10

Challenges in relation to improving access for agricultural technologies included[11]:

- Lack of well-functioning seed system
- The seed collected by the seed enterprise is far below the regional demand
- Farmers who signed contract with seed enterprise have limited awareness on the seed business and the price set by the enterprise is not encouraging for farmers to enter the business
- Shortage of supply for the livestock technologies
- Unless and otherwise the access and supply of technologies is improved the pace towards attaining food security would be in a weak position
- Difficult to increase the number of households graduating from the program every year
- Additional efforts are needed to keep the speed towards strengthen the technology supply system and deepening research and extension linkages

In order to address challenges associated with dissemination, The Operational Research Technology Dissemination Project (ORTDP) has been proposed as a continuation of the last two phases of the OR programme (established from 2003 to 2010). The programme goal is to enhance dissemination of appropriate technologies. One of the finding of the first phase of the project is that by 2010 over 40 technologies were judge to have been accepted in crops and livestock production by farmers and researchers. These technologies include 21 varieties of six cereal crops, 15 varieties of six pulse crops, two poultry breeds, two beekeeping technologies three feed technologies for sheep and goats, and various NRM technologies. The main forms of dissemination identified were[12]**:**

- Farmer Research Groups (FRG) bringing together groups of farmers to work with researchers on mutually agreed research and test potential solutions.
- Farmer Training Centers (FTC's) focal point for research and extension at the kebelle level. (Training, information, demonstrations and advices) but lacking operating equipment and inputs to carry out activities on demonstration farms. FTC's are a means for PVS processes
- FREGs (Farmer Research and Extension Groups) similar to FRG, they bring farmers together to work with researchers and extensions to analyse their own problems and experiments with different technologies and innovations; as well as for trainings and capacity building activities. Using of FRG and FREGs is depending on what exists in different technologies (e.g. beekeeping/poultry technologies for FRGs).
- Use of lead or model farmer is a new approach existing
- Popularization through farmer field days and farmer-to-farmer exchanges.
- Through direct beneficiary: farmer sharing varieties to two neighbouring farmers Seed multiplication
- Close collaboration between the project, BoA, and Ethiopian Seed Enterprise to capacitate seed producing cooperatives and promote seed production as an income generating activity due to shortage of supply for the early generation and certified seeds most of the time seed is transported from other regions which makes the delivery cost to be much higher and price of improved seed becomes unaffordable to the resource poor households.
- Mainly performed project activities give more emphasis to multiply seed of the major crop commodities (Wheat, Teff, Maize and Chickpea): 35% of these crops allocated for seed multiplication purpose.

Before the initiation of Phase III or The Operational Research Technology Dissemination Project

[11] Irish Aid Operational Research Technology Dissemination Project in Tigray Annual Report (Technical and Financial) for the Period 2013/2014 July,2014 P,6

[12] Irish Aid, Operational research Technologies dissemination project, September, 2011, p.9

(ORTDP), a baseline survey was commissioned by Irish Aid to have indictors to monitor future progress in dissemination and adoption by farmers of the improved technologies. A household survey questionnaire was done in 6 operational research programme woredas in Tigray regions with a total of 238 households. The survey was conducted in one kebele from each woreda. In each of them, the sample households included both participating (with some female headed HH) and non-participating households. In total, both in SNNRP and Tigray, the study sample of 514 HH with 53% of male and 47 % of female were done. The analysis of this documents helps to have an overview of the programme areas of Tigray in terms of livelihood profile and outcomes mainly. It is crucial to better understand and interpret later on the results we are going to find during the fields trips early January.

Based on the baseline survey, the number of households engaged in either off-farm or non-farm activities were minimal, only 1%. Sales of cereals crops seems to be the most common income source with 24% of the households, followed by petty trade with 21% of the households, livestock sales 17% and horticulture 16%[13]. Female-headed households are more engaged in all occupation than male (11% compared to 2%). The baseline result also indicated that land is the single most important livelihood asset in rural, predominantly agricultural economy. Livestock holding were also crucial part of the livelihood strategies for production of food for both household consumption and sale. Breeding, fattening and trading in livestock are lucrative sources of cash income for rural households.

Studies have shown than the project has achieved some level of success. Final project evaluation done in 2011 also identified there had been improvement in food security.[14] The Impact Study found that 64% and 70% of the direct beneficiaries of OR activities in Begasheka and Debrebirhan respectively were able to cover more than 50% of their household food demand from their own production. This compared with 57% and 55% for indirect beneficiaries, and only 21% and 24% for the non-participant control group. Annual farm incomes of direct beneficiaries were found to be more than double those of indirect beneficiaries and non-participants. According to the report, the extent these results are attributable to OR is still somewhat unclear but the DAs ensure that farmers get the required amount of fertilizers, and follow up on the production of farms; they also provide technical support on the use of the improved seed. It is highly likely that the inputs the DAs referred to are connected to the variety testing activities introduced by OR.

The Impact Study did find that farm income, educational status, sex of household head and adoption index were all statistically significant explanatory variables of the differences in food security status between the different groups. In particular, the more adoptive farmers were more productive and efficient as a result of using improved technologies, which in turn helps them to be more food secure. The most frequently cited livelihood benefits relate to improved food security, either through improved self-sufficiency or increased ability to buy in food, the ability to send children to school and to buy clothes and household items, and investments in house building and improvements.

2. Theory of change

Establishing a Theory of Change (ToC) is a crucial step in applying the TAMD framework. As a roadmap identifying the expected changes in a process pathway, a ToC defines all the steps required to achieve a given long-term goal. It draws out the causal mechanisms that lead from specific inputs and activities to desired outcomes and impacts. In order to establish the case study ToC, the research team held a

[13] Operational research technology dissemination project (ORTDP), Baseline survey, April 2013,p.17
[14] Final Evaluation report, Roman Moges Asefaha, Ray Purcell, January 2011, p.11

one day workshop with the TARI researchers and conducted scoping visits in communities to better understand the background in terms of climate change, OR activities and more generally the agricultural development system.

2.1 TARI workshop: functioning of the agricultural development

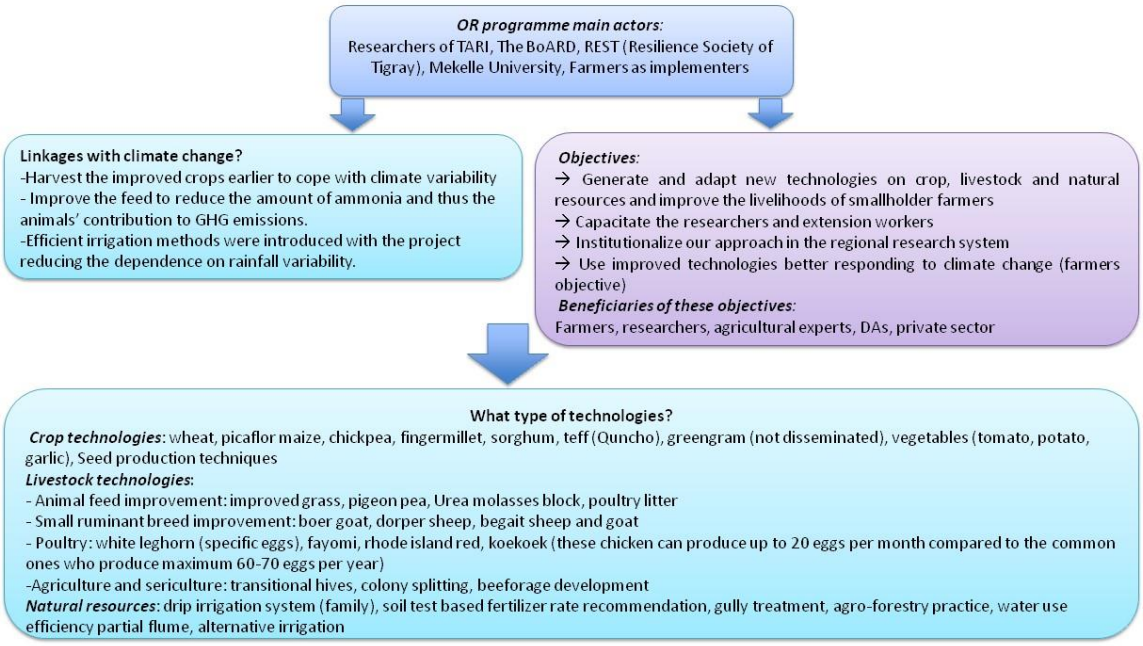
A workshop was organized with the TARI researchers to inform the broader ToC of the case study. The overall goal was to begin to understand how, from the TARI researchers perspective, research is supporting development by providing options to adapt in the climate change context. We looked at the inputs of the OR programme as well as their planned outputs and outcomes. A brainstorming was initiated with the TARI researchers to develop an over-arching description of the agricultural development in Tigray as well as to start map out the stages of the OR programme and how farmers within and outwith the OR process are adapting to increased climate variability.

Agricultural development in the Tigray region is institutionally supported through an annual innovation platform called ARDPLAC (Agricultural Development Partners Linkage Advisor Council)[15] where TARI's role is to identify the problem observed in farming communities, and set proposals to respond to these problems to then monitor and evaluate these proposals. An interactive group exercise helped to identify the different components and steps of the OR programme as well as the current local adaption processes to climate change challenges. A full workshop report has been produced presenting in detail the discussions findings.

The diagram below presents the rationale of the OR project according to TARI researchers. It indicates what are the main actors involved in the OR Programme including the beneficiaries of the programme, the objectives as well as the different technologies disseminated (livestock, crop and NRM). The discussions with the TARI researchers also clarified the role of climate change in the improvement of the technologies as shown in the figure 1.

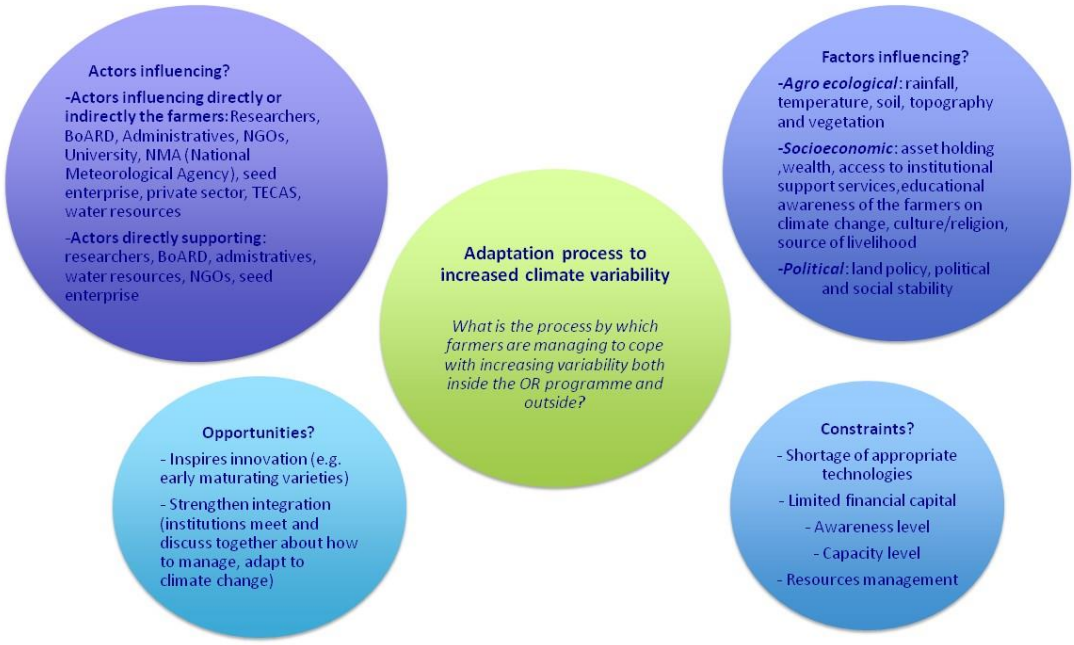
[15] The ARDPLAC includes several different actors: - Regional administration/government Agricultural Bureau (cooperatives, NRM, extension, livestock), Bureau of Water resources Research institutes/centres, Farmers at kebele level, University, NGOs, seed enterprise, TAMPA, TVAT

Figure 1: OR programme ToC from TARI perspective



In a second phase, adaptation mechanisms coping with increasing climate variability were discussed with the researchers: identifying actors involved, factors influencing as well as existing constrains and opportunities – these are illustrated in figure 2.

Figure 2: Factors affecting adaptation mechanisms



2.2 Scoping visits

The scoping process gathered evidences from the visits to communities (with farmers and woreda experts) and enabled to give a context to the Theory of Change. These visits gave an insight of what types of climate hazards are experienced in the area and how they are impacting the communities. A scoping field trip was organized on the 9Th of November 2014 in Hawzen woreda both in the operational research kebele (Debrebirhan) and in its comparable kebele[16] (Degum) in order to apply a with and without approach through focus group discussions (FGD). The goal was to understand how climate change is affecting the communities and how are they coping with the different hazards in a kebele benefiting from the OR and a kebele which is not. These FGD, including both men and women, were used to understand how the Tigray farmers perceive and are impacted by climate change but also how they deal with it. Three methods were used to determine the severity of the climate risks: seasonal calendar, rain calendar and historical profile of the area. They helped to identified droughts, hailstorm, strong wind and rainfall variability as main climate hazards.

Table 1: Hazards prioritization and related impacts

No.	Hazard	Impacts of the hazards
1.	Rainfall variability	Less production of crops, fruits in yield; Shortage of livestock feed; Crop disease (crop rest)
2.	Hailstorm	Destroy crops on the farm land; Damage livestock feed and fodder; Damage crops on the farm lands
3.	Drought	Food insecurity; Malnutrition; Health problem; Loss of lives of livestock; Migration of people with their livestock in search of water to other woredas or other part of the region
4.	Strong wind	Damage crops on the farm land especially Barley; Damage their physical capital such as house, school healthcare centre and so on; It can also damage perennial fruits such as Banana

In addition to the prioritization of climate related hazards, the FGD discussion gave information about how the main livelihood capitals (financial, social, physical, natural and human) were impacted - *detailed results are presented in the table below p.17*. The farmers seemed to clearly perceive and understand climate change and its consequences for their livelihoods and according to them, the challenges due to climate change are getting lower. Some scoping interviews were also carried out with woreda experts (crop expert, livestock expert and extension service expert) to get additional and complementary inputs and information. These experts have close ties with the farmers, therefore it was interesting to have their perspective on the OR programme and especially on the dissemination phase. The detailed results of the interviews are available in annex n° 2. The main findings are the following:

→Woreda experts are involved in the farming system through support to farmers (training, knowledge sharing)

→Climate change is clearly perceived by the woreda experts especially through rainfall variability and it has impacts for crop and livestocks. Weather forecasts are used to cope up with climate risks

→ Farmers get information about improved farming technologies through different channels (research centre, bureau of agriculture, NGOs)

→ Dissemination of technologies happen through technology effectiveness and technology demonstration process

[16] The term « comparable kebele » refers to a similar kebele than the project one but not benefiting from it.

