Working Strategy for Strengthening Ethiopia’s Tef Value Chain

Vision, Systemic Challenges, and Prioritized Interventions

July 2013
Table of Contents

Acknowledgements ........................................................................................................... ii
List of Exhibits ..................................................................................................................... v
Acronyms ............................................................................................................................ vi
Executive Summary .......................................................................................................... 1
Section 1  Introduction ...................................................................................................... 6
  1.1  Purpose and Scope of this document ..................................................................... 6
  1.2  Importance of tef in Ethiopian agriculture ......................................................... 7
  1.3  The tef value chain and its steps ......................................................................... 12
  1.4  Major stakeholders .............................................................................................. 13
  1.5  Strategy development process ............................................................................ 15
Section 2  Key developments in the tef sector ............................................................... 17
Section 3  Vision, challenges, and interventions by value chain step ......................... 18
  3.1  Research development ....................................................................................... 18
      3.1.1  Vision ............................................................................................................ 18
      3.1.2  Systemic challenges ................................................................................... 18
      3.1.3  Interventions .............................................................................................. 24
  3.2  Inputs production ................................................................................................. 30
      3.2.1  Vision ............................................................................................................ 30
      3.2.2  Systemic challenges ................................................................................... 30
      3.2.3  Interventions .............................................................................................. 35
  3.3  Inputs supply and distribution ............................................................................. 40
      3.3.1  Vision ............................................................................................................ 40
      3.3.2  Systemic challenges ................................................................................... 41
      3.3.3  Interventions .............................................................................................. 46
  3.4  On-farm production ............................................................................................... 48
      3.4.1  Vision ............................................................................................................ 48
      3.4.2  Systemic challenges ................................................................................... 49
      3.4.3  Interventions .............................................................................................. 56
  3.5  Post-harvest processing and utilization ............................................................... 59
      3.5.1  Vision ............................................................................................................ 59
      3.5.2  Systemic challenges ................................................................................... 59
      3.5.3  Interventions .............................................................................................. 62
  3.6  Market access and growth .................................................................................... 66
      3.6.1  Vision ............................................................................................................ 66
      3.6.2  Systemic challenges ................................................................................... 66
      3.6.3  Interventions .............................................................................................. 73
Section 4  Summary of interventions ............................................................................ 77
Section 5  Implementation Framework ........................................................................... 79
  5.1  Prioritization and sequencing of interventions .................................................... 79
  5.2  High-level Implementation plan .......................................................................... 83
  5.3  Monitoring, Learning and Evaluation framework (MLE) ...................................... 87
References ......................................................................................................................... 95
Appendix ............................................................................................................................ 98
Acknowledgements

It is with the support and contribution of many collaborators that this vision and strategy document was developed for the Ethiopian tef value chain. Sincere appreciation must be expressed for the data, insights, and guidance of stakeholder organizations, from the public, private, and NGO sectors at the federal, regional, and international levels. The following stakeholders deserve special gratitude:

Federal
MoA, Directorate of Input Marketing
MoA, Directorate of Agricultural Extension
MoA, Directorate of Natural Resource Division
Ethiopian Institute of Agricultural Research (EIAR)
Federal Cooperative Agency
Ministry of Water and Energy
Ethiopian Health, Nutrition and Research Institute
National Soil Testing Center (NSTC)
Ministry of Trade (MoT)
Ethiopian Commodity Exchange (ECX)
Institute of Biodiversity Conservation (IBC)

Regional
Amhara Regional Bureau of Agriculture
Amhara Regional Agricultural Research Institute (ARARI)
Oromia Regional Bureau of Agriculture
Oromia Agricultural Research Institute (ORARI)
SNNP Regional Bureau of Agriculture
Southern Agricultural Research Institute (SARI)
Tigray Regional Bureau of Agriculture
Tigray Region Research Institute (TARI)
Amhara Seed Enterprise
Oromia Seed Enterprise

Private Sector
Cooperatives, Unions, and Associations
Mama Fresh Injera

Higher Learning Institutions
Mekelle and Axum Universities (Tigray)
Addis Ababa University
Bahirdar and Debre Birhan Universities (Amhara)
Haremaya, Jimma, Ambo, Welegga and Meda Welabu Universities (Oromia)
Hawassa, Mizan-Tepi Universities (SNNPR)

International
Alliance for Green Revolution in Africa (AGRA)
The Bill and Melinda Gates Foundation (BMGF)
International Food Policy Research Institute (IFPRI)
International Livestock Research Institute (ILRI)
United States Agency for International Development (USAID)
Water and Land Resource Center
International Fertilizer Development Center
Africa Fertilizer Agribusiness Partnership
McKnight Foundation
University of Bern
Syngenta Foundation for Sustainable Agriculture
A NOTE FROM THE MINISTER’S DESK

Agriculture is one of the pillars of the Ethiopian economy and the overall economic growth of the country is highly dependent on the success of the agriculture sector. The Government of Ethiopia has demonstrated strong commitment to agriculture and rural development through the consistent allocation of over 10% of the national budget to deliver enhanced production technologies and support services.

This working strategy document outlines a forward-looking approach to improving the tef value chain and aims to align tef value chain stakeholders on short- and long-term objectives, identify tasks and milestones to achieve these objectives, and outline an action plan to accomplish specific tasks within an established schedule.

This working strategy document aims to outline the vision, bottlenecks and interventions needed to transform Ethiopia’s tef value chain. The development of this strategy has included the collective efforts of many stakeholders from the public and private sectors. Various syndication workshops organized by the MoA, ATA and EIAR have been held to ensure this document reflects the input of all relevant parties. In addition, a working group has been established, which includes representation from MoA, ATA, EIAR, regional research institutes and universities to refine and continue to update the tef strategy document. A wide range of public and development partners have provided valuable input that has been incorporated to form this version of the strategy.

The strategy is released as a working document to kick start implementation and guide all stakeholders involved in the tef value chain. In the remaining period of the GTP, the strategy will be tested and refined as feedback and lessons learned will be collected from implementing stakeholders. Once completed, this strategy will be launched formally with the next 5-year National Development Plan.

On behalf of the Government of Ethiopia, I would like to thank all stakeholders who were involved in the development of this working strategy document and encourage these and other stakeholders to build upon this commitment as we move into implementation of the interventions contained in the strategy.

I strongly believe that together we will continue to create a highly effective tef value chain that fulfills the promise of sustainably improving the livelihoods of smallholder farmers while contributing to Ethiopia’s overall vision of achieving a middle-income status by 2025.

Tefera Deribew
Minister, Ministry of Agriculture
List of Exhibits
Exhibit 1: Overview of Systemic challenges and Interventions by Value Chain Step ................................. 2
Exhibit 2: Sequencing of interventions ........................................................................................................... 4
Exhibit 3: Total Annual Tef Production during 2004-2011 ........................................................................... 8
Exhibit 4: Production, area cultivated, and productivity of Tef .................................................................. 9
Exhibit 5: Nutritional content of Tef (per 100 grams of grain) ........................................................................... 10
Exhibit 6: Urban and rural consumption of tef and other cereals ................................................................. 11
Exhibit 7: Tef production by high-producing regions ...................................................................................... 12
Exhibit 8: Tef Value Chain Steps ................................................................................................................... 13
Exhibit 9: Flow chart of strategy development process .................................................................................... 15
Exhibit 10: Comparison of Availability of Fulltime Human Resources for Different Crops .................... 19
Exhibit 11: Existing variation in Tef germplasm ............................................................................................. 21
Exhibit 12: Average yield of tef varieties released between 1970 and 2006 .................................................. 21
Exhibit 13: Overview of current status of research by tef research area ...................................................... 24
Exhibit 14: Use of improved technologies in tef ............................................................................................ 31
Exhibit 15: Count of seed imbalances by region ............................................................................................. 33
Exhibit 16: Average size of seed imbalance by region .................................................................................... 34
Exhibit 17: Overview of seed distribution process .......................................................................................... 41
Exhibit 18: Fertilizer cost build-ups by region (in USD per MT) ..................................................................... 44
Exhibit 19: Process flow of both product and cash for fertilizer distribution ............................................... 45
Exhibit 20: Use of fertilizer by type and region .............................................................................................. 50
Exhibit 21: Farmer-level cost breakdown ........................................................................................................ 51
Exhibit 22: Maximum tef yields obtained by technology implemented during 2009-2011 ...................... 52
Exhibit 23: Estimates of farm-level production costs in Ada’a area ............................................................... 54
Exhibit 24: Estimates of farm-level production costs in Shashemene area .................................................. 54
Exhibit 25: Estimate of farm-level labor days by tef production activity ...................................................... 61
Exhibit 26: Profitability analysis of mechanical thresher use, based on Dejen trial ...................................... 63
Exhibit 27: Overview of potential operating model to provide farmer access to threshers ....................... 65
Exhibit 28: Process flow of tef sales between farm-gate and end consumer ................................................. 67
Exhibit 29: Price increase and value-addition along tef value chain from farm-gate to end-consumer ... 68
Exhibit 30: Monthly price of tef by type ......................................................................................................... 69
Exhibit 31: Wholesale Price Trends of Tef and Other Staple Crops ............................................................... 70
Exhibit 32: Tef Grades by Class and Characteristic ....................................................................................... 71
Exhibit 33: Tef production by household consumption, sale, and other uses ............................................... 72
Exhibit 34: Export of tef from 2008-2011 ....................................................................................................... 73
Exhibit 35: Overview of interventions by tef value chain step ...................................................................... 77
Exhibit 36: Prioritization of interventions by feasibility and impact ............................................................. 80
Exhibit 37: Sequencing of interventions over time .......................................................................................... 82
Exhibit 38: Institutional Owners and Implementing Partners ......................................................................... 85
Exhibit 39: Monitoring, Learning, and Evaluation framework ................................................................. 88
Acronyms
ACDI/VOCA  Agricultural Cooperative Development Intl./Volunteers in Overseas Coop. Assistance
AGP        Agricultural Growth Program
AISE       Agricultural Inputs Supply Enterprise
ATA        Agricultural Transformation Agency
BBM        Broad-bed Maker
CBE        Commercial Bank of Ethiopia
CGIAR      Consultative Group on International Agriculture Research
CSA        Central Statistical Agency
DA         Development Agent
DAP        Di-ammonium Phosphate
DFID       Department for International Development
DZARC      DebreZeit Agricultural Research Center
EARC       Ethiopian Agricultural Research Council
ECA        Ethiopian Custom Authority
ECX        Ethiopian Commodity Exchange
EDRI       Ethiopian Development Research Institute
EEA        Ethiopian Economic Association
EEPRI      Ethiopian Economic Policy Research Institute
EGTE       Ethiopian Grain Trade Enterprise
EIAR       Ethiopian Institute for Agricultural Research
ESE        Ethiopian Seed Enterprise
ESSP       Ethiopian Strategy Support Program
ETB        Ethiopian Birr
FCA        Federal Cooperative Agency
FTC        Farmer Training Center
GTP        Growth and Transformation Plan
IBC        Institute of Biodiversity Conservation
IFPRI      International Food Policy Research Institute
INM        Integrated Nutrient Management
MFIs       Microfinance Institutions
MoA        Ministry of Agriculture
MoARD      Ministry of Agriculture and Rural Development
MoT        Ministry of Trade
MoST       Ministry of Science and Technology
NGO        Non-Governmental Organization
PHT        Post-Harvest Technology
PSE        Public Seed Enterprise
QSANS      Quality and Standards Authority of Ethiopia
RARIs      Regional Agricultural Research Institutes
RBoAs      Regional Bureaus of Agriculture
RUSACCOs   Rural Savings and Credit Cooperatives
SNNP       Southern Nations, Nationalities, and People’s Region
TILLING    Targeted Induced Local Lesions in Genomes
Executive Summary
Tef is a hugely important crop to Ethiopia, both in terms of production and consumption. In a country of nearly 90 million people, tef accounts for about 15% of all calories consumed. Furthermore, approximately 6 million households grow tef and it is the dominant cereal crop in high-potential agricultural woredas. In terms of production, tef is the dominant cereal by area planted and second only to maize in production and consumption. However, it has been historically neglected compared to other staple grain crops, yields are relatively low (around 1.26 tons/hectare\(^1\)), and some farmers under certain conditions sustain high losses which result in reduced quantity of grain available to consumers.

In addition, while wholesale prices for tef are relatively high, making the crop attractive to some producers as a cash crop, the production costs are also high as reflected by the high fertilizer prices and the labor intensity of cultivation, weeding, harvesting, and threshing. Despite the relatively high cost structure, however, production has been increasing at approximately 11% per year (due to land expansion and increase in yield), with high latent demand resulting in price increases as well\(^2\).

This National Strategy document has been designed to refocus national attention on tef and work towards doubling productivity in the next five years by defining a vision, identifying challenges, and proposing interventions to drive transformation of the tef value chain. Using literature reviews, rapid assessments in tef-producing areas, and extensive stakeholder consultations, this document proposes interventions that aim to address each systemic challenge. Finally, a prioritization of interventions and activities is proposed, based on potential impact and expected feasibility, culminating in a high-level blueprint that is set forth to achieve national goals for the tef value chain.

Vision

**Overall Vision for the Tef Value Chain:** An efficient and well-functioning tef value chain that enables a sustainable increase in smallholder tef farmer productivity and profitability while providing high quality output at an affordable price to tef consumers.

Overview of challenges and proposed interventions
Given the above stated vision, work has been done to identify the challenges that currently prohibit Ethiopia from achieving this vision. These challenges have been grouped according to the steps in the value chain and addressed through specific interventions proposed here.

---

\(^1\) CSA (2011/12)
\(^2\) CSA (2004/05-2010/11)
Exhibit 1: Overview of Systemic challenges and Interventions by Value Chain Step

<table>
<thead>
<tr>
<th>Value Chain Step</th>
<th>Systemic challenges</th>
<th>Interventions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Research</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>development</td>
<td>▪ Insufficient priority is given to tef research, resulting in limited institutional</td>
<td>▪ Enhance institutional system and capacity in financial, human and material</td>
</tr>
<tr>
<td></td>
<td>and resource capacity</td>
<td>capacity</td>
</tr>
<tr>
<td></td>
<td>▪ Limited basic research on tef exists to serve as a basis for further exploration</td>
<td>▪ Strengthen basic research (physiology, genetics, cytogenetics and genomics)</td>
</tr>
<tr>
<td></td>
<td>▪ Genetic resource collection and management is insufficient</td>
<td>on tef</td>
</tr>
<tr>
<td></td>
<td>▪ Tef varieties released so far do not adequately address lodging, biotic/abiotic</td>
<td>▪ Develop comprehensive genetic resources collection and characterization</td>
</tr>
<tr>
<td></td>
<td>stress, shattering, food products, etc.</td>
<td>▪ Strengthen and accelerate varietal development through breeding</td>
</tr>
<tr>
<td></td>
<td>▪ Limited applied research in many areas such as socioeconomics, soil, physiology,</td>
<td>▪ Enhance applied research in areas such as socioeconomics, soil, physiology,</td>
</tr>
<tr>
<td></td>
<td>crop protection and mechanization</td>
<td>food chemistry, crop protection and mechanization</td>
</tr>
<tr>
<td></td>
<td>▪ Enhance institutional system and capacity in financial, human and material capital</td>
<td>▪ Strengthen research related to other value chain steps</td>
</tr>
<tr>
<td></td>
<td>▪ Strengthen basic research (physiology, genetics, cytogenetics and genomics) on tef</td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ Develop comprehensive genetic resources collection and characterization</td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ Strengthen and accelerate varietal development through breeding</td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ Enhance applied research in areas such as socioeconomics, soil, physiology, food</td>
<td></td>
</tr>
<tr>
<td></td>
<td>chemistry, crop protection and mechanization</td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ Strengthen research related to other value chain steps</td>
<td></td>
</tr>
<tr>
<td><strong>Inputs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>production</td>
<td>▪ Production of seed is inconsistent, containing high variability in quality and</td>
<td>▪ Strengthen capacity of public and private enterprises to improve seed</td>
</tr>
<tr>
<td></td>
<td>quantity produced</td>
<td>production efficiency</td>
</tr>
<tr>
<td></td>
<td>▪ Lime, which is used to treat highly acidic soil, is both in limited supply and</td>
<td>▪ Develop a system to accurately predict demand for seed</td>
</tr>
<tr>
<td></td>
<td>costly to farmers</td>
<td>▪ Increase the availability and affordability of lime to treat acidic soils</td>
</tr>
<tr>
<td></td>
<td>▪ Existing farm implements (e.g., row planters, broad-bed makers, and ploughs) are</td>
<td>▪ Facilitate the development of improved farm implements by public and private</td>
</tr>
<tr>
<td></td>
<td>inadequate and not readily available to farmers</td>
<td>enterprises</td>
</tr>
<tr>
<td></td>
<td>▪ Pesticides are currently costly and are not widely accessible for farmers</td>
<td>▪ Disseminate knowledge on integrated pest management and encourage pesticide</td>
</tr>
<tr>
<td></td>
<td>▪ Strengthen capacity of public and private enterprises to improve seed production</td>
<td>production</td>
</tr>
<tr>
<td></td>
<td>efficiency</td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ Develop a system to accurately predict demand for seed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ Increase the availability and affordability of lime to treat acidic soils</td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ Facilitate the development of improved farm implements by public and private</td>
<td></td>
</tr>
<tr>
<td></td>
<td>enterprises</td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ Disseminate knowledge on integrated pest management and encourage pesticide</td>
<td></td>
</tr>
<tr>
<td></td>
<td>production</td>
<td></td>
</tr>
<tr>
<td><strong>Inputs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>supply and</td>
<td>▪ Current complexities in seed distribution process cause delays and supply shortages</td>
<td>▪ Enhance the efficiency of the seed distribution process by improving existing</td>
</tr>
<tr>
<td>distribution</td>
<td>▪ Fertilizer prices remain high for farmers, partly due to importation and domestic</td>
<td>alternative channels</td>
</tr>
<tr>
<td></td>
<td>distribution processes</td>
<td>▪ Enable flexibility in the fertilizer shipping, inland transport and distribution</td>
</tr>
<tr>
<td></td>
<td>▪ Institutional constraints limit the effectiveness of inputs suppliers and distributors</td>
<td>process to lower costs</td>
</tr>
<tr>
<td></td>
<td>▪ Strengthen the efficiency of the seed distribution process by improving existing</td>
<td>▪ Provide policy, financial, and organizational support to promote use of inputs</td>
</tr>
<tr>
<td></td>
<td>alternative channels</td>
<td>▪ Promote use of organic fertilizer as a cost-effective alternative to inorganic,</td>
</tr>
<tr>
<td></td>
<td>▪ Enable flexibility in the fertilizer shipping, inland transport and distribution</td>
<td>internationally-sourced fertilizer</td>
</tr>
<tr>
<td>On-farm production</td>
<td>Post-harvest processing and utilization</td>
<td>Market access and growth</td>
</tr>
<tr>
<td>--------------------------------------------</td>
<td>----------------------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>• Farmers have insufficient knowledge of and financial ability to purchase and use inputs, such as fertilizer and seed</td>
<td>• Support scale-up of proven yield-enhancing technologies</td>
<td>• Link smallholder tef producers (through cooperatives) to direct market outlets</td>
</tr>
<tr>
<td>• Yield-enhancing farming practices are not well utilized or applied</td>
<td>• Create financial mechanisms to support farmers in purchasing inputs, such as fertilizer</td>
<td>• Create Community Warehouse Receipt Systems (CWRS) to increase potential earned income of farmers</td>
</tr>
<tr>
<td>• Cropping systems (rotation, double, relay cropping, and agroforestry) are not efficiently practiced</td>
<td>• Promote efficient cropping systems (crop rotations, double, relay, agroforestry)</td>
<td>• Improve tef market transparency and enforce standardization by adding tef to ECX in the future</td>
</tr>
<tr>
<td></td>
<td>• Traditional post-harvest activities incur large quality and quantity losses</td>
<td>• Develop and strengthen systematic demand by investing in tef value-addition opportunities</td>
</tr>
<tr>
<td></td>
<td>• Labor-intensive practices increase operating costs, especially gathering, piling, threshing and cleaning</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Improper straw handling and utilization</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Limited information available on tef food product development</td>
<td></td>
</tr>
</tbody>
</table>