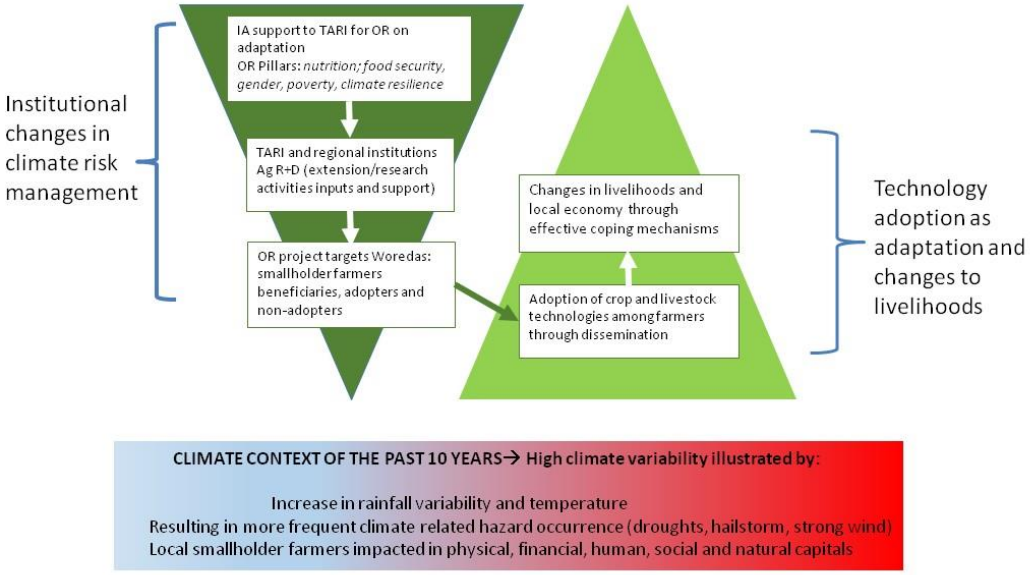
→ *Improvement have been observed in crop and livestock technology adoption though time as farmers are participating more.*

Table 2: Linkages between climate changes and livelihoods in Debrebirhan and Degum

Livelihood resources	Intervention and comparable kebeles	Impacts	Indicators	Some of other changes affecting their livelihood (risks and assumptions)
Natural Capital (Land, Water, Forest)	Debrebirhan	Low production, Increase number of weeds, Soil fertility	Increase hectare of land covered with weeds Increase hectare of land that loss soil fertility	
	Degum	Farm land loss soil fertility, Low production, Increase number of weeds, Increase loss of ground water volume	Farm land loss soil fertility, Low production, Increase number of weeds, Increase loss of ground water volume	Increase hectare of land covered with weeds Increase hectare of land that loss soil fertility
Physical Capital (School, Health post, Health care centre, Irrigation scheme, Hand pump well, road, Market place, Weather station, SWC work)	Debrebirhan	Strong wind damaged , FTC, school rooms, and health care center	1 FTC damaged, 2rooms of school	**Distance to market:** There is no problem especially distance to market the market place is nearby to our community
	Degum	Strong wind damaged, FTC, school rooms, electricity transformer and health care center	1 FTC damaged, 4rooms of school, 1health care center, 1transformer	
Financial Capital (cattle & their products, Savings and credit, Crops/grains, Casual lab or, Remittances)	Debrebirhan	Price fluctuation especially to sell major and minor crops	Especial wheat of the area named Meklle one its price vary Tomato during high production time sell up to 1ETB/1kg	**Price fluctuation:** The price fluctuation is the main problem especially in the production of tomato we produce too much tomato so we have always faced a problem of supply and demand
	Degum	Price fluctuation especially to sell livestock during dry season		
Human Capital (Education level, health status)	Debrebirhan			**Food security and Nourishment** The main problem of the area is food insecurity and malnourishment
	Degum	Health problem		
Social Capital (customary institutions, Associations, Relief aid	Debrebirhan	No impact on our social network or the customary institution even they help us to handle the problem		
	Degum	No impact on our social network or the customary institution even they help us to handle the problem		

2.3 Detailed ToC

Figure 3. Theory of change as a basis for the case study



From the exploratory activities with TARI researchers and consultations with local people in targeted communities the team developed the ToC using the TAMD framework. This is shown in figure 3 above. It provides the basis for the next steps in the case study.

3. Defining and constructing the indicators

Indicators are metrics that are used to measure change. They can be used to describe a situation to monitor the evolution of a situation and/or measure achievements against an objective[17]. For the Tigray case study, indicators have been selected to better analyse the two TAMD tracks processes: climate risk management at institutional level and adaptation outcomes at community level.

3.1 Track 1 – Institutional aspects of climate risk management

The Track 1 indicators are used to assess the extent and quality of institutional processes and mechanisms for addressing climate-related risks[17]. The table below presents the types of indicators used with the several regional institutions that have been interviewed to better understand how they manage climate risk.

Table 3: Track 1 indicators used with the different regional institutions

Institutions	Type of Track 1 indicators
Tigray Agriculture Research Institute	i. Climate change integration into planning ii. Institutional coordination for integration iii. Budgeting and finance iv. Use of climate information v. Participation of stakeholder vi. Uptake of CRM measures
Regional Metrology Bureau	i. Climate change integration into planning ii. Institutional coordination for integration iii. Budgeting and finance iv. Use of climate information v. Participation of stakeholder
Regional Water and Resource Bureau	i. Climate change integration into planning ii. Institutional coordination for integration iii. Budgeting and finance iv. Use of climate information v. Planning under uncertainty vi. Participation of stakeholder
Regional Agriculture Bureau	i. Climate change integration into planning ii. Institutional coordination for integration iii. Budgeting and finance iv. Use of climate information v. Participation of stakeholder

[17] TAMD Step by step guide, December 2014, p.26

3.2 Track 2 – technology adoption, cost benefit analysis of adoption, livelihood changes

For the Track 2, focusing on adaptation and development performance, the aim was to highlight progress and to measure change in:
→ Technology adoption (economic value of improved technologies, dissemination process)
→ Livelihood (changes occuring)

The objective was to observe these changes under the recent climate change context to analyse if the farmers indeed managed to adapt to emerging risks due to increased climate variability and to thus be more resilient. To understand if farmers managed to adapt to climate change, there was a need to verify if livelihoods have been improving while climate challenges have been increasing.

The TAMD framework uses 3 types of indicators under Track 2:

- Resilience indicators (1)
- Well-being indicators (2)
- Climate hazard indicators (3)

(1): ***Resilience indicators*** seek to capture the ability of people and systems to anticipate, avoid plan for, cope with, recover from and adapt to stresses and shocks, with emphasis varying depending on which term/concept is used. They describe characteristics or attributes of people or systems that affect their propensity to cope with or be harmed by shocked and stresses[18].

(2): ***Well-being indicators*** represents costs in terms of assets, livelihoods and lives as a result of climate relates shocks and stresses and other aspects of human wellbeing that could be undermined by climate change[19].

(3): ***Climate hazard*** indicators are required to identify and track trends and variations in climate hazard that may complicate the interpretation of wellbeing indicators. They represent the hazards that are most relevant to the adaptation context being assessed[20].

The table below presents the types of indicators used to understand and analyse the climate change context, the technology adoption process, the changes in livelihoods and therefore the level of adaptation for the farmers. These indicators aimed at assessing the outcomes and impacts of the OR programme.

[18] TAMD Step by step guide, December 2014, p.29
[19] TAMD Step by step guide, December 2014, p.34
[20] TAMD Step by step guide, December 2014, p.35

Table 4: Track 2 indicators selected

<table>
<tr><td colspan="3">CLIMATE CHANGE CONTEXT
Climate hazards indicators:
- Average annual temperature
- Number of hot days during the past 20 years
- Average annual rainfall
- Average seasonal rainfall
- Types of hazards experienced in the recent past years (drought, hail storm etc..)</td></tr>
<tr><td>Types of indicators:</td><td>Technologies adoption
(Dissemination and CBA)</td><td>Livelihoods changes</td></tr>
<tr><td>Well-being indicators:</td><td>- Number of labour employed at the farm
- Amount of livestock
- Number of farming equipment
- Number or percentage of households with their own land
- Number or percentage of household with irrigated farm land
- Average costs of new technologies needed
- Quantities of expected surplus from sale of products (increase income)</td><td>- Increase in food security status
- Increase in income
- Increase in assets
- Ability to send children to school
- Ability to hire additional labour if needed
- Amount shared/rented lands</td></tr>
<tr><td>Resilience indicators:</td><td>- Number of new technology/ varieties adopted
- Number of years adopted the technologies
- Means to access new technologies
- Level of Idiosyncratic factors of the household</td><td>- Level of graduation out of PSNP
- Amount of crops proportion marketed</td></tr>
<tr><td colspan="3">ACHIEVEMENT: ADAPTATION – RESILIENCE</td></tr>
</table>

4. Measuring the indicators

4.1 Institutional climate risk management: Track 1 Scorecards results

The results presented in this section are based on the finding from Track 1 Climate Risk Management scorecards that have been completed by several stakeholders (regional and local institutions) early in 2015. The results are summarized in two tables: the first one presents results from regional and woreda level institutions and the second table shows results from seed enterprise bureau. The assessment of different key stakeholders or institutions was important for the research and dissemination phase of improved technologies in the watershed. The detailed results of the scorecards' indicators are available in annex n°3.

Institutional scorecards were conducted at the regional, woreda and bureau levels to understand the institutional context of managing climate challenges. At the regional and woreda level, the assessment shows varying level of capacity in managing climate risks. Table 3 summarizes the scorecard results of the regional and woreda level. The main focus of the assessment of seed enterprise bureau is to clearly understand the process of improved seed dissemination and the support of the bureau to the farmers.

Based on Track 1 scorecard results, we see that interviewed institutions have in place climate change strategies. Various numbers of initiatives were taken in the past years to reduce climate risks for instance: watershed management work mobilized by the government and the PSNP program of "work for food". However, the extent to which climate risk management is coordinated across relevant institutions is minimal.

In terms of budget, except for the Regional Bureau of Meteorology and TARI, the rest of the institutions do not have allocated specific budget to mainstream climate change or to cover the cost of pilot measures that can address climate change. The Regional Bureau of Metrology has 'stand-alone' responsibility for the issues related with climate and its challenges in the region. TARI, as an institution responsible for research and dissemination phases of improved crop varieties, actions in response to climate change is one of its four pillars. Their main source of information comes from the National Meteorological Agency (NMA) and little use of external information sources (e.g. IPCC). The Water Resource Bureau has little institutional capacity for decision-making to address climatic uncertainty and therefore there is the risk that some planning can lead to maladaptation. There is stakeholder engagement in decision making to address climate change but with very limited quality of participation across different level of governmental and non-governmental institutions.

In addition to those institutions assessed shown in Table 5, we also examined the role of the Seed Enterprise Bureau. The bureau is an important stakeholders that can add a value to the dissemination phase of the OR project supporting disbursement of improved seeds in the woreda. The bureau has a plan to involve in integrated work of seed multiplication activities which is based on the regional seed demand in terms of kind amount and variety of crops needed for the next production year or production season. Their collaboration work with the Woreda Agriculture Bureau is helping to create strong linkage with the bureau and easily understand each other in terms of needs and priorities. Currently, the seed enterprise bureau has limited number of farmers who actively work with them but they plan to increase the number of farmers in order to increase the seed production capacity.

Table 5: Results of Track 1 scorecards [colour coding - climate change is integrated; no or little climate change integration; no information found]

No.	Indicator	Regional Water and Resource Bureau	Regional Agriculture Bureau	Regional Metrology Bureau	Hawzen Woreda Agriculture Bureau	TARI Researcher
1.	**Climate change integration/ mainstreaming into planning**	There are climate change strategies that embedded in the principal planning document of the bureau.	There is minimal representation of plans that address climate challenges in the preparation of principal planning document.	There are climate change plan/strategies and adequate enough initiatives and specific measures to address climate change	There are climate change strategies that embedded in the principal planning document of the bureau.	There are strategies that address climate change integration into the planning document.
2.	**Institutional coordination for integration**	There are good integration with Environment and Protection Authority, Land Administration, REST, IFAD and AGP. However there are still some gaps in the extent and quality of coordination and integration.	The extent to which climate risk management coordination across relevant institutions are minimal.	There is coordination of climate risk management across the relevant institution but no regular contact between the institutions.	The extent to which climate risk management coordination across relevant institutions are minimal.	The extent to which climate risk management coordination across relevant institutions are minimal.
3.	**Budgeting and Finance**	Funding is available to pilot some measures which can address climate change but there are no specific fund to support mainstreaming of climate change and no particular or direct actions are taken to address climate change. However, the bureau allocates 32.2% of the budget for water well construction activity.	No specific fund is available to cover the cost of pilot measures or related initiatives, which addresses climate change.	Funding is available for climate change mainstreaming processes and various piloting measures.	No budget or financial support for mainstreaming climate change.	Funding is available for climate change mainstreaming initiatives.
4.	**Use of climate information**	Less use of climate information and no access to climate information generated by foreign and international organizations.	The extent to which climate information used is minimal.	There are access to use climate information, the information are based on national level metrology.	Less use of climate information and no access to climate information generated by foreign and international organizations.	Less use of projection, access to climate information generated by foreign and international organizations and information from external sources.
5.	**Planning under uncertainty**	There is low institutional capacity for decision making which leads to the problem of 'maladaptation' to happen. For instance; 25% of the well water non-productive and 5.1% is non-functional.				
6.	**Participation**	Less quality of stakeholder engagement in decision making to address climate change.		Less quality of stakeholder engagement in the decision making process.	Good level of participation across different level of government and non-government institution.	Stakeholder engagement in decision making to address climate change is of good quality.