Source: ATA Team analysis based on stakeholder input
Overview of sequencing of interventions along short-, medium-, and long-term timelines

Exhibit 2: Sequencing of interventions

- **Agronomic practices** such as row planting, reduced seed rate, and use of improved seeds
- Increasing access to **Mechanization** such as threshers and row planters
- Increased support for **tef research** across multiple areas, e.g., breeding, mechanization

These activities could drastically increase yields and also decrease post-harvest losses and **have the potential to be implemented and adopted immediately**

- **Expanded market opportunities** (e.g. value addition, improved grading systems)
- **Capacity building and resource development** for tef-focused institutions

This will ensure that institutions are strengthened so **productivity can continue to improve**, while **ensuring a strong market exists** to absorb the increased supply

- **Promotion of new, proven technologies** based on testing and approval which can take several planting cycles to accomplish
- **Policy shifts** that enable market growth (e.g., export of grain)

Long-term interventions are more focused on **systemic issues which are less immediately implementable** given resource and political changes required to be fully possible
Sequencing of interventions/implementations

The interventions needed to realize Ethiopia’s vision of a well-functioning tef value chain necessitate a careful prioritizing and sequencing of activities divided into short-term, medium-term and long-term. In the short-term (1-2 years), implementation will focus on boosting production through agronomic practices, enhancing access to multi-crop threshers with cleaners while strengthening research activities. In the medium-term (3-4 years), attention will be on increasing support for tef research and expanding market opportunities while continuing to enhance tef productivity. The emphasis in the long-term (5-7 years) will be on dealing with systematic issues which are less immediately implementable due to resource and time demands.

At the same time, the policy environment and regulatory framework must be enhanced to encourage new, productive, and efficient public and private sector partners to enter into the system. Given tef’s role as a key value chain that is required to enable the achievement of Ethiopia’s Growth and Transformation Plan, the implementation of the National Tef Strategy is characterized by a sense of urgency, including the need to identify issues that can be addressed quickly in order to build momentum towards the transformation envisioned by this Strategy.
Section 1 Introduction

1.1 Purpose and Scope of this document

Purpose of the National Tef Strategy

The National Tef Strategy was created to align all tef stakeholders on a unified, comprehensive strategy that will improve the production and profitability of tef farmers, while also improving opportunity for tef consumers. This Strategy hopes to transform the Ethiopian agriculture industry through promotion of one of its main crops. In particular, this document aims to achieve the following objective:

To improve tef productivity, profitability, and sustainability by implementing a set of comprehensive, actionable interventions.

To achieve this objective, the Strategy will:

• Identify and prioritize systemic obstacles in each value chain step
• Design and prioritize interventions to successfully implement the strategy
• Address obstacles with a set of comprehensive, actionable interventions and key activities

Through doing so, this document will serve as a blueprint for tef-related interventions and activities going forward and will enable the pursuit of efforts that are collectively exhaustive and aligned by all.

Scope of the National Tef Strategy

This Tef Strategy has been prepared following a value chain approach, which includes coordination of all steps in the chain, added value at each stage, and a market-led approach to address local, national, and international consumer demand. It starts by setting a vision for the strategy followed by identifying challenges at each step of the value chain. Finally, the strategy proposes one (or more) interventions per each challenge within the value chain step. A Monitoring, Learning, and Evaluation framework is also included for tracking implementation progress. In addition, the strategy includes a list of lead and collaborating stakeholders responsible for implementing activities at each value chain step.

Methodology employed for developing the National Tef Strategy

This National Tef Strategy was created in close collaboration with all relevant stakeholders along the tef value chain. The strategy relies heavily on the use of secondary data with limited use of primary data. The primary data was collected through group discussions, key informant interviews, and demonstration plots at Farmer Training Centers and farmers’ lands, based on Regional Bureau of Agriculture and Sasakawa Global 2000 interventions.

In addition, secondary data was collected from relevant sources such as the CSA, Ethiopian Grain Trade Enterprise, Ethiopian Commodity Exchange, and other published and unpublished tef research documents. The information collected and preliminary findings were presented to a select team of experts, and the feedback gathered was used to develop the document further.

The data collected was analyzed by using qualitative and quantitative analytical tools. Most of the qualitative data collected was narrated and summarized and the quantitative data was analyzed using
descriptive statistics tools. Finally, all key stakeholders have reviewed draft versions of the document through bilateral as well as workshop engagement.

1.2 Importance of tef in Ethiopian agriculture

Agriculture is a major contributor to the national economy of Ethiopia, representing 41% of Ethiopia’s GDP\(^3\). The tef value chain is of vital importance as the grain sector comprises a large part of the agriculture sector. Specifically, tef is one of the most important cereal crops in Ethiopia and there are many reasons to improve the tef value chain, including the opportunity to:

- Enhance the sustainability of the tef production process to increase the income of over 6 million farmers, and so that the future potential of tef production in Ethiopia remains fruitful and intact
- Create local economic multipliers resulting from increased tef-based employment that benefits the local economy through production and marketing activities
- Develop and strengthen tef value-addition opportunities through the exploration of new tef-based products; products such as biscuits, scones, breads, and other dishes can be created from tef for both domestic consumption and international export

As Ethiopia’s population has increased, so has the demand for tef. However, little improvement in tef yields has led to ever-increasing prices. From 2007 to 2008, the price of tef skyrocketed, hitting above the 1,000 USD/metric ton mark, which is four times more than the 2000-2008 average of 250 USD/metric ton. In 2010, the tef price was still above 700 USD/metric ton, which created hardships for many Ethiopian families who were forced to switch to other cereals as substitutes. By the end of 2012, retail tef prices in Addis Ababa had reached over 800 USD/metric ton\(^4\). Still, tef has remained the preferred staple cereal for Ethiopians, as evidenced by persistently high prices in recent years.

---

\(^3\) CIA World Factbook: Ethiopia (2012)
\(^4\) EGTE (2008-12)
As the exhibit above shows, annual tef production has been increasing year after year by about 11%, which has resulted in a 100% increase over seven years. Increased productivity is believed to contribute about 6% of that 11% growth while about 5% was attributed to expansion in area cultivated for tef.

During 2009-2010, it was estimated that 3.2 million tons of tef was produced on 2.6 million hectares of land\(^5\). This is equivalent to 21% and 28% of the total cereal production and acreage in the country, respectively, making tef the leading crop among cereals and other annual crops.

Despite the domestic preference for tef, it can be internationally classified as an “orphan” crop given that it has been largely unnoticed by the global scientific community and relatively unimproved by modern production technologies. However, tef remains an important crop for many reasons:

- It is the most preferred crop in the diet of most Ethiopians (as Injera)
- Tef can be grown under drought-prone and waterlogged areas in different soil types
- Early planting time is advantageous in areas with a short growing season; if unpredicted drought incidence or pest infestation occurs, the field can be re-planted with tef as a reliable cash crop
- Tef sells at higher market prices than all other cereals; it can serve as a cash crop
- The straw (chid) is of relatively higher digestibility to livestock, due to lower levels of lignin, as compared to straw from other cereal crops such as wheat, barley or sorghum

Given these positive aspects, there should be refocused attention placed on tef and its improvement. Farmer-level productivity of tef is much lower than other cereals. The national average yield is 1.2 metric tons/hectare (see Exhibit 4) compared to 2.8 metric tons/hectare for maize and 1.9 metric tons/hectare for wheat.