4.2 Track 2 Results: climate hazards, technology adoption and livelihood changes

The Track 2 results present the outcomes of the farmers' interviews and Focus Group Discussions (simple and two-way ranking) carried out in both the OR intervention and dissemination kebeles as well as the secondary information review (climate data, socio-economic data). The main goal of these interviews aimed at properly understand the OR programme technology adoption process from perspectives of the smallholder farmers and to assess relevance to climate adaptation. The interviews were carried out with original farmers beneficiaries, technology adopters and also non-adopters both in the OR original kebele (Debrebirhan) and the OR dissemination kebele (Megab). The questionnaires used for the interviews and focus group discussion are available in annex n°1. Based on the various indicators listed in part 3 related to climate hazard, wellbeing and resilience; the following issues are analysed in this section:

- Climate hazards and variability over the past 20 years
- Technology adoption (process, Internal and external drivers, costs and benefits)
- Livelihoods changes resulting from the technology adoption

This section presents the results and the first conclusions that can be drawn out of them. Their signification is discussed in the Part 5.

4.2.1 Climate Change context

Insights of the Climate hazards experienced in Hawzen woreda- reminder of the scoping visit observations:

As presented in details in part 2 .2 (scoping visits), several climate hazards have been experienced during the past few years, impacting livelihoods in different ways. Rainfall variability, hailstorm, drought and strong wind were the main types of hazards impacting natural, physical, financial, human and social capitals.

Picture n°4: Farmers' Focus Group Discussion

In addition to the climate hazards experience collected with the communities during the scoping visits: the average annual temperature, number of hot days during the past 20 years, the average annual rainfall and the average seasonal rainfall have been collected from meteorological station of Hawzen woreda. The main observations are depicted below.

Climate Data Observation over Hawzen woreda:

- **Rainfall**

Analysis of the Hawzen woreda climate data available from National Metrological Agency shows the trends of seasonal and annual rainfall distribution, anomalies of Hawzen and the average day's

temperature. The main rainy season for Hawzen woreda starts from June to September (kiremt) and contributes up to 69% of its annual rainfall. The second short rainy season is March to May (Belg) and contributes up to 21%. The region has a bi-modal type of rainfall (figure 3). The annual average rainfall is 884.5mm with a range of 576.2mm - 1126.7mm. The peak months are March, for Belg season, July and August for the main rainy season which is kirmet, an average rainfall of 60.7mm, 224.8mm, 216.9mm belg and winter season, respectively.

This analysis examines the observed climate patterns and the trends at Hawzen woreda

Figure 2: Mean monthly rainfall over Hawzen

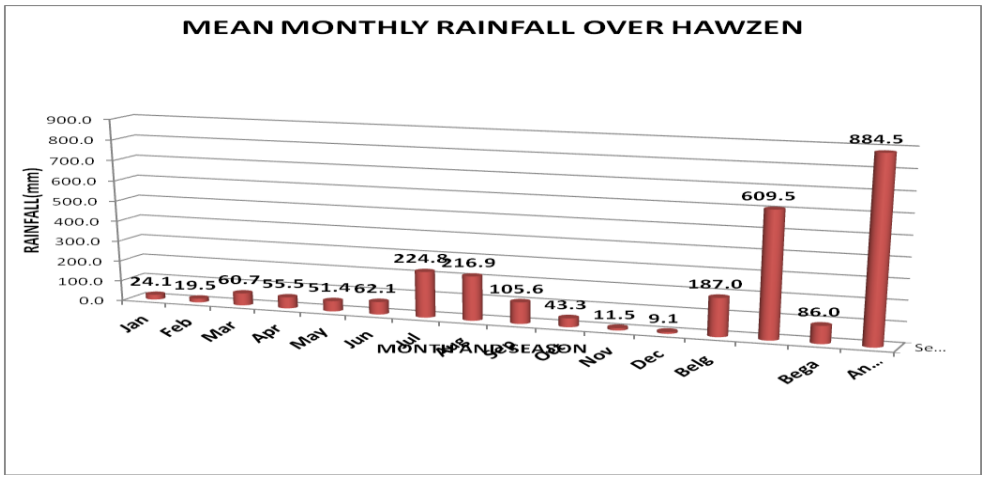
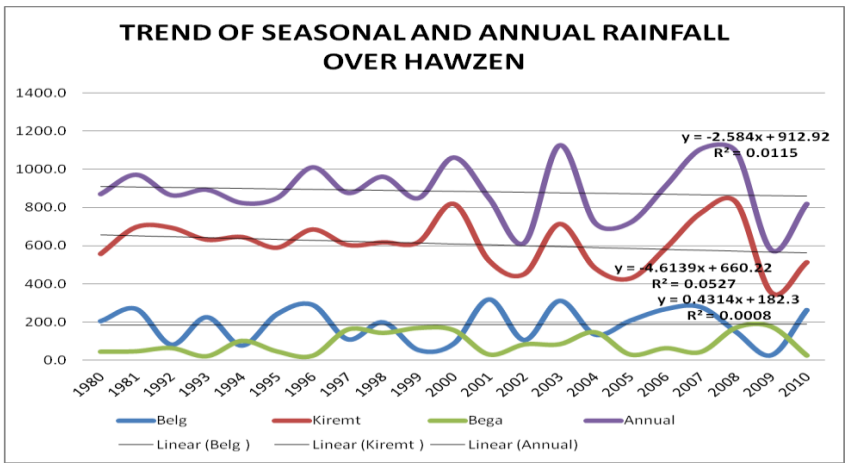


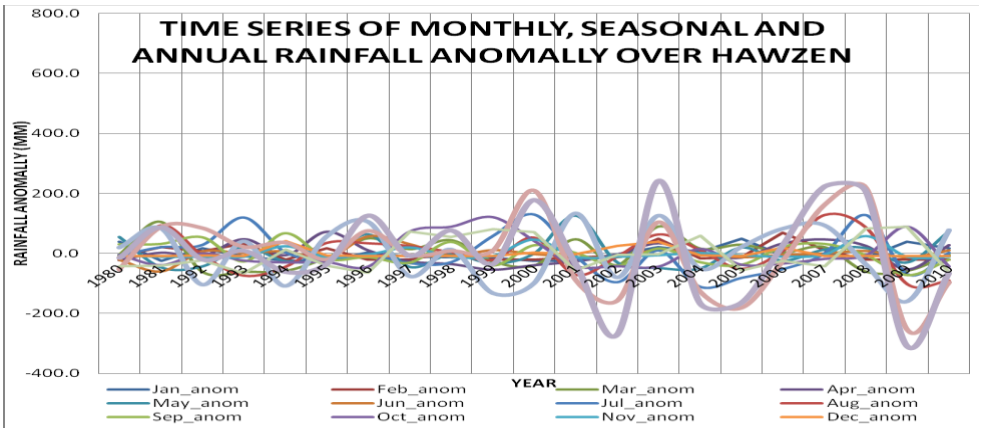
Figure 3: Trend of seasonal and annual rainfall over Hawzen



The trend of the rainfall indicates that the annual and kiremt rain is showing a decreasing trend. However, Belg, which has nearly 20% of the annual rainfall, has shown an increasing trend. These changes are not statistically significant.

Figure 5 illustrates monthly, seasonal and annual rainfall anomalies for the year from 1980 to 2010. In line with what is evident over much of the country, it has high variability across different time scales. Even though the variability is common since the 1980s and 90', starting from 2000, however, it shows a much higher variation from year to year.

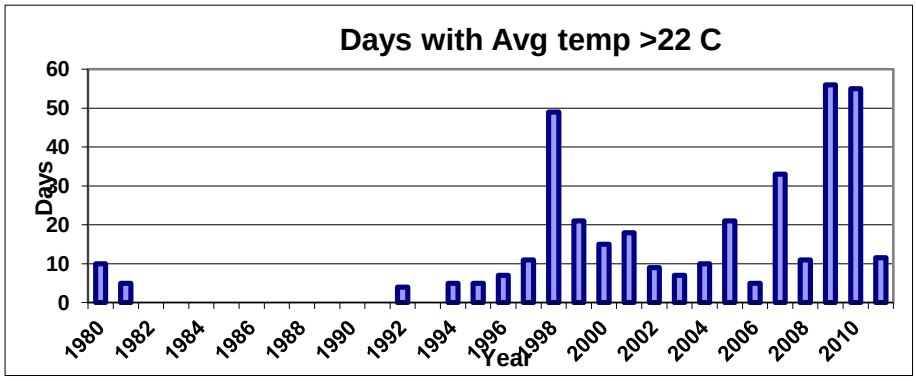
Figure 4: Rainfall anomaly over Hawzen



- **Temperature**

According to Ethiopia's NAPA, 2007 average annual mean minimum temperature throughout the country indicates an increase of 0.37 °C every decade. The following graph shows days with average temperature of above 22 °C in the year between 1998- 2010. The average temperature, which is a clear indication that hot days are becoming more frequent.

Figure 5: Days with average temperature above 22°C



4.2.2 Technology adoption

This section presents the evidence on the technology adoption process. It looks at the types and number of technologies adopted, the processes, and the reasons for adoption by answering four main questions:

1. What technologies have been adopted and why?

2. How did the technology dissemination happen?

3. What are the additional costs and inputs needed for implementing OR technologies

4. What are the Cost and Benefit in investing in improved technologies?

1) What technologies have been adopted and why?

To answer this question, the following indicators are used: number of livestock; number of new technology/varieties adopted; number of years the technologies are adopted; level of idiosyncratic factors of the household. The evidence from 2-way ranking exercises also helps to better understand the *what* and *why*.

- Types of technologies Adopted

In the initial kebele Debrebirhan, it is estimated that more than 80% of Smallholder farmers are cultivating improved varieties and in the dissemination kebele Megab approximately 94% of the farmers adopted OR technologies[21].

Adopter SHF are likely to be progressive farmers, more wealthy farmers, owners of farming equipment (like drip irrigation, wells, motor pumps), and have good social ties in the neighbourhood.

The following table summarizes the technologies adopted by SHF in the initial and dissemination kebeles:

Table 6: Technologies adopted in the kebeles

Initial kebele (Debrebirhan) OR initial kebele (5 original & 5 adopters)								**OR dissemination kebele (Megab) (5 adopters)**			
# of Livestock's		**Improved Crops**		**Vegetables**		**Fruits**		**# of Livestock's**		**Crops**	
Cattle	62	Wheat	9 farmers	Tomato	2 farmers	Apple	1 farmer	Cattle	5	Wheat	5 farmers
Cow	8	Teff	4 farmers	Onion	2 farmers	Mango	1 farmer	Cow	6	Teff	4 farmers
Ox	5	Maize	3 farmers	Potato	9 farmers	Avocado	1 farmer	Ox	9		
Sheep	86			Sweet potato	3 farmers	Orange	3 farmers	Sheep	54		
Goat	-			Lettuce	1 farmer	Guava	3 farmers	Goat	4		
Poultry	75			Pepper	1 farmer	Papaya	1 farmer	Poultry	55		
Calf	2			Chickpea	5 farmers			Calf	1		
Heifer	1							Heifer	1		
Donkey	7							Donkey	6		

- Reasons for technology adoption (why?)

Both in the initial and dissemination kebeles, SHF reasons for adopting improved varieties from the OR project were the following:

[21] DA's interview

- Increased yield - reports of doubling Wheat and Teff production
- Fruit production - additional income (up to 5000 birr/per year)
- Some improved varieties are early maturing and/ or draught resistance, which helps to cope better with erratic and foreshortened long rains.
- Irrigation allows dry season production of Tomato, Potato and Onion etc.
- High adaptability (soil-related, early maturing)
- High disease resistance
- Grain bigger than the local varieties

The profiles of the SHF are major drivers of adoption and implementation of technologies into practice. The large majority of early adopters were selected by the OR project to become intervention or dissemination targeted farmers. According to TARI and the DAs, there was emphasis on poorer farmers and women. Adopters are those able to acquire the necessary supporting technologies, have more family labour for farming activities, and those that have the capability and willingness to share-crop or rent land.

Non-adopters were seen to have smaller plots, and less capacity and willingness to share-crop or rent land and to hire labour. In some cases, weak social ties kept these SHF apart from farmer to farmer exchanges important for adoption. Idiosyncratic factors also reduce capability to adopt in some cases e.g. being widowed women headed households.

- Duration of the adoption process

In the initial intervention kebele (Debrebirhan) targeted by the OR project, some of the improved varieties were adopted in 2008 when the project started. While in dissemination kebele (Megab) the earliest date of technology adoption is 2011.

Early technology adoption has allowed some SHF to become specialized as seed multipliers. This has contributed to improvements in SHF livelihood, but also stronger resilience at the community level due to better improved seed access and therefore wider opportunities to use early maturing varieties that suit the changing climatic conditions.

- Idiosyncratic factors affecting adoption by the household

SHF household profiles are one of the major factors in technology adoption. However, there are other factors that push households to adopt. Idiosyncratic factors of the household vary from family to family. In some households negative idiosyncratic factors (e.g. losing a husband or wife, having physical disability) can be a reason for not adopting and but in some households it could be the reverse. We found cases of both in the survey. In the initial kebele (Deberbirhan) one of the interviewees rom the non-adopting farmers justified her non-adoption of technologies by the fact that her husband is sick and paralyzed. She is relying on PSNP to feed her family and one of her child supports her in farming activities. However, we also identified cases of women-headed households that had adopted and benefited from improved varieties.

- Two Way Ranking results

The two-way ranking at FGD helps the community to examine and prioritize problems and solutions. In the case study ranking was carried out by the key informants of the initial kebele. It was conducted taking into account gender to determine different preferences.

Participants prioritized improved crop varieties for their livelihoods, they then identified shared problems and prioritized these. Crop varieties were ranked according to how well they enabled SHF to overcome the problems identified. In addition of the ranking, participants briefly summarized the main reason of the problems to happen. The results are given in the table below.

Picture n°5: Two-way ranking materials

Table 7: Two-way ranking results

Problems	1st Wheat	2nd Tomato	3rd Potato	4th Teff	5th Chickpea	Reason
Rainfall variability	**	**	**	*	*	Shortage of rainfall
Soil fertility	***	***	***	***	***	Poor soil management work of the farmers
Supply of improved seed	*	*	*	**	**	Shortage of seeds, not available, very expensive to afford and no credit

***: High priority **: Medium priority *: Lowest priority

Pictures n°6: Two way ranking Focus Group Discussions

2) How did the technology dissemination happen?

Dissemination of the OR technologies happened through various mechanisms. The most important means to access new technologies for SHF from both kebeles are summarized in the Table 8 below:

Table 8: Dissemination mechanisms

Debrebirhan	Megab
- On-farm research (OFR) changed farmer perceptions of improved varieties food and cash crops - Demonstration activities: through development groups lead by one leader farmer and field day - Farmer to farmer (F2F) it is more successful in dissemination kebele involving risk-averse SH farmers – "seeing is believing" - Advisements between farmers - Local seed multipliers - trusted seed sources - Comments: men seem to be too proud sometimes to come and see women + jealousy between women	- Field days (formal experience sharing - farmers traveling to initial kebele to share experience with original beneficiaries) - FTC (Farming Training Centres): the dissemination kebele farmers purchase seeds from FTC, Seed/eggs exchange between adopters and farmers willing to adopt + advise between farmers - Through cooperatives - Agricultural Bureau (technical support) - Listening from media (Radio)

3) What additional costs and inputs are needed for implementing OR technologies?

In order to implement OR technologies, additional costs accrue and inputs are needed. The main ones mentioned by the SHF of the two kebeles are listed in Table 9 below.

Table 9: Additional costs and inputs

Debrebirhan	Megab
- Irrigation equipment - Communal well - Fuel for the pump - Inorganic fertilizer	- Inorganic fertilizer, additional labour to be hired for -various crop management practices - Veterinary service for poultry, - Feeding of the livestock.

Implementing OR technologies also requires more labour compared with the local cultivars. Table 10 shows the summary of the quantitative findings of both intervention and dissemination kebeles including additional labour and farming equipment required.

Table 10: Additional labour force and type of households

Quantitative result of the interview	Debrebirhan (Intervention kebele) Number of interviewee 10	Megb (Dissemination kebele) Number of interviewee 6
Average family size	7	7
Average number of family engaged in farming	4	3
Number of HH who hire labor	7	1/6
Average hectare of land owned	0.68ha	1.0833Ha
Number of farmer share crop	7	4
Average hectare of irrigated land	0.18575ha	No irrigation
Farming equipment		
Plough	All the interviewer has two sets of ploughs	All the interviewer has two sets of ploughs
Water motor pumps	12	1
Sickle	6	-
Treadle pump	-	2

4) What are the Costs and Benefits of investing in improved technologies?

Cost-Benefit Analysis (CBA) was used in the case study to assess how improved varieties have performed in spite of increasingly negative impacts of climate variability. Cost-benefit analysis is an economic analysis to aid decision-making used to evaluate the desirability of a given intervention or interventions. It is a method of checking if a given investment is worthwhile. The method compares all costs and benefits that can be expressed in monetary terms. To indicate the most efficient method, cost-benefit ratios for improved varieties as adaptation strategies were compared. Cost and benefits interviews were carried out in the dissemination kebele (Megab) with 9 OR technology adopting-farmers in order to understand the contributions and impacts of the OR crop varieties technologies in terms of economic returns. The methodology of the CBA as well as the main findings are presented below (questions used for the CBA are presented annex n°6).

- Conceptual Framework of CBA and methodology

The conceptual framework was developed on the basis that climate change (especially rainfall variability in terms of its amount and timing) has negative impact on the amount of crop production. To enhance this situation, households adopt improved varieties, which have high yields and are early maturing and drought tolerant. Therefore, the benefits of this adaptation strategy (improved varieties) over the local varieties which where assume to have low yield, late maturing were compared though CBA in interviews.

The CBA compared improved and local varieties of wheat, maize and Teff grown by nine households in Megab Kebele (dissemination kebele). It analysed adaptation strategies in terms of effectiveness and economic returns. Data were obtained from the 2014 cropping seasons. The data were collected using personal interviews through structured questionnaire and triangulation with secondary data. A Cost-benefit analysis for the three improved varieties (Wheat, Maize and Teff) was conducted using cost-benefit ratio (CBR). When the CBR ratio is low the benefit is higher than the cost of production.

The detailed costs and benefits crop production account of nine interviewed farmers are taken as an average to arrive at the representative total costs and total benefits, which is necessary to calculate CBR. Thus, the following formulas are used in analysis:

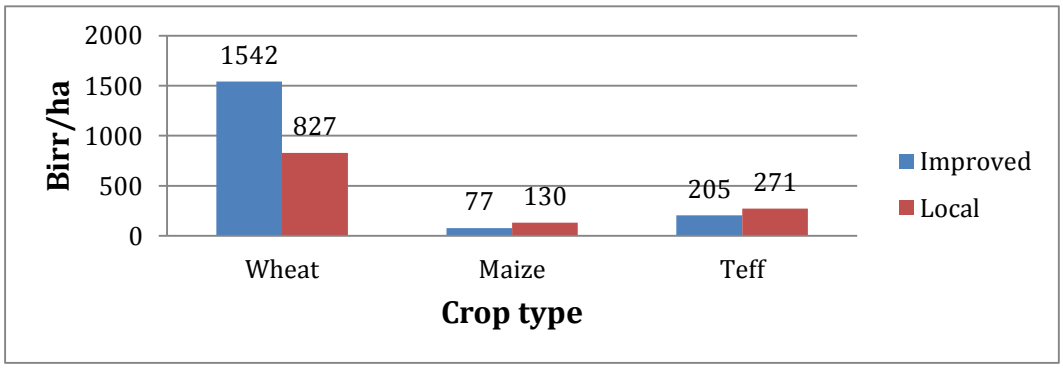
- Seed Cost (SC) = the average cost of a seed per hectare of improved / local variety (Total seed cost per hectare incurred for a variety by farmers over number of farmers)
- Management practices cost (MPC) = the average cost of crop husbandry practices per hectare such as land preparation, fertilizer etc. (Total management practices cost per hectare incurred by farmers for a crop husbandry over number of farmers)
- Total Cost(TC)=The summation of seed cost (SC) and management practices costs (MPC)
- Total Revenue (TR) = Average total quintal per hectare harvested times price sold per quintal
- Net Benefit (NB)=Total revenue(TR) deduct total cost(TC)
- Cost benefit ratio (CBR)=Total cost (TR) over total revenue (TC)

- Results and Discussion

Cost of Seeds

The cost of all improved varieties is higher than the local varieties. The analysed data showed that improved Wheat and Maize seeds cost per hectare are nearly double that of the local. (See Figure 7).

Figure 6: Seed costs per variety per hectare

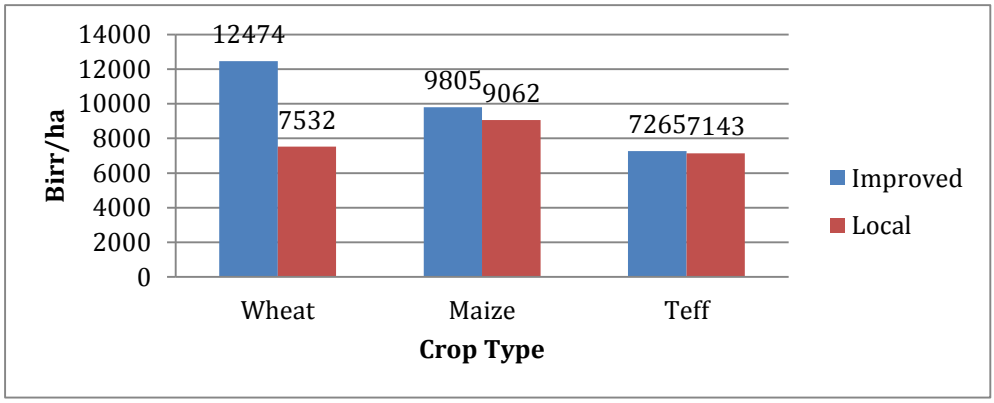


Management Practices Costs

The management practices under consideration include land preparation, planting, weed control, irrigation, fertilization, pest control and harvesting. The findings showed that cost of management

practices required for local and improved varieties for Teff is very similar, for maize is a little different, and with regards of wheat there is a big difference (Figure 8).

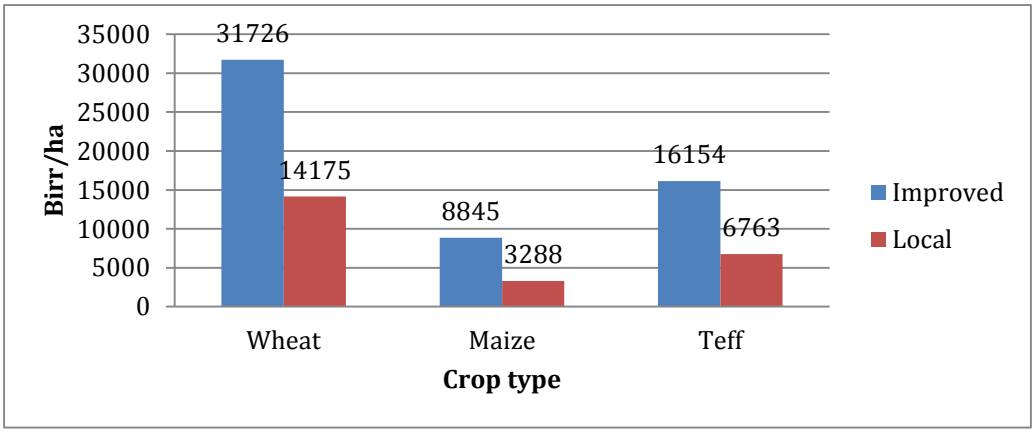
Figure 7: Management practices costs per variety



Benefits of Local and Improved varieties

All the improved varieties have higher revenue per hectare than respective local varieties. The benefits obtained from improved varieties double than their respective local varieties. Wheat has the highest average cost and revenue per hectare. Teff and maize follow as second and third respectively (See Fig 8).

Figure 8: Revenue obtained by crop varieties per hectare



Cost Benefit Analysis for Improved Over Local Varieties

- Wheat Varieties

The net benefit (NB) for these varieties is calculated based on the total average revenue against the total average cost. The NB for those producing with local wheat varieties is lower than that of improved Wheat varieties (Table 11). The results show that the CBR for using improved wheat (i.e. 0.31) is lower than the CBR for using local Wheat (i.e. 0.37). CBR ratio is higher for local than improved

Wheat. The cost of production for local Wheat is higher relative to the benefit than the improved. Thus, improved Wheat variety is more economical than local Wheat variety.

Table 11: Rate of return switching from local to improved wheat variety

Crop	Total Cost (TC)	Total Revenue(TR)	Net Benefit (NB)	Cost-benefit ratio (CBR)
Improved Wheat	14016	45742	31726	0.31
Local Wheat	8358	22533	14175	0.37

- *Maize Varieties*

The net benefit (NB) for these varieties is calculated based on the total average revenue against the total average cost. The NB for those producing with local Maize varieties is lower than that of improved Maize varieties (Table 12). The results show that the CBR for using improved Maize (i.e. 0.53) is lower than the CBR for using local Maize (i.e. 0.74). CBR ratio is higher for local than improved Maize; the cost of production for local Maize is higher relative to the benefit than the improved. Thus, improved Maize variety is more economical than local Maize variety.

Table 12: Rate of return switching from local to improved Maize variety

Crop	Total Cost (TC)	Total Revenue(TR)	Net Benefit (NB)	Cost-benefit ratio (CBR)
Improved Maize	9882	18727	8845	0.53
Local Maize	9192	12480	3288	0.74

- *Teff Varieties*

The net benefit (NB) for these varieties is calculated based on the total average revenue against the total average cost. The NB for those producing with local Teff varieties is lower than that of improved Teff varieties (Table 13). The results show that the CBR for using improved Teff (i.e. 0.32) is lower than the CBR for using local Teff (i.e. 0.52). CBR ratio is higher for local than improved Teff; the cost of production for local Teff is higher relative to the benefit than the improved. Thus, improved Teff variety is more economical than local Teff variety.

Table 13: Rate of Return switching from local to improved Maize

Crop	Total Cost (TC)	Total Revenue(TR)	Net Benefit (NB)	Cost-benefit ratio (CBR)
Improved Teff	7469	23623	16154	0.32
Local Teff	7414	14177	6763	0.52

- Conclusion

The analysis of results from SHF CBA interviews showed that in all cases income increased as result of using improved varieties. Net benefits of improved varieties are higher than local varieties. The net benefit from improved wheat is higher than other crops, followed by Teff and local wheat respectively. Moreover, the improved varieties show better CBR than their respective local varieties. The interviewees asserted that improved varieties maintain their yields better in spite of rain calendar fluctuations. Unfortunately, local varieties often encounter total losses when such variability happens. Therefore, improved varieties have high economic and adaptation benefits for the SHF. However, the costs of crop management practices were higher for improved wheat. This may act as a barrier to poor SHF adoption of these varieties.

4.2.3 Livelihoods changes

Some livelihoods changes have resulted from the technology adoption by SHF. The various indicators identified in the part 3 (wellbeing and resilience) help to understand how the technology adoption have changed the livelihoods and what are the main outcomes in terms of development. The indicators selected were the following: increase in food security status; increase in income; Increase in assets; ability to send children to school; ability to hire additional labour if needed; amount shared/rented lands; level of graduation out of PSNP and amount of crops proportion marketed. These outcomes have been observed both in intervention and dissemination kebeles and illustrate the resilience achieved by the SHF while climate variability increases.

The table 14 below presents the main benefits from technology adoption in terms of livelihood changes. These results are based on the interviews and focus group discussions carried out with the original beneficiary farmers and the adopters as well as the interviews realized with the DAs in both kebeles.

Similar livelihood changes have been observed in both originally OR adopted kebele (Debrebirhan) and in dissemination kebele (Megab). They are summarized in table 14 below:

Table 14: Livelihoods changes resulting from OR technologies adoption

Debrebirhan	Megab
- Increased household food security - Increased income from cash crops (e.g. opening bank account to save money) - Sharecropping and renting land arrangements - Graduation out of PSNP - Able to send their children to school - Increased assets for farming (more practical knowledge) - Able to build new house - Increased hiring of farm labour	- Increased household food-sufficiency - Increased income from cash crops - Able to sell seeds to purchase fertilizer - Graduation out from PSNP - Able to send their children to school - Able to cook with oil - More variety in the food (able to purchase different types of commodities) - Able to use solar light - Able to build assets like a new house

Discussions with 2 DAs from the intervention kebele and 3 from the dissemination kebele (see annex n°5 for the questionnaires used during the interviews) complement the information from SHF interviewed. The DAs mentioned that the number of PSNP beneficiaries graduated out of the cash and food transfer system have increased since the OR technologies have been disseminated among farmers.

Picture n°7: DA's interview in Megab

According to them in Debrebirhan 1756 farmers have been graduated out of PSNP, and in Megab 1690 farmers have been graduated.

These figures were triangulated with the official PSNP figures and statistics provided by the Woreda Agricultural PSNP Desk. This Desk provided data on the number of farmers per kebele graduating out of PSNP from 2009 to 2013 in Hawzen Woreda. The figures for the initial kebele (Debrebirhan) and the dissemination kebele (Megab) show a clear increase in the number of farmers graduated out of PSNP between these dates[22] and corroborate the evidence from DA's.