\(^5\) CSA (2010)
Exhibit 4: Production, area cultivated, and productivity of Tef

<table>
<thead>
<tr>
<th>Year</th>
<th>Area (ha)</th>
<th>% change</th>
<th>Production (t)</th>
<th>% change</th>
<th>Yield (t/ha)</th>
<th>% change</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003-04</td>
<td>1,989,068</td>
<td>-</td>
<td>16,773,480</td>
<td>-</td>
<td>0.8</td>
<td>-</td>
</tr>
<tr>
<td>2004-05</td>
<td>2,135,553</td>
<td>7.36</td>
<td>2,025,521</td>
<td>20.76</td>
<td>0.9</td>
<td>12.45</td>
</tr>
<tr>
<td>2005-06</td>
<td>2,246,017</td>
<td>5.17</td>
<td>2,175,598</td>
<td>7.41</td>
<td>1.0</td>
<td>2.22</td>
</tr>
<tr>
<td>2006-07</td>
<td>2,404,674</td>
<td>7.06</td>
<td>2,437,749</td>
<td>12.05</td>
<td>1.0</td>
<td>4.64</td>
</tr>
<tr>
<td>2007-08</td>
<td>2,565,155</td>
<td>6.67</td>
<td>2,992,924</td>
<td>22.77</td>
<td>1.2</td>
<td>15.09</td>
</tr>
<tr>
<td>2008-09</td>
<td>2,481,333</td>
<td>-3.27</td>
<td>3,028,018</td>
<td>1.17</td>
<td>1.2</td>
<td>4.54</td>
</tr>
<tr>
<td>2009-10</td>
<td>2,588,661</td>
<td>4.33</td>
<td>3,179,374</td>
<td>5</td>
<td>1.2</td>
<td>0.66</td>
</tr>
<tr>
<td>2010-11</td>
<td>2,761,190</td>
<td>6.66</td>
<td>3,483,483</td>
<td>9.57</td>
<td>1.3</td>
<td>2.77</td>
</tr>
<tr>
<td>2011-12</td>
<td>2,731,112</td>
<td>-1.09</td>
<td>3,497,690</td>
<td>0.41</td>
<td>1.3</td>
<td>1.51</td>
</tr>
<tr>
<td>Average</td>
<td>2,396,456</td>
<td>4.85</td>
<td>2,625,002</td>
<td>11.28</td>
<td>1.1</td>
<td>6.05</td>
</tr>
</tbody>
</table>

Source: CSA (various years), Estimates of Meher season Area, Production and Yield of Tef

**Nutritional Value of Tef**

Breaking down its nutritional content, tef has the highest amount of protein among the commonly consumed cereals in Ethiopia and its energy content is surpassed only by maize (Exhibit 5). In addition, tef has high levels of calcium, phosphorous, iron, copper, barium, and thiamin. It is considered to have a well-balanced amino acid composition, with lysine levels higher than wheat or barley and slightly less than rice or oats\(^6\). One specific reason for tef’s nutritional value is the size of its grain: the grain is small compared to the other components of the tef plant (the bran and endosperm). Thus, during milling, it is impossible to separate out the endosperm from the bran so the whole grain is milled into flour. This makes tef flour highly rich in fiber and nutrients, because the bran and germ are the most nutritious parts of the grain.

The composition of tef includes many chemical components that make it a highly-nutritious cereal. Beyond this, given that tef is a cereal, it is possible to use tef to make any product that is already produced with other cereals, such as wheat. Given its composition, tef could play an important role as a substitute in school feeding programs, as well as for emergency food aid programs and as a counteracting force to malnutrition in youth. Enhancing the industrialization of this crop will result in a more attractive and stable market for the producers and will incentivize the adoption of yield-enhancing investments.

Importantly, tef is also gluten-free so it is well-suited to address growing global gluten-free demand. Moreover, tef flour can be artificially enriched with specific nutritional components at the time of milling the grain. This process could be used to create value-added products with even more nutritional content, such as enriched injera, cookies, bread, or cakes.

Having a prominent place in the staple Ethiopian diet, tef plays a vital role in promoting good nutrition for the average Ethiopian. In particular, the consumption of injera contributes to the prevention of

---

\(^6\) Stallknecht (1997)
many diseases and conditions that can result from an unbalanced diet, including anemia, obesity, osteoporosis, and diabetes.

Exhibit 5: Nutritional content of Tef (per 100 grams of grain)

<table>
<thead>
<tr>
<th>Nutrient Content</th>
<th>White Tef</th>
<th>Brown Tef</th>
<th>Mixed Tef</th>
<th>Millet</th>
<th>Barley</th>
<th>Maize</th>
<th>Wheat</th>
<th>Sorghum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy (kcal)</td>
<td>339</td>
<td>336</td>
<td>336</td>
<td>326</td>
<td>334</td>
<td>356</td>
<td>339</td>
<td>338</td>
</tr>
<tr>
<td>Moisture (%)</td>
<td>10.4</td>
<td>11.1</td>
<td>10.7</td>
<td>12.1</td>
<td>11.3</td>
<td>12.4</td>
<td>10.8</td>
<td>12.1</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>11.1</td>
<td>10.5</td>
<td>8.3</td>
<td>7.2</td>
<td>9.3</td>
<td>8.3</td>
<td>10.3</td>
<td>7.1</td>
</tr>
<tr>
<td>Fat (g)</td>
<td>2.4</td>
<td>2.7</td>
<td>2.9</td>
<td>1.4</td>
<td>1.9</td>
<td>4.6</td>
<td>1.9</td>
<td>2.8</td>
</tr>
<tr>
<td>Carbohydrate (g)</td>
<td>73.6</td>
<td>73.1</td>
<td>75.2</td>
<td>77.1</td>
<td>75.4</td>
<td>73.4</td>
<td>71.9</td>
<td>76.8</td>
</tr>
<tr>
<td>Fiber (g)</td>
<td>3.0</td>
<td>3.1</td>
<td>3.6</td>
<td>5.6</td>
<td>3.7</td>
<td>2.2</td>
<td>2.0</td>
<td>2.3</td>
</tr>
<tr>
<td>Ash (g)</td>
<td>2.5</td>
<td>3.1</td>
<td>3.0</td>
<td>3.3</td>
<td>2.0</td>
<td>1.3</td>
<td>1.5</td>
<td>1.6</td>
</tr>
<tr>
<td>Calcium (g)</td>
<td>156</td>
<td>157</td>
<td>140</td>
<td>386</td>
<td>47</td>
<td>6</td>
<td>49</td>
<td>30</td>
</tr>
<tr>
<td>Phosphorus (g)</td>
<td>366</td>
<td>348</td>
<td>368</td>
<td>220</td>
<td>325</td>
<td>276</td>
<td>276</td>
<td>282</td>
</tr>
<tr>
<td>Iron (g)</td>
<td>18.9</td>
<td>58.9</td>
<td>59</td>
<td>85.1</td>
<td>10.2</td>
<td>4.2</td>
<td>7.5</td>
<td>7.8</td>
</tr>
</tbody>
</table>

Source: Agren and Gibson (1968)

One other point of note related to tef consumption is that it is starkly split between urban and rural populations. Tef remains a luxury cereal and consumption is mostly an urban phenomenon. People in rural areas are unable to afford much tef and rely mostly on maize, sorghum, wheat, and barley to make injera and other staple foods. The average urban Ethiopian derives 600 calories per day from tef (around 30% of total daily caloric intake), whereas for rural residents this figure is only around 200 calories per day. This disparity has nutritional consequences, since tef is the most nutritionally valuable grain in Ethiopia.

---

Exhibit 6: Urban and rural consumption of tef and other cereals

Ecology and production areas of tef

Ethiopia has broadly divided its climate into five zones, based on elevation, and each zone has its own rainfall pattern and agricultural production system. In general, the highland (Dega and Weina Dega) zones contain most of the agricultural areas, while the semi-arid and arid lowlands zones (Kolla and Bereha) are dominated by livestock in agro-pastoral and pastoral production systems.

Tef is grown in almost all regions of the country under diverse agro-climatic conditions: from sea level up to 3,000 m.a.s.l.\(^8\). Much the same as wheat, tef can be grown in highlands where it is too cold for other major cereal crops such as sorghum and maize. This versatility gives tef (and wheat) an advantage as it has a wider altitudinal range than any other cereal in Ethiopia, though it is mostly cultivated in the mid-altitude areas.

**Climate:** The average annual rainfall in tef growing areas is 1,000 mm, but the range is from 300 to 2,500 mm. Tef resists moderate drought, but most cultivars require at least three good rains during their early growth, flowering, and seed-setting stages, and a total of 200 to 300 mm of water. Some early-maturing cultivars can obtain the 150 mm they need from water retained in soils at the end of the normal growing season. In terms of temperature, while tef has some frost tolerance, it will not survive a prolonged freeze. It also tolerates high temperatures (at its lower altitudinal range) well above 35°C\(^9\).

---

\(^8\) Seyfu (1993)

\(^9\) Abuhay et al. (2001)
Soil: Tef is highly adaptable to a wide range of soil types. It has the ability to perform well in black soils and, in some cases, in low soil acidities. In addition, tef has the ability to withstand waterlogged, rainy conditions, often better than other cereal crops (other than rice).

Dry Areas: The role of tef as a security crop in the dry land is well known. Tef is a reliable cereal during unreliable rainfall, especially during the occurrence of unpredictable dry spells. This makes tef an important crop for drought-prone and food-insecure areas. Its production is currently expanding to include many drought-prone areas of the country.

Priority Regions: In Ethiopia, tef is mainly produced in Amhara and Oromia with smaller quantities in SNNP and Tigray (Exhibit 7). There are 19 major tef-producing zones in the country. The Central and South Tigray zones are the major zones in Tigray. Within Amhara, the East Gojam, West Gojam, North Gonder, South Gonder, North Wollo, South Wollo, North Showa, and Awi zones are the major producers of tef. In Oromia, the major zones include East Shoa, West Shoa, Southwest Shoa, North Shoa, East Wallaga, Horo Guduru Wollega, Jimma, Illuababora, and Arsi.

Exhibit 7: Tef production by high-producing regions

<table>
<thead>
<tr>
<th>Region</th>
<th>Area (ha)</th>
<th>% share of total area planted</th>
<th>Production (ton)</th>
<th>% share of total production</th>
<th>Yield (ton/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tigray</td>
<td>165,804</td>
<td>6.01</td>
<td>209,507</td>
<td>6.02</td>
<td>1.264</td>
</tr>
<tr>
<td>Amhara</td>
<td>1,014,268</td>
<td>36.77</td>
<td>1,279,108</td>
<td>36.75</td>
<td>1.261</td>
</tr>
<tr>
<td>Oromia</td>
<td>1,289,405</td>
<td>46.74</td>
<td>1,671,803</td>
<td>48.04</td>
<td>1.297</td>
</tr>
<tr>
<td>SNNPR</td>
<td>265,377</td>
<td>9.62</td>
<td>296,759</td>
<td>8.53</td>
<td>1.118</td>
</tr>
<tr>
<td>Benishangul</td>
<td>23,648</td>
<td>0.86</td>
<td>23,107</td>
<td>0.66</td>
<td>0.977</td>
</tr>
<tr>
<td>Total/average</td>
<td>2,758,502</td>
<td>100</td>
<td>3,480,284</td>
<td>100</td>
<td>1.262</td>
</tr>
</tbody>
</table>

Source: CSA (2011), Agricultural Sample Survey: Area Planned and Production of Major Crops, Meher

1.3 The tef value chain and its steps

Tef Value Chain steps

A value chain describes the full range of activities which are required to bring a product or service from conception, through the different phases of production, on to delivery to final consumers, and final disposal after use. Taking a “value chain approach” to economic development helps to address the major constraints faced by a sector or business under consideration. The process also presents an approach that will leverage opportunities available at multiple steps along the value chain.

For tef, the steps of the value chain identified are: Research development, Input production, Input supply and distribution, On-farm production, Post-harvest processing and utilization, and Market access and growth.

10 Kaplinsky and Morris (2000)
1.4 Major stakeholders

The Ministry of Agriculture (MoA): The MoA is responsible for developing and refining the overall national agricultural and rural development policies, strategies, and programs for Ethiopia, with input and support from the regions and other stakeholders.

The Regional Bureaus of Agriculture (RBoAs): The RBoAs are responsible for agricultural and rural development in each region. RBoAs develop extension packages and provide support to woreda offices of agriculture in delivering extension services. They also facilitate coordination and alignment across development partners to ensure delivery of coordinated agricultural development services at the woreda level. Zonal offices of agriculture provide coordination and technical support for woreda offices of agriculture.

Research Institutions: The Ethiopian Institute of Agricultural Research (EIAR) and the Regional Agricultural Research Institutes (RARIs) have the mandate to generate, develop, and adapt agricultural technologies that focus on the overall development and needs of smallholder farmers. These institutes play a key role in the development of solutions and technologies towards provision of improved inputs (including improved varieties and adapted farm implements) and recommended agronomic practices.

EIAR is responsible for the coordination of tef research nationwide, while other agricultural researchers and the RARIs are responsible for targeted research within various geographies to identify region-specific recommendations. EIAR manages a number of federal research centers, with each mandated to work on a specialized set of agricultural research topics. Four federal research centers are especially important to the tef sector: Debre Zeit Agricultural Research Center (DARC), Holetta Agricultural Research Center (HARC), Jimma Agricultural Research Center (JARC), and Melkassa Agricultural Research Center (MARC).

Regional Agricultural Research Institutes, namely Axum in Tigray, Areka in SNNPR, Bako in Oromia, and Adet and Sirinka in Amhara, also engage in tef variety development and agronomic research efforts.

Universities: Apart from being main learning institutions, universities also engage in research and technology generation. Furthering the development of research will require the engagement of both faculty and students throughout Ethiopia’s university systems.

Public Seed Enterprises (PSEs): Public seed enterprises include the Ethiopian Seed Enterprise (ESE) and Regional Seed Enterprises (RSEs) in Amhara, Oromia, and SNNPR. PSEs are responsible for implementing government targets to produce sufficient quantities of improved seed for key crops, including tef, while also functioning as independent, profitable businesses.
ESE is the oldest and largest seed producer in the country; its board of directors is led by the head of EIAR, with other members from EIAR and MoA. RSEs are governed by respective RBoAs and receive operational support, including deployment of Bureau staff. RSEs are relatively new seed producers – the oldest, OSE, being three years old – established to meet the needs of the regions.

**Federal Cooperative Agency:** The Federal Cooperative Agency develops and enforces federal regulations and oversight criteria, regulates and oversees cooperatives, regulates and oversees enabling services for the cooperatives in the country, promotes federal market infrastructure development, capacitates regional officials, and assists the regions.

**Regional Cooperative Offices:** Regional Cooperative Offices, in adherence to federal rules and regulations, develop and enforce intra-region regulations and oversight criteria, regulate and oversee intra-region enabling services, regulate and oversee intra-region coops, promote regional market infrastructure development, and capacitate local officials.

**Cooperatives/Unions:** Agricultural cooperatives have an important role to play in organizing smallholder farmers, providing inputs and output marketing services.

**Ministry of Trade:** The Ministry of Trade has a mandate to manage the licensing and registration of traders and improve the country’s competitiveness in foreign markets. It does this through the formulation and implementation of pro-export policies and strategies, and through the collection, analysis, and dissemination of export trade-related information to relevant members of the business community.

**Ministry of Industry:** The MoI has a mandate to develop agro-processing industries, by creating conducive conditions to encourage investment in the sector, generating agro-processing industrial project ideas and linking relevant stakeholders, attracting joint ventures from abroad, and providing support to agro-processors, in line with the country’s industrial development strategy.

The Ministry of Foreign Affairs and foreign missions contribute in facilitating contacts and assisting in business deals, organizing trade missions, creating opportunities for tef value-added products, encouraging Injera exporters to participate in international trade fairs, exhibitions, conferences, and workshops, and creating awareness on export market opportunities.

**Private sector:** The tef value chain will benefit from increased private sector investment and involvement, particularly through participation in seed and input production and distribution, agro-processing, and the creation and support of large-scale domestic and international demand. The private sector will also spur the innovation of business models, including Public-Private Partnerships (PPP).

**Non-government, multilateral, and bilateral organizations:** These are major players in agricultural and rural development, many of which implement programs in food security and natural resource management, through the provision of resources and operational support.

**ATA:** The ATA will continue to provide implementation support in the form of continued problem solving, resource mobilization, project management, and coordination at various levels of the Ethiopian agriculture system.
1.5 Strategy development process

Developing the National Tef Strategy has included several key components. The first step was to define a vision: a snapshot of the future that conveys a desired situation. Given the challenges faced and the current state of the tef value chain, the vision statement for tef aims to provide an illustration of what the tef value chain within Ethiopia could look like in the near future.

Exhibit 9: Flow chart of strategy development process

![Diagram of strategy development process]

Source: ATA team analysis

After defining the vision, strategy development has gone through a series of steps, starting with a Tef Value Chain Diagnostic\(^\text{11}\) to develop a roadmap, and ending with the preparation of the Strategy Document. The study used both primary and secondary data. The primary data was collected through group discussions (DZARC team; farmer groups in Ada’a, Becho, Shashemene and Dejen) and key informant interviews. Information on tef marketing was obtained from tef market actors, including assemblers, brokers, wholesalers, millers, and processors. In addition, secondary data was collected from sources such as the CSA, Ethiopian Grain Trade Enterprise, workshop proceedings, and published and unpublished documents. Extensive reviews of the relevant literature were conducted.

This work led to the development of the Tef Vision and Roadmap that was discussed at a stakeholder workshop held in January 2012. Since then, the ATA, MoA, and EIAR, in close collaboration with key stakeholders (e.g., RBoAs), have been working on the development of the full-fledged National Tef Strategy. In September 2012, the draft Strategy document was presented at a key stakeholders’ consultative meeting. The meeting was attended by federal and regional stakeholders. Individual stakeholder meetings have also been conducted, including ones with the tef research team at DZARC.

\(^{11}\) Bekabil et al. (2011)
Finally, all key stakeholders were provided draft copies of the strategy at various stages of the process to provide detailed comments before a national launch.
Section 2  Key developments in the tef sector

Over the last decade, the Ethiopian tef sector has taken various steps towards fulfilling this long-term vision. A number of developments in the involvement of various stakeholders signal a fundamental shift towards an environment where more actors are engaged. Key developments include:

1. **National Agricultural Research Systems (NARS):** NARS, including the federal EIAR, RARIs, and the higher learning institutes, will continue to be the major facilitators and catalysts for breeder and pre-basic seed production. NARS is also the primary mandate for the generation and development of new tef varieties, along with other associated improved tef technologies suitable for different agro-ecologies and addressing biotic and abiotic stresses. In addition to NARS, the Debre Zeit Agricultural Research Center has also been striving to meet these targets.