4.3 Conclusions from Tracks 1 and 2

Technologies adoption: a way to increase resilience

The results presented above suggest that the SHF in both the intervention and dissemination kebeles have found ways to maintain and indeed increase agricultural productivity as risks due climatic variability increase. The technology adoption and dissemination over the last few years happened during this period of increased climate variability. The evidence gathered among the farmers as well as the testimonies from the DAs demonstrate that the technology adoption played a critical role in supporting smallholder farmers in reaching better livelihoods, helping them to adapt to climate change, and therefore, to be more climate-resilient. In the part 5 (discussing and interpreting the results), a mind map of the adoption/ adaptation process presents how the former influences the latter.

Remaining challenges for beneficiaries, adopters and non-adopters

Despite the numerous challenges being tackled though the dissemination of OR projects, some remain. They are mainly related to environmental, technical aspects and to research and extension activities:

- Ground water shortage,
- Shortage of livestock food during rainy season
- Irrigation system insufficient

[22] The detailed number per kebele and per year are available in annex n°5 bis

- Decline of improved seeds productivity
- Road access to markets
- Availability of improved seeds

Picture n°8: Communal well of the kebele

Picture n°9: Farmers at work

Based on the discussions with DAs, it seems that they are also trying to provide inputs to respond to the remaining challenges in the communities and especially ground water shortage directly related to climate variability. DAs have a central role in identifying the sites and the beneficiaries of wells in collaboration with the Water Resources Bureau. While, the water experts determine where there is water potential, the DAs as well as the Agricultural Bureau negotiate with the farmers if they are keen on investing in irrigation activities and management. There is integration between the different levels of stakeholders – the woreda experts have the mandate for wells construction whereas the DAs and the farmers are in charge of their utilization and management. Building wells is partly helping farmers to find solutions to irrigate their lands but the more in-depth problem about ground water shortage is still important. According to DAs, some options could help farmers to cope with rainfall shortage in the future:

- Advice farmers to grow crops which require low moisture, using early maturing seeds
- Increase the wells depth up to maximum 10 meters
- Limit the irrigated plots
- Continue the soil and water conservation activities,
- Start irrigation activities immediately after the harvesting season

Adopting improved seeds are part of the solution advised by DAs, which reiterates the fact that OR crop-related technologies are supporting farmers in dealing with climate variability and its consequences in terms of rainfall. Rainfall profiles are also influencing the message conveyed by the

DAs to the farmers about the utilization of fertilizer. Depending on the level of moisture, either organic or inorganic fertilizer (e.g.urea) application is recommended.

Picture n°10: Child doing helping at threshing time

5. Analysis and interpretation of results

5.1 Technology adoption and climate adaptation

What technologies have been adopted?

It is estimated that more than 80% of SHF are currently cultivating improved varieties in areas targeted by the OR project. This is a significant level of adoption and a strong indicator of the success. The improved varieties include staples and trade-able crops – wheat, teff, potato, tomato, onion and chick pea.

Adapted livestock breeds of small ruminants and poultry have also been adopted but the evidence from this case study is not sufficient to properly examine this aspect.

Reasons for the adoption of improved varieties

Improved varieties have increased yields. There are reports of doubling of wheat and Teff production. But in the case of wheat at least, crop management costs are higher for the improved varieties, while the productivity of the improved varieties more than compensates for higher management costs.

Some improved varieties have shorter growing seasons so cope better with erratic and foreshortened long rains. And irrigation allows dry season production of tomato, potato and onion etc.

Improved technology adoption is made possible in some cases (dry season crops) by farmers having access to irrigation when cultivated plots are close to streams and watercourses. Those farmers without resources to exploit irrigation rent out or sharecrop suitable land to those that have. Land quality including soil fertility was mentioned as an important factor in adoption. Land holding size is also important, even given the generally small farm size in the region. Labour availability is important as the new technologies and the expanded cultivation areas require more labour. This has led to an increase in labour demand but day wages remain low at 50 to 100bir per day. The availability of sharecrops and rented land is also important.

Profiles of adopting and non-adopting farming HHs observed in the kebeles

Adopting SHF are the large majority. Early adopters were selected by the OR project in both intervention and dissemination kebeles. There was emphasis on poorer farmers and women. Adopters are those able to acquire the necessary supporting technologies, have more family labour for farming activities, and those that have the capability and willingness to sharecrop or rent.

Non-adopting SHF are a minority. Some feel that they have been marginalised from the intervention and dissemination processes. Non-adopters have smaller plots, also less capacity and willingness to sharecrop or rent land. Non-adopters have lower capacity to hire labour. There are also idiosyncratic factors reducing capability to adopt e.g. being widowed women head of households.

DAs interviews revealed that non-adopters suffer from a lack of social ties, which can reduce their ability/ opportunity to adopt OR technologies through farmer to farmer exchange. As stated by the 'Saint Thomas principal', some farmers *don't believe if they don't see* and in this case, lack of social ties do not help. Owning only small plots sometimes limits SHF in trying out something new and to take risk despite what they might observe in their neighbour's plots. On another hand, non-adoption can sometimes be explained by the fact that SHF are already well-equipped with their own crops and livestock. Some farmers prefer to prioritize local seeds which provide more straw for the livestock compare to the improved seeds.

How has technology adoption changed livelihoods?

The case study found evidence that adoption of the improved varieties and technologies increased household food security. It also increased income from cash crops. Adoption led to more sharecropping and arrangements for renting land. In the opinion of DA's and some farmers adoption of improved technology can be linked as a causal factor in the graduation of the household out of the PSNP. Adoption is linked to increased assets for farming and for households and the increased hiring of farm labour.

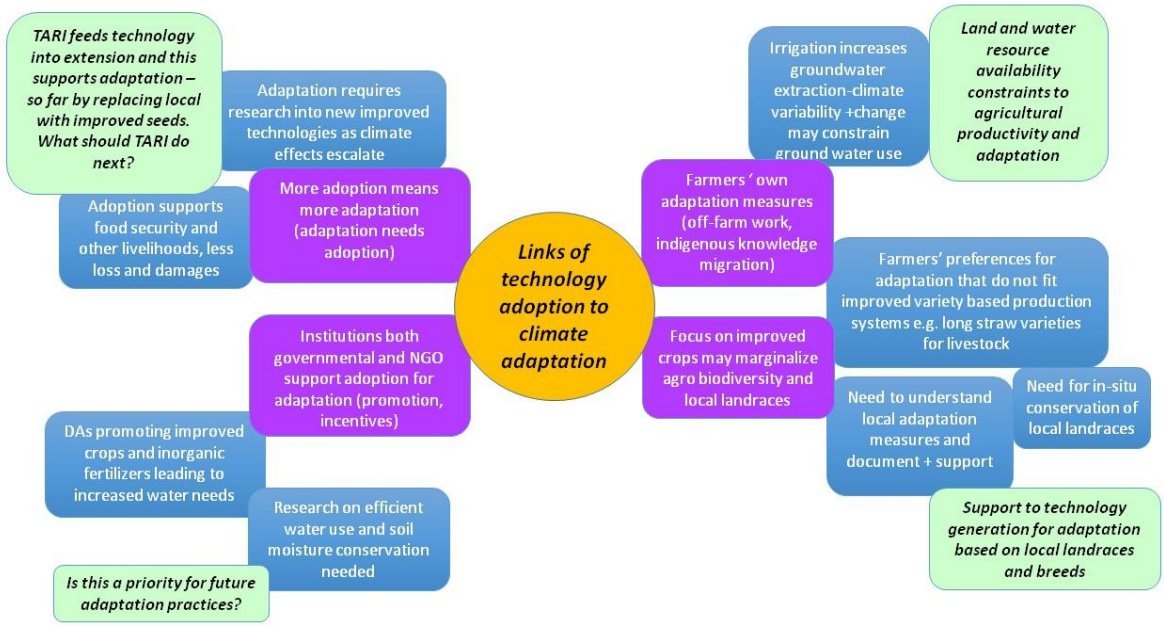
Picture n°11: Woman Farmer during focus group discussion

Climate adaptation?

Adoption of improved technologies enables both livelihood improvements and adaptation to increasingly variable rainfall and rising temperatures. Early adoption and specialisation e.g. as seed multipliers, enables enterprise development that provides services relevant to adaptation process. Cases were found where adoption of improved varieties enabled households to cope with idiosyncratic shocks (e.g. loss of male household head) and still benefit from per area yield increases.

The mind map below presents the different linkages identified between adoption and adaptation based on the results and evidences collected from the farmers and DAs' interviews. OR technology adoption have enabled the wider adaptation process among SHF communities allowing them to better cope with climate variability and its various consequences.

Figure 9: Mind map adoption-adaptation



5.3 External factors in technology adoption

The evidence gathered during the case study from various sources indicates that land restoration and watershed management achieved through social mobilization, food for work and PSNP has led to reduced soil erosion, greater forage availability, higher water tables and improved water availability and local climate changes that are favourable to agriculture. These interventions were planned at a stage before there was concern on the likely effects of climate change in the region. The trigger was food insecurity of agricultural dependent households and communities. The soil and water

conservation investments have provided a basis upon which crop technology adoption can contribute significantly to the climate resilience of SHF.

The timely investment in crop variety improvement, following the identification of farmers' demands for shorter cycle crops, has enabled TARI to generate technologies relevant to the needs of SHF coping with increased climate variability. This has been supported by, and the results multiplied through, large scale public sector investment in agricultural development and extension. Added to this the farmer organization that includes local structures of networks (5 farmers) and development groups (6 networks) enables farmer to farmer dissemination of technologies.

There has been complementarity among overlapping initiatives also. For example, the Millennium Project operating in adjacent areas of Tigray has similar objectives and strategies to the OR programme.

Also important has been the development of markets for introduced crops (e.g. sweet potato) and the improved varieties of wheat and teff.

The agricultural bureau and related organisations under the Ministry of Agriculture represent significant resources into the development of smallholder agriculture. This has enabled the dissemination work of the OR programme to be very effective in the targeted kebeles.

However, there are issues around the promotion of agricultural technologies that do not facilitate climate adaptation. The use of inorganic fertilizers does not help maintain soil moisture whereas organic fertilizers do. An other way to strengthen adaptation by smallholder farmers would be for the agricultural development agencies and the water resources bureau to better coordinate their actions – particularly in regard of projections over time of groundwater availability for extraction.

Interviews demonstrated that some farmers do not consider that they have equal access to the benefits from technology adoption. It was observed that the number of women DAs remains low.

Climate adaptation in smallholder agriculture is facilitated by a vibrant seed system. The OR programmes has supported access to crop varieties that are undergoing continual improvement, and improved seed availability has been assured through local multiplier seed producer farmers. Local markets for both improved and traditional seeds are an essential part of the seed system.

The significant increases in the extraction of ground water as measure to increase cash crop production and to counter rainfall variability and shortage bring into question the limits to ground water supply in the medium term. Hydrological surveys and sensitivity analysis using climate projections are required to assess the sustainability of the ground water supplies to facilitate this climate adaptation strategy.

6. Learning on integrating climate change into development programming

The main steps in integrating climate adaptation into development programming are set-out in the table below. These are used to draw out lessons from the evidence generated through the case study on Irish Aid with TARI have approached integration and the outcomes achieved.

Integration step	Case study finding	Lessons
Select the entry points	Irish Aid identified food security in Tigray as the development objective, and the entry point selected is the OR project now managed by the regional research organisation TARI. As the process has gone ahead the project entry point has widened to cover the ways that research integrates into agricultural development.	Following selection of a research project level entry point this development programme investment by Irish Aid has moved up toward a regional level. Incremental opening up of entry point levels is a pragmatic approach to integration of climate when outcomes uncertain.
Carry out assessments of the climate risks to achieving the development objectives	The risk assessment by Irish Aid focused on historic information on drought related hunger. Initial observations of food insecurity driven by rainy failure have been followed local level assessments by TARI to understand how crop improvements could address inter-annual climatic variability.	The OR project maintains a direct link to farmers and thereby is able to continually assess local climate risks perceptions. This then translates into crop improvement objectives. This process shows how engaged plant breeders can keep up with emerging climate risks and incorporate them into crop breeding decision making.
Screen the climate risks identified to identify those that need addressed	The risks identified that were addressed through the OR project relate to crop production in the main. Other climate risks mentioned by local people are not addressed – e.g. increasingly frequent wind and hail storms.	
Use climate projections information to assess likely future risks and vulnerability	The Track 1 assessments showed a lack of access to and use of climate projections in climate risk management by agencies at the regional level.	This is a weak point in the climate risk component of the OR programme. Retrospective assessment of weather observation data and better use of climate projections would strengthen the effectiveness of the process and could benefit other regional level agencies.
Identify climate adaptation options relevant to the risks that need addressed	The OR project focused on technology generation and adoption as the main adaptation option. Some SHF are using other strategies and for some (few) others the technology adoption route is not a viable option.	In the short-term the adaptation option prioritised by the OR project is working. Better assessment of water resource availability and the need for soil moisture maintenance technologies is required and may widen the range of adaptive technologies generated.
Build adaptation options into the design of the development intervention	This has been effectively achieved.	
Implement the designed intervention	Implementation is proceeding well.	The case study shows how implementation has worked.
Assess the effectiveness of the climate adaptation	The role of research as an enabler of adaptation by SHF is demonstrable. However, this OR way of working should be a long-term strategy adopted by Government.	This case study is part of the assessment process.

In summary, the way that Irish Aid has integrated climate change into its development programming through the OR project has been insightful. The steps of integration have been followed to varying degrees and in an incremental way.

Having said that there are various ways to improve and take further the integration:

- Better analysis and use of historic weather observation data available from the local weather stations to inform climate risk assessment.
- Access and use of climate projections for the different agro-ecoregions of Tigray again to inform the climate risk assessment.
- Increase the sensitivity of the climate risk assessment at local levels by monitoring climate risk perceptions of adopting and non-adopting SHF.
- Assess how local adaptation strategies diverge from improved crop variety adoption e.g. use of traditional long straw varieties, soil moisture management methods etc.

7. Conclusions

The case study found evidence that:

- Climatic variability is increasing and there are demonstrable trends toward warming and drying, particularly in the short rains period of the year.
- Soil and water conservation measures through social mobilization have been very effective in creating better conditions for agriculture and as a precursor for the adoption of improved varieties of crops and livestock.
- The OR initiative has provided improved crop varieties and livestock breeds that farmers want to adopt.
- Widespread adoption of new technologies has contributed to greater productivity and food security for a large proportion of the population during a period of increased climatic variability.

Integrating climate change into development programming through research support

- Irish Aid's decision to support smallholder farmer climate adaptation through technology generation and dissemination has been vindicated by the success of the OR project.
- Continued support to TARI operational research would contribute to smallholder farmer adaptation to new and emerging climate risks to food security and agricultural productivity.

Issues that warrant follow-up examination include:

- The interaction of PSNP and social mobilization scheme for soil and water conservation with technology adoption as drivers of climate adaptation by smallholder farmers.
- The sustainability of ground water extraction for irrigation under different scenarios of future rainfall and temperature variability and changes.
- The use of inorganic fertilizer use for yield increases vs soil organic matter management for soil moisture.

8. Annexes

Annex n°1: Questionnaires used in kebeles for adopters and non-adopters

Questionnaire for the 5 original beneficiaries farmers in Debrebirhan kebele

This survey will be addressed to 5 farmers of Debrebirhan (one of the initial OR kebeles): farmers who benefitted from the technologies in the framework of the OR programme. We want them to inform us on the dissemination process existing between them and other farmers that adopted the same technologies as them.

Part I: Information about the Household

Composition of House hold

1. What is your household headship?

   A. Male headed B. Female headed

2. How many members of the family do you have?

3. Numbers of the family engaged in farming activity?

4. Current Assets livestock's, Equipment

Land holding

5. Do you have your own land?

6. Do you have access to additional land?(crop sharing/renting)

Technology adoption by household

7. What kind of technology you adopt?

8. When did you adopt? If continued

9. Why they adopted? initial adoption, abandoned, benefit expected

Technologies	2010	2011	2012	2013	2014	2015
1.						
2.						
3.						
4.						
5.						
6.						

How the adoption change livelihood

Benefits gained from the technology adopted

10. What benefits have been gained from technologies?

11. What are costs of using different technologies?
12. Farmers evidence of impact on livelihoods

[Impacts on food security, income assets, labor requirements, proportion marketed, status etc]

13. Where expected benefits achieved?

14. If it is needed before and after comparison

Dissemination process

15. How did you participate in the farmer to farmer dissemination?

16. What methods do you prefer for farmer to farmer dissemination?

17. Do women have equal access and opportunity through dissemination?

18. What proportions of farmers have adopted the different technologies?

Questionnaire for the dissemination kebele, Hawzen woreda:

ADOPTERS

This survey will be addressed to 5 or more farmers of one of the dissemination kebele in Hawzen woreda. They adopted some of the OR programme technologies. We want them to inform us on the dissemination process existing between them and original beneficiaries farmers from the original OR beneficiaries or other farmers. The idea is also to know about how these technologies helped them in adapting to climate change.

Composition of Household

1. Who is your household headship?

   B. Male headed B. Female headed

2. How many members of the family do you have? ----------

3. Numbers of the family engaged in farming activity?

4. Current Assets (livestock, farming equipment)

Land holding

5. Do you have your own land? Do you irrigate? If so how much? (rain-fed/ irrigation process). Do you share crop out any of your land?

6. Do you have access to additional land? (crop sharing/renting). Is that land irrigated? Who owns the land you rent or share crop?

Technology adoption by household

7. What technologies did you adopt? (livestock, crops, NRM)

8. When did you adopt? If continued

Technologies	2010	2011	2012	2013	2014	2015
1.						
2.						
3.						

4.						
5.						
6.						

9. Why did you adopt? (motivation for initial adoption, abandoned, benefit expected)

How the adoption change livelihood

Benefits gained from the technology adopted

10. What benefits have been gained from these technologies?

11. What are costs of using these different technologies?

12. Farmers evidence of impact on livelihoods (related to benefits)
    [Impacts on food security, income assets, labor requirements, proportion marketed, status etc]

13. Where expected benefits achieved? (before and after comparison)

Dissemination process (we want to know how they adopted the technologies)

14. How did you participate in the famer to farmer dissemination?
15. How did you participate in the farmer to farmer dissemination?
16. Do women have equal access and opportunity through dissemination? (only women)
17. What proportion of farmers have adopted the different technologies in your community? What do farmers need to be able to adopt these technologies?

Questionnaire for the dissemination kebele, Hawzen woreda:

NON-ADOPTERS

This survey will be addressed to 5 farmers of one of the dissemination kebele who didn't adopt the technologies. Through these interviews, we want to understand why they didn't adopt and what are their mechanisms to cope with climate variability.

Composition of Household

1. Who is your household head?

   C. Male headed B. Female headed

2. How many members of the family do you have? ----------

3. Numbers of the family engaged in farming activity?

4. Current Assets (livestock's, farming Equipment)

Land holding

5. How much land do you own? How much is irrigated? (rain-fed/irrigation process). How much do you share crop out?

6. How much additional land do you access? (crop sharing/renting). How much of that land is irrigated?

Technologies:

7. What do you know about the OR technologies? Why did you not adopt these technologies?

8. What crops do you cultivate?

Livelihood status and challenges encountered:

9. What is your current livelihood

Crops	**2013**	**2014**	**2015**
1.			
2.			
3.			
4.			
5.			
6.			

10. What types of challenges do you encounter in your farming of crops and livestock?

11. What are your coping mechanisms?

Annex n°2: Results of the scoping process interviews with woreda experts

This annex n°2 is presenting the main findings of the interview organized with the woreda experts in the Hawzen Woreda Agriculture Bureau. The objective of conducting short interview with the woreda experts was to get additional inputs and information from those people who involved in the processes especially focusing on the dissemination processes of the project. These experts have close approach with the farmers, therefore it was interesting to have their perspective on the OR programme.
Participants of the interview and their department

1. Assefa Birhane Crop expert
2. Birhane Haile Livestock expert
3. Abreha Gebru From Extension service (FTC)

The discussion was interactive and mainly based on questions and answers. The main finding at presented below:

Q1. How the experts provide their support for the farming system?

A1. We have used various methodologies or approaches for different sectors such as

Crop expert: We will tell to them ways of how they used improved technologies through technical trainings in their farm land or in the woreda agriculture bureau, through using the model farmers.

FTC: Using exchange of knowledge from those farmers who can adopt easily and through development group (1 to 5 networks).

Livestock expert: The support is provided through training, follow up, and knowledge sharing. The varieties of technologies are bee hives, forage, sheep, poultry… the farmers can get various technologies in credit or sell with a lower price.

Q2. How is the process of the initial stage?

Initially the woreda experts have select farmers based on the farmer willingness, interest and active participation therefore once the farmer willing and tested the technology after a year the farmer start to sell to the woreda and to the other farmers.

The farmers also can get varieties of seed from seed multiplication department in the woreda with this process the bureau can reach to additional more new number of farmers.

Q3. Have you done survey to estimate the adoption of indirect beneficiaries?

DA's have the list of mostly and widely used seed by the farmers in addition they have the number of benefited farmers.

We did a study that shows the farmers are not using not more than two years for one genetic variety especially wheat and maize. The improved maize is not hybrid we are only using open pollinated.

Q4. How do you see the variability of rainfall?

We don't have measurement tool to measure temperature but for the rainfall there is rain gauge in every kebele. The type of rain is very erratic in the previous years. This year the rain was erratic at the beginning but on the final date of the winter it becomes good and enough to grow. In Hawzien the amount of rainfall in different sites are not the same.

Q5. How do you see the variability of rainfall in ten years time?

Rainfall varied a lot in the past years, it seems increasing but the amount is decreasing from time to time. In 2009/2010 and 2010/2011 cropping years, the amount of rainfall is increasing but later from this year it is decreasing.

Q6. What changes in the farming system? (In crops, livestock's)

There are visible changes in the community livelihood:

In crop: The production is increasing and the awareness/acceptance of farmers to new technologies has increased.

In livestock's: At the beginning farmers were complaining to accept the new technology but now they are asking more improved varieties and starting to shift from one to the other for instance; poultry shift to small ruminants.
In FTC: The numbers of farmers who participate in FTC start increasing, the society highly exchange technologies, creating demanding society and a paradigm shift.
Livelihood of the farmer starts improving and the household start to use nutrition wise food with their family.
Was this harvesting season good?
Yes, this year harvesting season has good production.

Q7. How easy to include women to technology adoption?
At the beginning it was not easy to include them but we used the development group of women then they share the new idea with the rest of the community. Even though it is not easy to deliver the training to women because of household responsibility and difficulty of culture, as we have a plan to make 30% of women benefited from the project we did our best.

Q8. Do the women have preference to different technologies to look after?
Yes, they participate in all technologies however, most of the time they prefer to engage from crops in irrigation work, home gardening and raw seeding.
For livestock as well they like to look after in poultry and sheep because they can see the change in a very short time.

Q9. How many women expert do you have?
A total of 61 experts in the woreda agriculture bureau
11 of them are women experts and the rest (50) are male.

Q10. How is the trend in the yield?
In 2009/2010 and 2010/2011 cropping years there is improvement in the yield because of good rainfall. 2011/2012 and 2012/2013 cropping years it is decreasing, in 2013/2014 there are some slight improvement because of the rainfall was good at the final date of the winter.

Q11. Where do the farmers get information about variety of technologies?
Farmers get information from the research centres such as Mekelle Research Centre, Regional Bureau of Agriculture, NGO's (Millennium Project introduced improved seed by purchasing from Seed Enterprise and Private Sector, REST they did not introduced by themselves but by purchasing from others).

Q12. How do you see the process of technologies?
Mainly the process is based on technology effectiveness and technology demonstration process together with the FTC and farmers. In addition, the involvement of cooperatives to provide inputs for farmers in a form of credit supports the process. It was not easy at the beginning because they were resisting to accept the technologies but now it is going well and easy therefore we can see the change easily.
Example: At the beginning Motor pump for irrigation was sell 3000 – 4000 ETB however, it was difficult to get acceptance by the community now the price of Motor pump for irrigation reaches 14,000ETB but farmers are asking more.

Q13. How do you see to benefit more number of farmers?
Some activities are needed to benefit more number of farmers for instance: mobilization work, training, awareness creation work, create a means of strong seed multiplication, create field day to

farmer which support to transfer knowledge, need practical training in FTC and encourage the farmer to use credit and decide to take a risk to use.

Q14. What are you using to cop up climate risks?

We are using weather forecast the information is from regional metrology and the information passed through Ethiopia Television, radio and circular letter from the region to each woreda; then based on the forecast we will provide advice for the farmers to grow early maturing, drought tolerant and pest resistance crops, to engaged in soil and water conservation work, to practice moisture conservation, to use organic fertilizers which helps them to hold moisture and advice them to sowing early and to sow legumes.

Q15. Are you invited to the ARD PLAC annual meeting?

No, we as experts are not invited but high office managers of the Woreda Agriculture Bureau and Department heads are invited. The process to appear on the ARD PLAC annual meeting is first problem appraisal conducted in each department after the discussion the experts start to prepare proposal and take to the meeting through the high officials. The finance comes from NGOs and government or from the region capital budget but all the proposal will pass through the process of ARD PLAC decision and approved by its members. In the preparation of the proposal basic research are not accepted only coping mechanism is needed, every proposal prepared with the local language (Tigrina) to clearly understood by the farmers and the farmers have equal right on the discussion of the ARD PLAC.

Annex n°3: Track 1 Scorecards indicators

Scorecard indicators for TARI researchers and Hawzen woreda experts

Indicator 1: Climate change integration into planning Representation of plans that address climate challenges in preparation of OR document and process				
No.	**Milestone**	**No**	**Partial**	**Yes**
1.	Is there a climate change plan that embedded in the principal planning document of OR?			
2.	Is there a climate safeguard system that integrates climate risk assessment, climate risk screening and climate risk reduction measures (identification, prioritization, and implementation) evaluation and learning into planning?			
3.	Have a specific measures to address climate challenges			
4.	Are climate-relevant initiatives routinely screened for climate risks?			
5.	Is there a criterion to integrate climate risk assessment in preparation of OR document			
Score (No. of Yes answers × 2, No. of Partial answers × 1				

Indicator 2: Institutional coordination for integration Extent and quality of coordination of climate risk management across relevant institutions				
No.	**Milestone**	**No**	**Partial**	**Yes**
1.	Has the respective OR implementing institution been tasked with coordinating climate change planning and actions			
2.	Does the coordination of climate risk management strong across important cross sect oral departments or institutions			
3.	Is there a climate change / climate risk management working groups established and focused their work			

4.	Is there a regular contact between the coordinating body of OR and relevant institutions (in key climate sensitive sectors)?			
5.	Does the Agriculture Bureau fully engaged and functional to manage climate risks?			
Score (No. of Yes answers × 2, No. of Partial answers × 1				

Indicator 3: Budgeting and Finance Financial support for climate change mainstreaming and initiatives-funding available for local initiatives, locally owned /driven				
No.	**Milestone**	**No**	**Partial**	**Yes**
1.	Is funding available to pilot measures that address climate change (e.g. adaptation, risk management, mitigation, and low-carbon development)?			
2.	Is funding available to roll out/support mainstreaming/integration of climate change in the OR planning			
3.	Do mechanisms/capacities exist for assessing the costs associated with measures to address climate change, such as those identified during climate screening/risk assessment?			
4.	Is funding available to cover the costs of the necessary climate change measures identified (and costed) during climate screening/risk assessment?			
5.	Are actions to address climate change supported by an authoritative financial entity (e.g. at national level, Ministry of Finance)?			
Score (No. of Yes answers × 2, No. of Partial answers × 1				

Indicator 4: Use of climate information Extent to which climate information is used to inform responses to climate change and				
No.	**Milestone**	**No**	**Partial**	**Yes**
1.	Does planning take account of observational data relating to climate trends and variability?			
2.	Does planning of OR take account of climate projections? Is climate information (forecasts, projections, information on responses) readily accessible via information sharing platforms or networks?			
3.	Is there sufficient access to climate information generated by foreign and international organizations (IPCC, research bodies, academic institution)			
4.	Is the use of scientific information from external sources complemented by the use of domestically generated information including local/traditional/indigenous knowledge?			
5.	Climate related information and analysis (vulnerability assessments, scenario planning, modelling) is used for decision making.			
6.	Does the capacity to interpret and use climate information (e.g. in scenario planning, risk frameworks, vulnerability assessments) exist?			
Score (No. of Yes answers × 2, No. of Partial answers × 1				

Indicator 5: Participation

Quality of stakeholder engagement in decision-making to address climate change				
No.	**Milestone**	**No**	**Partial**	**Yes**
1.	Are all relevant levels of stakeholders (regional, district/woreda, researchers, small holder and local community) represented in OR planning process?			
2.	Are those who might be adversely affected by climate change initiatives represented in planning/decision-making			
3.	Are those most in need of/ likely to benefit from measures to address climate change represented?			
4.	Are the poorest and most marginalized members of society represented?			
5.	Are the majority of the small holder protected from climate risks by applying OR?			
6.	Is the participation of all the above groups sustained throughout planning and implementation (i.e. at the start, end and throughout and initiative)?			
7.	Is all responsible stakeholders from different institution are engaged in the ARDPLAC regular progress review.			
Score (No. of Yes answers × 2, No. of Partial answers × 1				

Indicator 6: Uptake of CRM Measures Extent and quality of CRM measures such as risk spreading mechanisms (financial, livelihood, social)			
No.	**Milestone**	**No./proportion**	**Score 0,1,2**
1.	No. of different agricultural products/income streams per household(average)		
2.	No. of improved technologies disseminated to the household		
3.	No. of farmers protected from climate risks after applying OR		
4.	Proportion of household using improved agriculture technologies (seed varieties, livestock's, etc.)		
5.	Proportion of household using climate forecasts (seasonal, long-term)		
6.	Proportion of households using financial risk spreading mechanisms (e.g. Weather- related insurance)		
Score sum of scores over all 6 questions			

Scorecards indicators for the Regional Metrology Bureau

National/Regional level

Indicator 1: Climate change integration into planning Representation of plans that address climate challenges in preparation of OR document and process				
No.	**Milestone**	**No**	**Partial**	**Yes**
1.	Is there a climate change plan or strategy that embedded in the principal planning document?			