2. **Sasakawa Africa Association (SAA):** founded by Dr. Norman Borlaug, President Jimmy Carter, and Ryoichi Sasakawa, SAA has been working in agricultural extension in Ethiopia since 1993, in collaboration with the MoA and Rural Development (MoARD). This partnership has resulted in investigative research that has supported the promotion of current tef technologies in the country.

3. **University of Bern, Department of Biology and Plant Sciences, Switzerland:** the University has an ongoing research effort known as TILLING to identify dwarfing genes in tef. Several short elite lines have been identified and have been delivered to the Debre Zeit Agricultural Research Center where they are now being used in the crossbreeding program.

4. **McKnight Foundation, support of tef project:** this project, conducted in collaboration with the Debre Zeit Agricultural Research Center, has been pivotal in the development of PCR based molecular markers, construction of chromosome linkage maps, and identification of Quantitative Trait Loci (QTLs) to be used in future marker assisted breeding. McKnight Foundation also helped the tef improvement project in research capacity development. Cornell University had a longstanding tef collaborative research project with the Debre Zeit Research Center and EIAR, through a grant from McKnight Foundation.

5. **The International Atomic Energy Agency (IAEA):** this organization designed and completed a collaborative research project with the Debre Zeit Agricultural Research Center over several years, starting in 1975. The project was aimed at solving the problem of lodging in tef through mutation breeding.

6. **Human resource development:** Human resource development in the areas of tef genetics, cytogenetics, entomology, tissue culture, and biotechnology, have been supported through human capacity building by non-governmental organizations such as DFID, Sida/SAREC, etc.

Despite these great strides in tef sector development, much more must be done to systematically accelerate the positive trend of the past years.
Section 3  Vision, challenges, and interventions by value chain step

3.1  Research development

3.1.1  Vision

**Overall vision for research development:** Research institutions have easy access to a wide genetic pool and are fully engaged to make critical advances in all research areas involving tef.

3.1.2  Systemic challenges

Ethiopia is the center of origin and diversity of tef\(^\text{12}\). Because tef was relatively unknown elsewhere, the burden of tef improvement has rested upon domestic efforts. This also means that, in the absence of possibilities for the introduction of any useful tef genetic stocks from abroad, its genetic improvement depends entirely upon indigenous germplasm resources. Tef research and development efforts in Ethiopia began in the late 1950s.

The Debre Zeit Agricultural Research Center (DZARC) is the main center for tef research within the Ethiopian Institute of Agricultural Research (EIAR), and other national and regional agricultural research centers play a pivotal role in conducting on-station and on-farm trials of tef. In particular, three other research centers (Holetta, Melkassa, and Jimma) have contributed to tef agronomic research. The tef research activities conducted by DZARC include breeding, agronomy, crop protection (management of weeds, diseases, and insect pests), nutrition, socioeconomics, and extension. Tef research is an integral part of each of the subsequent steps in the tef value chain and research activities should be considered as vital to the success of each step.

Later, in 1970, three improved varieties (mass selections from collected germplasm) were released at DZARC. And in 1974, tef crossbreeding was discovered by Dr. Tareke Berhe, which opened the door to the creation of other new varieties, such as Cross 37 and Quncho. About 19 of the 33 currently released improved varieties of tef were developed by DZARC. According to the researchers, previously released varieties have not been widely accepted by farmers because of their color, despite high yield levels. However, because of its grain color and yield, the recently released Quncho (DZ-Cr-387) variety has become popular in many tef-growing areas\(^\text{13}\).

Today, limited scientifically-trained human resources, inadequate facilities, and insufficient financial resources are key constraints that limit tef research. Breeding is currently the best-functioning approach to tef research, but even this field is under-capacitated. Moreover, there is limited or absent applied research in many areas, such as agronomy, soil, physiology, crop protection, and pre-harvest mechanization.

**Challenge 1: Insufficient priority is given to tef research, resulting in limited institutional and resource capacity**

---

\(^{12}\) Vavilov (1951)

\(^{13}\) Kebebew et al. (2011)
As mentioned above, resolving constraints within the research system will prove challenging as there is a human capacity shortage (mainly a retention problem): there are less than ten fulltime senior researchers on tef for the whole country. Obviously, this limits the scope of breeding, agronomy, and crop protection research, among other areas. Furthermore, in order to conduct comprehensive research on the crop, the facilities available at the research centers require significant improvement.

These resource shortages are compounded by the fact that tef is an “orphan crop” and is not internationally recognized. As a result, international funds for research are limited. In addition, the crop has received little attention in terms of domestic public research funding and is second to last for funding among cereals. Some clear examples of the under-emphasis on tef research include the lack of a CGIAR center on tef, as there exists for other crops, and the requirement of tef researchers to work in isolation from other similar scientists in the world. There has been little if any capacity improvement since the late 1950s, which is detrimental to tef research progress.

The below exhibit shows the count of fulltime human resources by research area for tef, coffee, and wheat. It is important to note that this table does not include part-time researchers (e.g., pathologists who may work across cereal crops) who also contribute to tef development. A comparison of fulltime resources indicates that tef has fewer dedicated breeders – and researchers generally – than other “priority” crops in Ethiopia, such as coffee and wheat. More researchers, including qualified breeders, agronomists/physiologists, and biotechnologists, are necessary to develop better improved tef varieties. In particular, there is a shortage of agronomy-focused research. Moreover, in order to fully capitalize on the synergies of part-time researchers’ efforts and developments, it is important to co-locate human resources effectively at centers of excellence (e.g., DZARC for tef).

Exhibit 10: Comparison of Availability of Fulltime Human Resources for Different Crops

<table>
<thead>
<tr>
<th></th>
<th>Plant breeding</th>
<th>Bio-technology</th>
<th>Agronomy</th>
<th>Pathology</th>
<th>Economics</th>
<th>Extension</th>
<th>Entomology</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tef</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PhD</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>MsC</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>BsC</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Coffee</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PhD</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>MsC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>BsC</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td></td>
<td>9</td>
</tr>
<tr>
<td>Wheat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PhD</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>MsC</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>BsC</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5</td>
</tr>
</tbody>
</table>

Note: Does not include part-time human resources
Source: ATA interviews with experts (2012)

**Challenge 2: Limited basic research on tef exists to serve as a basis for further exploration**

In addition to building and soliciting investments and resources to enable tef research, there is a need to create a strong knowledge base from which to pursue more complicated tef research and development. Given that tef is indigenous to Ethiopia and relatively unknown and unexplored elsewhere in the world,
it is necessary to build this strong research foundation specifically within the country. International and foreign national organizations and research institutes are not conducting significant research on tef, therefore, if Ethiopia is to make significant strides in tef research development, this lack of basic research must be corrected here in Ethiopia. In particular, there is a need to expand basic knowledge on tef in the areas of genetics, cytogenetics, genomics, and physiology.

**Challenge 3: Genetic resource collection and management is insufficient**

There is an insufficient comprehensive collection of genetic diversity among the tef germplasm and rapid characterization of collected materials. Tef belongs to the family Poaceae, sub-family Eragrostidae, and genus Eragrostis. This genus has 350 species and it is the only cultivated cereal species. Tef’s center of origin and diversity is here in Ethiopia.\(^\text{14}\)

Collection priorities need to be more systematic and set, based on factors such as natural disaster and resettlement programs, economic importance of the crop and its diversity, the rate of dissemination of improved varieties, threats on natural vegetation, agricultural policies, and researchers’ needs. In this regard, modern technologies such as GIS, well-organized data, and trained experts are compulsory to carry out the collection missions in systematic and methodological ways.

Characterization on the collections is generally conducted using international descriptor lists within the institute, while further evaluation activities are carried out by organizations such as EIAR. However, while many studies have been conducted on various field crop species, it was almost fully focused on the morphological characteristics of the crops, including tef. Now there is a need for the full range of well-identified and characterized genetic resources from tef. Therefore, IBC must conduct an intensive characterization assessment on tef and other crop genetic resources by applying bio-chemical and molecular techniques. In this regard, the institute requires well-organized molecular and bio-technology laboratories equipped with the required experts and laboratory chemicals.

Genetic diversity studies should be given priority to define the tef characters’ variability and their patterns of distribution, and to generate information for planned germplasm collection and utilization. Some cultivars have been identified using phenotypic characteristics, such as: plant size, maturity, seed color, and panicle form. As a result of using these characters for cultivar identification, a large variation has been observed. This variation can be explained because morphological characters are susceptible to environment.

Bai\(^\text{15}\) set up a study to evaluate genetic diversity of tef and its relatives. Out of forty-seven accessions of E. tef, some of them were described according to agronomic and morphological traits, along with three accessions from E. pilosa and six accessions from E. curvula. Two accessions from E. curvula came from the United States and another two from Argentina. The molecular marker used in this work was Random Amplified Polymorphic DNA (RAPD). This molecular marker has been used in many other crops to study the genetic relationships among species and cultivars.

---

\(^\text{14}\) Bai et al. (2000), Yu et al. (2006), Yu et al. (2007)  
\(^\text{15}\) Bai et al. (2000)
Challenge 4: Tef varieties released so far do not adequately address lodging, biotic/abiotic stress, shattering, food products, etc.

There are several challenges that exist within tef variety development. Firstly, there is incomplete genetic data on yield-limiting traits (e.g., plant physiology, morphology, growth habits, and root development). More broadly, there is limited data regarding the genetic compatibility between cultivars and wild relatives. Finally, consumer preferences are highly variable but also quite selective regarding the optimal grain type (e.g., white color, larger size, purity level).