2.	Is there a climate safeguard system that integrates climate risk assessment, climate risk screening and climate risk reduction measures (identification, prioritization, and implementation) evaluation and learning into planning?			
3.	Does the bureau have specific measures to address climate challenges			
4.	Are climate-relevant initiatives routinely screened for climate risks?			
5.	Is there a formal requirement for climate change (adaptation/mitigation) to be integrated or mainstreamed into development panning			
Score (No. of Yes answers × 2, No. of Partial answers × 1				

Indicator 2: Institutional coordination for integration Extent and quality of coordination of climate risk management across relevant institutions				
No.	**Milestone**	**No**	**Partial**	**Yes**
1.	Has an authoritative body been tasked with coordinating climate change planning and actions			
2.	Does the coordination of climate risk management strong across important cross sect oral departments or institutions			
3.	Is there a climate change / climate risk management working groups established and focused their work			
4.	Is there a regular contact between the coordinating body and relevant bureaus and agencies(in key climate sensitive sectors)			
5.	Does the regional metrology bureau fully engaged and functional to manage climate risks?			
Score (No. of Yes answers × 2, No. of Partial answers × 1				

Indicator 3: Use of climate information Extent to which climate information is used to inform responses to climate change and				
No.	**Milestone**	**No**	**Partial**	**Yes**
1.	Does planning take account of observational data relating to climate trends and variability?			
2.	Does planning take account of climate projections? Is climate information (forecasts, projections, information on responses) readily accessible via information sharing platforms or networks?			
3.	Is there sufficient access to climate information generated by foreign and international organizations (IPCC, research bodies, academic institution) ? How are you using them at the regional level?			
4.	Is the use of scientific information from external sources complemented by the use of domestically generated information including local/traditional/indigenous knowledge?			
5.	Climate related information and analysis (vulnerability assessments, scenario planning, modelling) is used for decision making.			
6.	Does the capacity to interpret and use climate information (e.g. in scenario planning, risk frameworks, vulnerability assessments) exist?			
7.	Are you sharing your climate data at the kebele levels? If yes, who are your interlocutors at the local levels?			
Score (No. of Yes answers × 2, No. of Partial answers × 1				

Indicator 4: Budgeting and Finance Financial support for climate change mainstreaming and initiatives-funding available for local initiatives, locally owned /driven				
No.	**Milestone**	**No**	**Partial**	**Yes**
1.	Is funding available to pilot measures that address climate change (e.g. adaptation, risk management, mitigation, and low-carbon development)?			
2.	Is funding available to roll out/support mainstreaming/integration of climate change			
3.	Do mechanisms/capacities exist for assessing the costs associated with measures to address climate change, such as those identified during climate screening/risk assessment?			
4.	Is funding available to cover the costs of the necessary climate change measures identified (and costed) during climate screening/risk assessment?			
5.	Are actions to address climate change supported by an authoritative financial entity (e.g. at national level, Ministry of Finance)?			
Score (No. of Yes answers × 2, No. of Partial answers × 1				

Indicator 5: Participation Quality of stakeholder engagement in decision-making to address climate change				
No.	**Milestone**	**No**	**Partial**	**Yes**
1.	Are all relevant levels of stakeholders (regional, district/woreda, researchers, small holder and local community) represented in planning process?			
2.	Are those who might be adversely affected by climate change initiatives represented in planning/decision-making			
3.	Are those most in need of/ likely to benefit from measures to address climate change represented?			
4.	Are the poorest and most marginalized members of society represented?			
5.	Is the participation of all the above groups sustained throughout planning and implementation (i.e. at the start, end and throughout and initiative)?			
6.	Does the regional metrology bureau included in the ARDPLAC agricultural development regular progress review			
Score (No. of Yes answers × 2, No. of Partial answers × 1				

<u>Scorecard Indicator for the Regional Water and Resource Bureau</u>
<u>National/Regional level</u>

Indicator 1: Climate change integration into planning Representation of plans that address climate challenges in preparation of annual document and process				
No.	**Milestone**	**No**	**Partial**	**Yes**
1.	Is there a climate change plan or strategy that embedded in the principal planning document?			
2.	Is there a climate safeguard system that integrates climate risk assessment, climate risk screening and climate risk reduction measures (identification, prioritization, and implementation) evaluation and learning into planning?			

3.	Have a specific measures to address climate challenges			
4.	Are climate-relevant initiatives routinely screened for climate risks?			
5.	Does the planning document have a criterion for water well construction?			
6.	How strong the bureau involve in the site selection for construction?			
7.	How many water well the bureau plan to build annually?			
Score (No. of Yes answers × 2, No. of Partial answers × 1				

Indicator 2: Institutional coordination for integration Extent and quality of coordination of climate risk management across relevant institutions				
No.	**Milestone**	**No**	**Partial**	**Yes**
1.	Has an authoritative body been tasked with coordinating climate change planning and actions			
2.	How strong water and resource bureau work together with other institutions			
3.	Does the coordination of climate risk management strong across important cross sect oral departments or institutions			
4.	How far the bureau work with the local community in selecting areas for water well			
5.	Is there a climate change / climate risk management working groups established and focused their work			
6.	Is there a regular contact between the coordinating body and relevant bureaus and agencies(in key climate sensitive sectors)			
7.	Does the water and resource bureau fully engaged and functional to manage climate risks?			
8.	Does the bureau check the wells are working or not			
Score (No. of Yes answers × 2, No. of Partial answers × 1				

Indicator 3: Use of climate information Extent to which climate information is used to inform responses to climate change				
No.	**Milestone**	**No**	**Partial**	**Yes**
1.	Does planning take account of observational data relating to climate trends and variability?			
2.	Does planning take account of climate projections? Is climate information (forecasts, projections, information on responses) readily accessible via information sharing platforms or networks?			
3.	Is there sufficient access to climate information generated by foreign and international organizations (IPCC, research bodies, academic institution)			
4.	Is the use of scientific information from external sources complemented by the use of domestically generated information including local/traditional/indigenous knowledge?			
5	Does the bureau used Climate related information and analysis (vulnerability assessments, pattern of rainfall, modelling) for decision making.			
Score (No. of Yes answers × 2, No. of Partial answers × 1				

Indicator 4: Budgeting and Finance Financial support for climate change mainstreaming and initiatives-funding available for local initiatives, locally owned /driven				
No.	**Milestone**	**No**	**Partial**	**Yes**
1.	Is funding available to pilot measures that address climate change (e.g. adaptation, risk management, water well construction)			
2.	Is funding available to roll out/support mainstreaming/integration of climate change			
3.	Do mechanisms/capacities exist for assessing the costs associated with measures to address climate change, such as those identified during climate screening/risk assessment?			
4.	Is funding available to cover the costs of the necessary climate change measures identified (and costed) during climate screening/risk assessment?			
5.	Is the budget assigned for water well construction annually			
6.	Is there a way to be financed by non-governmental actor in water well construction			
7.	How many percent of the bureaus budget goes to well construction			
8.	Are actions to address climate change supported by an authoritative financial entity (e.g. at national level, Ministry of Finance)?			
Score (No. of Yes answers × 2, No. of Partial answers × 1				

Indicator 5: planning under uncertainty Institutional capacity for decision-making under climatic uncertainty				
No.	**Milestone**	**No**	**Partial**	**Yes**
1.	Does planning of well construction use of uncertainties?			
2.	Does planning incorporate 'envelopes of uncertainty,' defined as plausible ranges of key climatic parameters over relevant timescales, informed by climate projections where feasible?			
3.	Does the planning explicitly address risks associated with 'maladaptation'?			

4.	Is planning guided by well-developed frameworks and methodologies that address uncertainty?			
Score (No. of Yes answers × 2, No. of Partial answers × 1				

Indicator 6: Participation Quality of stakeholder engagement in decision-making to address climate change				
No.	**Milestone**	**No**	**Partial**	**Yes**
1.	Are all relevant levels of stakeholders (regional, district/woreda, researchers, small holder and local community) represented in planning process?			
2.	Are those who might be adversely affected by climate change initiatives represented in planning/decision-making especially the local communities			
3.	Are those most in need of/ likely to benefit from measures to address climate change represented?			
4.	Are the poorest and most marginalized members of society represented?			
5.	Is the participation of all the above groups sustained throughout planning and implementation (i.e. at the start, end and throughout and initiative)?			
6.	Is all responsible stakeholders from different institution are engaged in the ARDPLAC regular progress review.			
Score (No. of Yes answers × 2, No. of Partial answers × 1				

Scorecard Indicator for the Regional Agriculture Bureau
National/Regional level

Indicator 1: Climate change integration into planning Representation of plans that address climate challenges in preparation of annual plan document and process				
No.	**Milestone**	**No**	**Partial**	**Yes**
1.	Is there a climate change plan or strategy that embedded in the principal planning document of the Regional Agricultural Bureau?			
2.	Is there a climate safeguard system that integrates climate risk assessment, climate risk screening and climate risk reduction measures (identification, prioritization, and implementation) evaluation and learning into planning?			
3.	Have specific measures to address climate challenges been identified and funded?			
4.	Are climate-relevant initiatives routinely screened for climate risks?			
5.	Is there a formal requirement for climate change (adaptation/mitigation) to be integrated or mainstreamed into development planning of the Regional Agricultural Bureau?			
Score (No. of Yes answers × 2, No. of Partial answers × 1				

Indicator 2: Institutional coordination for integration Extent and quality of coordination of climate risk management across relevant institutions				
No.	**Milestone**	**No**	**Partial**	**Yes**

1.	Has an authoritative body been tasked with coordinating climate change planning and actions?			
2.	According to you, is the coordination of climate risk management strong across other important cross sect oral departments or institutions (e.g. TARI)?			
3.	Is there a climate change / climate risk management working groups established within the regional BoA?			
4.	Is there a regular contact between the coordinating body and relevant bureaus and agencies (in key climate sensitive sectors)?			
5.	Does the Regional Agriculture Bureau fully engaged and functional to manage climate risks?			
6.	As the head of the ARDPLAC meeting, does the Regional Agricultural Bureau plan climate change as a topic during the meetings?			
Score (No. of Yes answers × 2, No. of Partial answers × 1				

Indicator 3: Use of climate information
Extent to which climate information is used to inform responses to climate change and

No.	Milestone	No	Partial	Yes
1.	Does planning take account of observational data relating to climate trends and variability?			
2.	Does planning take account of climate projections? Is climate information (forecasts, projections, information on responses) readily accessible via information sharing platforms or networks?			
3.	Is there sufficient access to climate information generated by foreign and international organizations (IPCC, research bodies, academic institution)			
4.	Is the use of scientific information from external sources complemented by the use of domestically generated information including local/traditional/indigenous knowledge?			
5.	Is climate related information and analysis (vulnerability assessments, scenario planning, modelling) used for decision making?			
6.	Does the capacity to interpret and use climate information (e.g. in scenario planning, risk frameworks, vulnerability assessments) exist?			
Score (No. of Yes answers × 2, No. of Partial answers × 1				

Indicator 4: Budgeting and Finance
Financial support for climate change mainstreaming and initiatives-funding available for local initiatives, locally owned /driven

No.	Milestone	No	Partial	Yes
1.	Is funding available to pilot measures that address climate change (e.g. adaptation, risk management, mitigation, and low-carbon development)?			
2.	Is funding available to roll out/support mainstreaming/integration of climate change?			
3.	Do mechanisms/capacities exist for assessing the costs associated with measures to address climate change, such as those identified during climate screening/risk assessment?			

4.	Is funding available to cover the costs of the necessary climate change measures identified (and costed) during climate screening/risk assessment?			
5.	Are actions to address climate change supported by an authoritative financial entity (e.g. at national level, Ministry of Finance)?			
Score (No. of Yes answers × 2, No. of Partial answers × 1				

Indicator 5: Participation Quality of stakeholder engagement in decision-making to address climate change				
No.	**Milestone**	**No**	**Partial**	**Yes**
1.	Are all relevant levels of stakeholders (regional, district/woreda, researchers, small holder and local community) represented in planning process?			
2.	Are those who might be adversely affected by climate change initiatives represented in planning/decision-making			
3.	Are those most in need of/ likely to benefit from measures to address climate change represented?			
4.	Are the poorest and most marginalized members of society represented?			
5.	Is the participation of all the above groups sustained throughout planning and implementation (i.e. at the start, end and throughout and initiative)?			
6.	Is all responsible stakeholders are engaged in the ARDPLAC regular progress review.			
Score (No. of Yes answers × 2, No. of Partial answers × 1				

Scorecard 1 indicator for Seed Enterprise Bureau

Indicator 1: Climate change integration into planning

1. Is there a climate change plan that embedded in the principal planning document of Seed Enterprise?

Indicator 2: Institutional coordination for integration

1. Has the respective Seed Enterprise implementing institution been tasked with coordinating climate change planning and actions?
2. Is there a regular contact between the coordinating body of OR and other relevant institutions in the process of seed multiplication?

Indicator 3: Use of climate information

1. Does the bureau planning take account of observational data relating to climate trends and variability?
2. Is there sufficient access to climate information?

Indicator 4: Participation

1. Are all relevant levels of stakeholders (regional, district/woreda, researchers, small holder and local community) represented in planning process?

2. Are the most in need and likely to benefit from the seed enterprise have equal access to benefit from the enterprise?

Indicator 5: Process

1. How does it look like the process of seed multiplication?
2. How is the bureau planning looks like in the process of seed multiplication?
3. What is your plan in coverage of the farmer's number?
4. How the bureau activity looks like in the process of the bureau coordination with the Woreda Agriculture Bureau in distributing the seeds?
5. How is it the bureau activity looks like in the process of its coordination with farmers who engaged in the seed multiplication activities? And with the farmers not involved

Annex n°4: Questionnaire used for DAs interviews

Follow-up Interview with the DAs-Initial OR kebele:

Follow-up questions on their role, their vision of the dissemination process and how it has helped or not the farmers to adapt to climate change. If possible: map out the different location of the original beneficiaries and the adopters within the initial kebele.

DAs role:

With original farmers:

- What role did you play with the original beneficiaries in the dissemination process?

With adopters:

- What was your role in disseminating the technologies to farmers in the initial kebele? How did you help farmers to become adopters?

What is now your role in disseminating the technologies to farmers in the initial kebele? How do you help farmers to become adopters?

- Did you help the initial beneficiaries farmers to meet some of the other farmers?
- What credit mechanisms exist to help the other farmers (non beneficiaries) to adopt the technologies?
- How did you try to target PSNP farmers in the dissemination process?
-what level of graduation out of the PSNP programmes is there among the adopter farmers?

Non-Adopters:

- How many non-adopters are there in this initial kebele?
- Why couldn't some farmer adopt the technologies?
- What strategy is their to involve them in the dissemination process? (future plans?)

Livelihood change:

- What are the main drivers of change in the livelihood the past 10 years?

Hydrology and water challenge : role in the water management?

- What relationship do you have with the Regional Water Bureau?
- How do you decide where and how to build irrigation infrastructure?
- For the shared well: do you play any role in controlling their access?
- What are the responses to the ground water challenges?

Seed system:

- How does the seed system work?
- What role do the DAs play in the seed multiplication activities?
- Do you know how many seed multipliers there are in this initial kebele? And how do they intervene in the market? (roles)

Soil-fertilizer:

- What role the DAs played in providing inorganic fertilizer to farmers?
- How do the inorganic fertilizers help farmers in adapting to climate challenges?
- What advice do you provide the farmers on using organic fertilizer?

Interview with the DAs-Dissemination kebele

DA's role

Adopters of the dissemination kebele

- What was your role in disseminating the technologies to farmers in the initial kebele? How did you help farmers to become adopters?
- What is your role now in disseminating the technologies to farmers in the initial kebele? How did you help farmers to become adopters?

What help was their to the initial beneficiaries farmers to meet some of the dissemination kebele farmers?
What credit mechanisms are there to help the farmers to adopt the technologies?
How do you target PSNP farmers in the dissemination process?
What level of graduation out of the PSNP programme is there among the adopter farmers?
How do the farmers exchange or trade crop seeds and/or livestock?

Non-Adopters of the dissemination kebele

- How many non-adopters are there in this dissemination kebele?
- Why have they not adopted the technologies?
- What strategy is there to involve non-adopting farmers in the dissemination process?

Livelihood change:

- What are the main drivers of change in the local livelihoods over the past 10 years?

Hydrology and water challenge

- What relationship do you have with the Regional Water Bureau?
- How is it decided where and how to build irrigation infrastructure?
- What role do the Das play in controlling shared well access?
- What are the possible responses to the ground water access challenges?

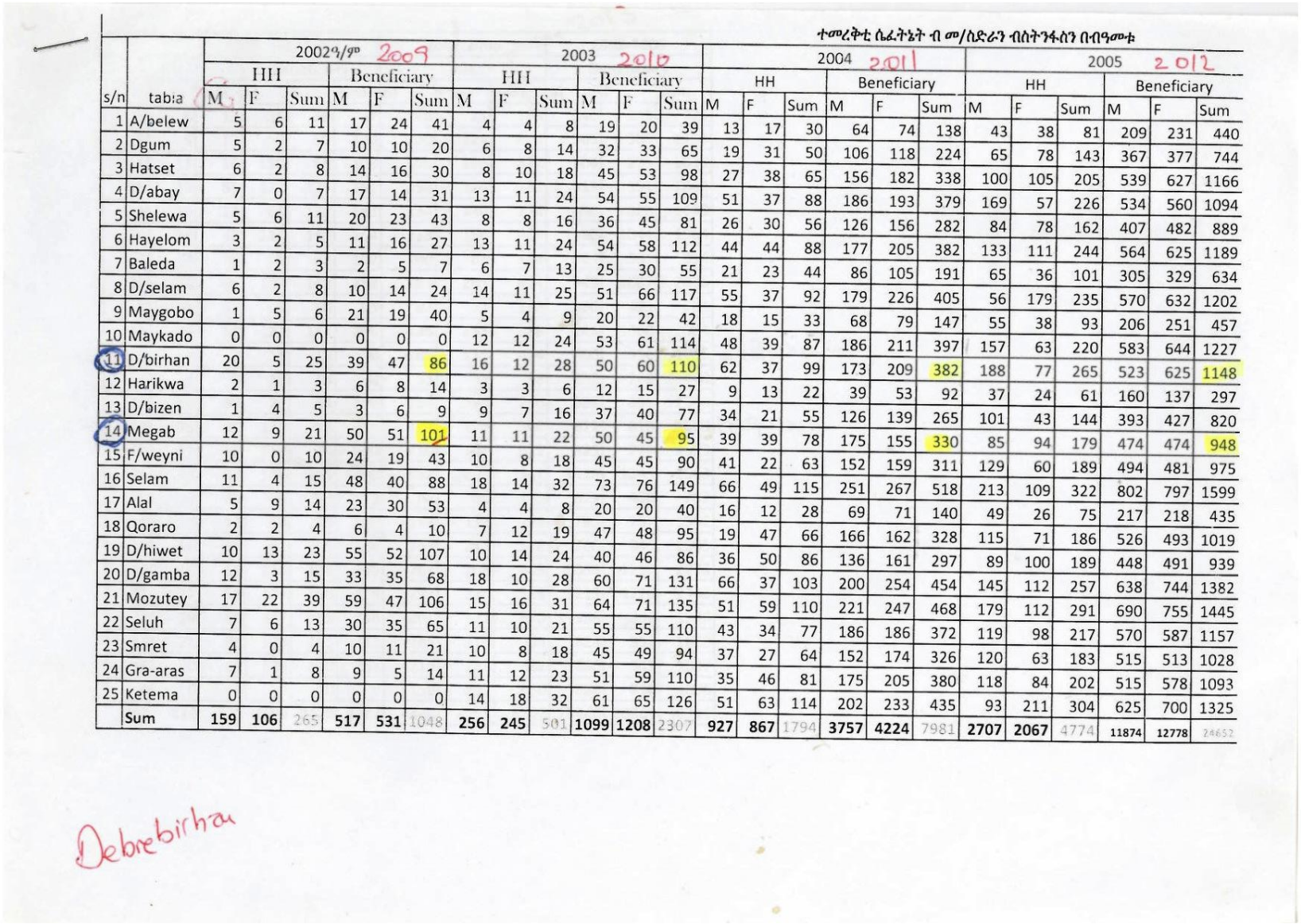
Seed system:

- How does the local seed system work? How do farmers get access to improved seeds?
- What role do the DAs play in improved crop seed multiplication?
- How many seed multipliers are there in this dissemination kebele?
- How have farmers become improved crop seed multipliers?

Soil-fertilizer:

- What role the DAs play in providing inorganic fertilizer to farmers?
- How does inorganic fertilizer help the farmers in adapting to climate challenges?
- What advice do you provide to the farmers on using organic fertilizer?

Annex n°5: PSNP data from the Woreda PSNP Desk



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		HH			Beneficiary			HH			Beneficiary			HH			Beneficiary			HH			Beneficiary		
s/n	tabia	M	F	Sum	M	F	Sum	M	F	Sum	M	F	Sum	M	F	Sum	M	F	Sum	M	F	Sum	M	F	Sum
1	A/belew	5	6	11	17	24	41	4	4	8	19	20	39	13	17	30	64	74	138	43	38	81	209	231	440
2	Dgum	5	2	7	10	10	20	6	8	14	32	33	65	19	31	50	106	118	224	65	78	143	367	377	744
3	Hatset	6	2	8	14	16	30	8	10	18	45	53	98	27	38	65	156	182	338	100	105	205	539	627	1166
4	D/abay	7	0	7	17	14	31	13	11	24	54	55	109	51	37	88	186	193	379	169	57	226	534	560	1094
5	Shelewa	5	6	11	20	23	43	8	8	16	36	45	81	26	30	56	126	156	282	84	78	162	407	482	889
6	Hayelom	3	2	5	11	16	27	13	11	24	54	58	112	44	44	88	177	205	382	133	111	244	564	625	1189
7	Baleda	1	2	3	2	5	7	6	7	13	25	30	55	21	23	44	86	105	191	65	36	101	305	329	634
8	D/selam	6	2	8	10	14	24	14	11	25	51	66	117	55	37	92	179	226	405	56	179	235	570	632	1202
9	Maygobo	1	5	6	21	19	40	5	4	9	20	22	42	18	15	33	68	79	147	55	38	93	206	251	457
10	Maykado	0	0	0	0	0	0	12	12	24	53	61	114	48	39	87	186	211	397	157	63	220	583	644	1227
11	D/birhan	20	5	25	39	47	86	16	12	28	50	60	110	62	37	99	173	209	382	188	77	265	523	625	1148
12	Harikwa	2	1	3	6	8	14	3	3	6	12	15	27	9	13	22	39	53	92	37	24	61	160	137	297
13	D/bizen	1	4	5	3	6	9	9	7	16	37	40	77	34	21	55	126	139	265	101	43	144	393	427	820
14	Megab	12	9	21	50	51	101	11	11	22	50	45	95	39	39	78	175	155	330	85	94	179	474	474	948
15	F/weyni	10	0	10	24	19	43	10	8	18	45	45	90	41	22	63	152	159	311	129	60	189	494	481	975
16	Selam	11	4	15	48	40	88	18	14	32	73	76	149	66	49	115	251	267	518	213	109	322	802	797	1599
17	Alal	5	9	14	23	30	53	4	4	8	20	20	40	16	12	28	69	71	140	49	26	75	217	218	435
18	Qoraro	2	2	4	6	4	10	7	12	19	47	48	95	19	47	66	166	162	328	115	71	186	526	493	1019
19	D/hiwet	10	13	23	55	52	107	10	14	24	40	46	86	36	50	86	136	161	297	89	100	189	448	491	939
20	D/gamba	12	3	15	33	35	68	18	10	28	60	71	131	66	37	103	200	254	454	145	112	257	638	744	1382
21	Mozutey	17	22	39	59	47	106	15	16	31	64	71	135	51	59	110	221	247	468	179	112	291	690	755	1445
22	Seluh	7	6	13	30	35	65	11	10	21	55	55	110	43	34	77	186	186	372	119	98	217	570	587	1157
23	Smret	4	0	4	10	11	21	10	8	18	45	49	94	37	27	64	152	174	326	120	63	183	515	513	1028
24	Gra-aras	7	1	8	9	5	14	11	12	23	51	59	110	35	46	81	175	205	380	118	84	202	515	578	1093
25	Ketema	0	0	0	0	0	0	14	18	32	61	65	126	51	63	114	202	233	435	93	211	304	625	700	1325
	Sum	**159**	**106**	265	**517**	**531**	1048	**256**	**245**	501	**1099**	**1208**	2307	**927**	**867**	1794	**3757**	**4224**	7981	**2707**	**2067**	4774	**11874**	**12778**	24652

Debebirhan

2006 2013						2002-2006 2009 2013			2002-2006		
HH			Beneficiary			HH			Beneficiary		
M	F	Sum	M	F	Sum	M	F	Sum	M	F	Sum
7	6	13	31	36	67	72	71	143	340	385	725
5	5	10	50	50	100	100	124	224	565	588	1153
15	11	16	150	53	103	156	166	322	904	931	1835
18	19	55	122	129	251	258	124	382	913	951	1864
11	18	29	61	122	183	134	140	274	650	828	1478
20	28	48	114	140	254	213	196	409	920	1044	1964
7	18	25	45	62	107	100	86	186	463	531	994
30	34	64	139	149	288	161	263	424	949	1087	2036
8	9	17	45	50	95	87	71	158	360	421	781
18	39	57	122	144	266	235	153	388	944	1060	2004
3	4	7	15	15	30	289	135	424	800	956	1756 D/Birhan
2	4	6	15	15	30	53	45	98	232	228	460
14	16	30	75	84	159	159	91	250	634	696	1330
23	25	48	123	93	216	170	178	348	872	818	1690 Megab
20	11	31	110	70	180	210	101	311	825	774	1599
24	33	57	144	165	309	332	209	541	1318	1345	2663
10	10	20	50	69	119	84	61	145	379	408	787
10	7	17	50	50	100	153	139	292	795	757	1552
18	36	54	81	95	176	163	213	376	760	845	1605
20	46	66	125	113	305	261	208	469	1056	1217	2273
31	27	58	179	100	279	293	236	529	1213	1220	2433
21	29	50	117	119	236	201	177	378	958	982	1940
14	21	35	106	105	211	185	119	304	828	852	1680
48	20	60	130	100	263	219	163	382	880	947	1827
0	0	0	0	0	0	158	292	450	888	998	1886
397	476	873	2199	2128	4327	4446	3761	8207	19446	20869	40315

Annex n°6: CBA questions

Crop varieties and seed per hectare used

Crop Varities(Local,Improved)	Area (ha)	Amount seed used (kg/ha)	Cost of Seed (Birr/Kg)	Average Cost of Seed (Birr/ha)	Period of year grown (1 time,twice,etc per year)

Cost estimation of management practices

Activity	Average Variable Costs for Production (Birr/ha)								Average Variable Cost for Local Seed	Average Variable Cost for Improved Seed
	Local				Improved					
	Machinery	Paid labor	Family labor	Materials	Machinery	Paid labor	Family labor	Materials		
Land preparation										
Planting										
Weed control										
Irrigation										
Fertilization										
Pest control										
Harvesting										
Marketing										
Other (Specify)										
Total										

Local crop varieties cost-benefit analysis

Crop	Varity Name	Average Crop Productivity (quintal/ha)	Average Crop Market price (Birr/quintal)	Average Crop residue Productivity (Kg/ha)	Average Crop residue Market Price (Birr/kg)	Revenue (Birr)	Average Cost of Cultivation	Profit

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