Since 1970, 33 improved varieties have been developed. As the chart below shows, the average on-farm research yields for these varieties are higher than average farmers’ yields. However, few varieties have been developed specifically to address some of the larger problems impacting tef plant development. For example, the improved variety called Quncho has become increasingly popular, but is still not universally applicable. Quncho does not fare well with acidic or waterlogged soils, so farmers in these agro-ecologies tend to prefer lower-yielding but more resilient varieties. Similarly, higher-quality and higher-value ‘white tef’ varieties do not grow well in all soils, limiting farmers’ ability to use these varieties. These types of limitations hinder yield potential and, as a result, also curb the potential earned income for farmers.

Exhibit 11: Existing variation in Tef germplasm

<table>
<thead>
<tr>
<th>Trait</th>
<th>Panicle Length</th>
<th>Culm Length</th>
<th>Peduncle Length</th>
<th>Plant Height</th>
<th>Culm Thickness</th>
<th>Lodging Resistance</th>
<th>Straw Yield</th>
<th>Grain Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variation</td>
<td>10-65 cm</td>
<td>11-82 cm</td>
<td>6-42 cm</td>
<td>20-155 cm</td>
<td>1.2-4.5 mm</td>
<td>1-9</td>
<td>20-90 grams/plant</td>
<td>8-22 grams/plant</td>
</tr>
</tbody>
</table>

Source: Hailu et al. 2000

Exhibit 12: Average yield of tef varieties released between 1970 and 2006

<table>
<thead>
<tr>
<th>No</th>
<th>List of Varieties</th>
<th>Released By</th>
<th>Technical Recommendations</th>
<th>Productivity (ton/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>D/Zeit</td>
<td>Altitude (m.a.s.l)</td>
<td>Annual RF (mm)</td>
</tr>
<tr>
<td>1</td>
<td>DZ-01-99</td>
<td>D/Zeit</td>
<td>1500-2400</td>
<td>300-700</td>
</tr>
<tr>
<td>2</td>
<td>DZ-01-196 (Maghna)</td>
<td>D/Zeit</td>
<td>1500-2400</td>
<td>200-700</td>
</tr>
<tr>
<td>3</td>
<td>DZ-01-354 (Enatiti)</td>
<td>D/Zeit</td>
<td>1600-2400</td>
<td>300-700</td>
</tr>
<tr>
<td>4</td>
<td>DZ-CR-787 (RIL 355):Kuncho</td>
<td>D/Zeit</td>
<td>1800-2500</td>
<td>400-700</td>
</tr>
<tr>
<td>5</td>
<td>DZ-CR-44</td>
<td>D/Zeit</td>
<td>1800-2500</td>
<td>400-700</td>
</tr>
<tr>
<td>6</td>
<td>DZ-CR-82</td>
<td>D/Zeit</td>
<td>1700-2000</td>
<td>300-700</td>
</tr>
<tr>
<td>7</td>
<td>DZ-CR-387 (RIL 355):Kuncho</td>
<td>D/Zeit</td>
<td>1500-2500</td>
<td>300-700</td>
</tr>
<tr>
<td>8</td>
<td>DZ-01-1278 (Ambo Toke)</td>
<td>D/Zeit</td>
<td>2200-2300</td>
<td>700-800</td>
</tr>
<tr>
<td>9</td>
<td>DZ-CR-37 (Tesdey)</td>
<td>D/Zeit</td>
<td>1500-2200</td>
<td>150-200</td>
</tr>
<tr>
<td>10</td>
<td>DZ-CR-255 (Gibe)</td>
<td>D/Zeit</td>
<td>1700-2000</td>
<td>300-700</td>
</tr>
<tr>
<td>11</td>
<td>DZ-CR-974 (Dukem)</td>
<td>D/Zeit</td>
<td>1400-2400</td>
<td>150-700</td>
</tr>
<tr>
<td>12</td>
<td>DZ-01-146 (Genete)</td>
<td>D/Zeit</td>
<td>1450-1850</td>
<td>660-1025</td>
</tr>
<tr>
<td>13</td>
<td>DZ-CR-358 (Zekula)</td>
<td>D/Zeit</td>
<td>1400-2400</td>
<td>150-700</td>
</tr>
<tr>
<td>14</td>
<td>DZ-01-1281 (Gerado)</td>
<td>D/Zeit</td>
<td>1850</td>
<td>600</td>
</tr>
<tr>
<td>15</td>
<td>DZ-01-1285 (Koye)</td>
<td>D/Zeit</td>
<td>1900-2200</td>
<td>300-700</td>
</tr>
</tbody>
</table>
Another immediate need within research is how to address the challenge of lodging. One way to do this is through on-farm agronomic practices, which will be addressed later. Pertaining to research, the primary solution lies in development of lodging-resistant varieties. Lodging of tef continues to be a problem despite attempts to breed lodging-resistant varieties. The development of a resistant variety could considerably increase grain yield, and enable the use of yield-enhancing input technologies and easier, less labor-intensive husbandry practices, such as the use of mechanical threshers with cleaners. Since the beginning of tef research, lodging has been identified as a major problem, however it was not until the early 1980’s that a comprehensive study was conducted\textsuperscript{16}. Seyfu identified transient and permanent types of lodging. He divided permanent lodging into three types: bend, break, and root lodging. Bend lodging was identified as the most economically important type of lodging, causing an average of 17% grain loss under natural conditions. Development of lodging-resistant varieties through breeding is important, but may require a great deal of time and resources.

In addition to conventional breeding and other currently utilized techniques, plant breeding research has to be assisted with advanced recent technologies, such as biotechnology, to efficiently tackle the daunting challenge of increasing agricultural productivity. So far, the potential of agricultural biotechnology has not been significantly leveraged in Ethiopia. This technology could complement the conventional breeding programs and be used to develop new varieties that are tolerant to diseases, biotic and abiotic stresses, and also to improve the nutritional quality of food and feed. Varieties developed can be tested for viability as food products, and for biotic and abiotic stress tolerance.

\textsuperscript{16} Seyfu (1983)
New biotechnology tools have been developed for cultivar identification. Molecular markers have been used to study genetic variation, the number of species, and the relationships between them. These new techniques are not affected by phenotypic nor by the environment.\(^7\)

**Challenge 5: Limited applied research in many areas, such as socioeconomics, soil, physiology, food chemistry, crop protection, and mechanization**

The focus of tef research has been on breeding, with limited attention given to applied research in many areas, such as socioeconomics, agronomy, soil, physiology, food chemistry, crop protection, and pre-harvest mechanization. Below is a list of the main topics within each area that must be further researched:

- **Socioeconomics:** adoption, impact, and cost-value ratio of various inputs
- **Agronomy:** seed rate, planting depth and pattern, planting method, fertilization, cropping system, and soil health and fertility (e.g., integrated nutrient management, drainage, acidity)
- **Physiology:** drought, heat and cold resistance mechanisms, and crop-water requirement
- **Food chemistry:** physical, chemical, nutritional
- **Crop protection:** loss assessment, and management of grass-weed, rust, head smudge, and shoot fly
- **Pre-harvest mechanization:** tillage methods and machinery/planters

The tef mechanization groups at the Melkassa Research station and others are now focusing on the important topic of mechanization and have developed several prototype row planters which are now being tested. However, tef production remains almost entirely un-mechanized. The failure to develop and/or provide affordable access to processing technology constrains both profitability and yields as post-harvest loss rates remain high.

There are numerous research areas that should be further developed to improve tef, but there is a need to prioritize efforts to ensure effective utilization of resources. Given this, the priority research areas to be developed include fertilizer and herbicides, mechanized implements (pre-harvest), and plant and human nutrition. As the table below shows, each of these areas has experienced varying levels of research thus far, with some progress in fertilizers and herbicides and mechanized implements but little done on plant and human nutrition. For each area, there are distinct next steps that should be taken.

---

\(^7\) Bai et al (2000)
### Exhibit 13: Overview of current status of research by tef research area

<table>
<thead>
<tr>
<th>Research area</th>
<th>Description</th>
<th>Current stage of research</th>
<th>Further research required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breeding and agronomic practices</td>
<td>- Tef research and development efforts in Ethiopia began in the late 1950s, and in 1970 three improved varieties were released at DZARC</td>
<td>- Demonstrated yield improvement of over 4x, together with improved agronomic practices (e.g., row planting, transplanting)</td>
<td>- Now over 20 improved varieties have been developed, yet there is potential for much more seed development</td>
</tr>
<tr>
<td>Fertilizer and herbicides</td>
<td>- Chemical fertilizers are used to replenish nutrients depleted by the crop and soil loss, and to provide an optimal base for high yields</td>
<td>- Demonstrated yield improvement of over 3x based on fertilizer type (DAP+ urea with added micronutrients)</td>
<td>- Further evaluate existing fertilizer formulas and develop improved blends to test</td>
</tr>
<tr>
<td></td>
<td>- Herbicides are used to minimize yield loss from weeds that reduce tef plant growth</td>
<td>- Herbicides that have been tested (e.g., 2-4-D) have killed weeds but also tef plants; product is banned in many countries</td>
<td>- Investigate other herbicides and optimal application rates</td>
</tr>
<tr>
<td>Mechanized implements: pre- and post-harvest</td>
<td>- Row planter: animal/hand-drawn to plant in rows and control seed rate</td>
<td>- Low adoption rate for some machines (e.g., thresher) due to high cost and insufficient crash/credit access for farmer</td>
<td>- Explore opportunities to modify existing models of row planter and thresher</td>
</tr>
<tr>
<td></td>
<td>- Thresher: automatically separates grain from straw and chaff</td>
<td>- Existing row planter and broad-bed makers difficult to use in vertisols</td>
<td>- Adapt machines that are more versatile (e.g., can be multi-crop and used in varying soil conditions)</td>
</tr>
<tr>
<td></td>
<td>- Broad-bed maker: places seed in the soil, raises seedsbeds to drain excess water and prevent waterlogging</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Processing</td>
<td>- Post-harvest process of tef includes various activities that are often labor-intensive or that risk adulteration of tef grain (e.g., packaging, storing, milling)</td>
<td>- Very limited research does not address efficient processing opportunities</td>
<td>- Investigate more efficient ways to process tef and convert grain to tef products (e.g., flour, ready-to-make injera, etc.)</td>
</tr>
</tbody>
</table>

Legend:  
- On average 75% reached  
- On average 50% reached  
- Almost nothing is done

Source: ATA Tef Program team analysis with stakeholder input

### 3.1.3 Interventions

#### Intervention 1: Enhance institutional system and capacity in financial, human, and material capital

In order to increase funding for tef and develop the institutional capacity of the tef research system, there are several key activities to undertake. Firstly, tef should be formally recognized as a priority crop for Ethiopia. This includes elevating its status on a domestic and regional level through efforts such as formalizing it as a priority crop within the government-driven and donor-supported Agricultural Growth Program (AGP) and by raising awareness of its importance in regional food security for East Africa. On an international level, tef should be promoted to be included in funding and other support mechanisms by international organizations, such as the World Bank, USAID, AGRA, and INTSORMIL\(^\text{18}\), etc.

Secondly, government policies should be created or redesigned to increase investment in tef and encourage non-governmental partners to support capacity building for the tef value chain. Capacity in

\(^{18}\) International Sorghum, Millet and Other Crops Collaborative Research Project, University of Nebraska-Lincoln
this case includes both human and institutional. In terms of human capacity, tef has only five full-time experts (see Exhibit 10) consisting of two PhDs, one M.Sc, and two B.Scs. Many more have been trained but are dispersed and have demonstrated retention problems. This number of experts is insufficient for a crop of such great importance. There is also a strong need for additional experts to focus on other related areas, such as plant pathology, entomology, weed science, physiology, food science, soil fertility, and mechanization, etc. Although there are part-time researchers in some of these areas, there is room to improve the effectiveness of resource utilization, through changes such as co-locating researchers at one center of excellence to effectively share resources and realize other synergies. Moreover, conducting biotechnology-based research requires specialized, scientific leaders with advanced expertise. The inherent complexity of biotechnology research makes it cost-intensive, and only well-trained scientists/technicians are able to conduct experiments to ensure efficient use of funding and other resources.

In terms of institutional infrastructure, tef research requires large areas of land to conduct demonstrations of new technologies. A study should be launched to identify the optimal land for planting segregating generations. Enabling the progress of tef research also requires high-quality working environments with lath houses and greenhouses. Both the quantity and quality of greenhouses and related location needs should be scaled up. Finally, institutional infrastructure must be built in the form of well-furnished, equipped office and laboratory buildings. One key activity that will facilitate this is streamlining the supply chain to facilitate smooth ordering processes and to leverage economies of scale by purchasing in bulk and setting up long-term contracts with suppliers.

In order to accomplish these goals, there is a strong need to recruit, train, and provide incentives to retain new and current researchers. The current shortage of human resources dedicated to tef hinders rapid progress in tef research and development. Hiring, training, and retaining high-quality human resources will require several key initiatives:

**Training:** In order to equip researchers with the necessary analytical and technical capabilities to achieve success in tef research, an international-standard of training must be provided. This may take on various forms (e.g., graduate scholarships, exchanges, technical consultation, visits, etc.).

**Investments in post-graduate expertise/experience:** Beyond standard undergraduate training, the Ethiopian research system should focus its talent search efforts on post-graduate experts, specifically by enlisting individuals with experience in agronomy, biological sciences, and biotechnology.

**Means to retain talent long-term:** Once individuals have been recruited, efforts must be made to improve retention by developing an incentive system. For example, greater funding support for research activities, higher salary and benefits offerings, and world-class laboratory and other facilities could all play a role in retaining top talent and avoiding “brain drain” to international research systems. Leveraging various financing tools, such as top-up or financing advances, should also be explored.

**Intervention 2: Strengthen basic research (physiology, genetics, cytogenetics, and genomics) on tef**

There are several specific ways that basic research on tef development can be strengthened in Ethiopia. In particular, an increased use of molecular markers would allow breeders to track genetic loci
controlling drought tolerance and other important genes and traits, without having to measure the phenotype, thus reducing the need for extensive field testing over time and space. Another area of basic research to pursue is expanding the collection of tef relatives as sources of new germplasm and to characterize genotypes of these collected species.

In addition, tef physiology knowledge should be further developed, helping to better understand the physiology of drought resistance and thereby to develop physiological screening techniques. Moreover, developing a strong knowledge foundation on the genetics and physiology of yield and yield component traits, and their response to major environmental stresses, will help to isolate findings and enhance the tef breeding program.

**Intervention 3: Develop a comprehensive genetic resources collection and characterization**

Ethiopia has diverse agro-ecological zones. This diversity has endowed the country with equally diversified fauna and flora. In particular, this makes Ethiopia the center of origin and diversity for many economically important crops, such as tef, among many other species. Tef is believed to have first been domesticated by pre-Semitic inhabitants in Ethiopia between 4,000 B.C and 1,000 B.C.

Regarding the collection status of the tef gene bank, large numbers of cultivars have already been found\(^\text{19}\). A comprehensive study was conducted to establish a collection of 35 cultivars on 1,000 individuals based on phenotypic character\(^\text{20}\). And Kebebew\(^\text{21}\) investigated a total of 3,600 individuals representing 36 landrace population of tef, based on morphological markers to measure the phenotypic diversity.

At the Institute of Biodiversity Conservation gene bank there are about 5,971 accessions of domesticated landraces and 5 accessions of wild relatives of tef, collected from different agro-ecological zones of twelve former administrative regions. These are conserved at below zero 10°C.

Identifying collection gap areas (geography, wild relatives, and special purpose collections), characterization (morphological, biochemical, and molecular), evaluation, utilization, and conservation are very important yet challenging to accomplish. According to the results of Bai and Yu\(^\text{22}\), the genetic distance between tef accessions was between 0.84 and 0.96, indicating high similarity or low polymorphism at the DNA level.

Therefore, tef has a narrow genetic base, and only few genes could control the morphological variations showed by tef germplasm. When they studied the genetic relationship between E. tef, E. pilosa, and E. curvula, a high polymorphism was found between the three species. The genetic distance between them was from 0.18 to 0.88, which indicates the high degree of genetic diversity. As a result, the three species were classified into two main groups. E. tef and E. pilosa were in one group because they had a higher polymorphism, and E. curvula was in another group.

\(^{19}\) Tadesse Eba (1975); Seyfu Ketema (1993)
\(^{20}\) Tadesse Eba (1975)
\(^{21}\) Kebebew assefa (2003)
Also, other researchers had concluded that the closest relative to E. tef was E. pilosa.\textsuperscript{23} These two species could cross and new genes from the wild relative could be transferred to E. tef, providing new genetic resources for tef improvement.\textsuperscript{24} Another result from Bai’s study was the higher genetic distance between accessions from E. curvula. Those accessions collected from Ethiopia were closely related (86%), but they were distant from those from the United States and Argentina.\textsuperscript{25} Even though E. tef has a very narrow genetic variation, it could be increased by wild relatives, mainly E. pilosa, which E. tef could be crossed with. However, E. curvula has the higher genetic distance and it could be a source of genes used to introduce to E. tef via biotechnology tools.

In addition to this, a research team at the University of Bern, supported by the Syngenta Foundation for Sustainable Agriculture, is working on addressing this problem through TILLING (Targeted Induced Local Lesions in Genomes) by using radiation breeding. As Exhibit 11 shows, the large genetic variability in tef’s own germplasm, as well as related species, indicates there is potential to cross-breed existing varieties (e.g., panicle length, lodging resistance levels).

**Intervention 4: Strengthen and accelerate varietal development through breeding**

In order to address the aspects of tef production that drive yield losses, new varieties should be developed to combat these specific aspects. To develop these varieties, breeding should first focus on identifying the key challenges to address. For example, some of the major yield loss drivers are related to thin stalks that lodge and shatter during pre- and post-harvest activities. In addition to shattering and lodging, other challenges to address include broad adaptation, and varying maturity cycles. After identifying the main challenges in tef production, research should be directed towards breeding for specific traits, in order to resolve these issues using modern biotechnology tools, such as marker assisted selection techniques, as a complement to classical breeding techniques.

Specific breeding activities to be executed include:

- **Increasing number of crosses:** Intensify crossing of existing genotypes to identify viable lodging-resistant combinations and maintain a high rate, as a large number of crosses are required to produce and detect optimal heterotic offsprings.
- **Breeding with semi-dwarf varieties:** Crossing high-yield varieties with promising short lines and genotypes.
- **Applying wide crosses:** Expand interspecific crosses with other Eragrostis species in order to expand upon the variability of the species by introgression.
- **Mutation breeding:** Limited earlier efforts did yield some positive results but should be re-tried since mutation breeding has been successfully utilized in other cereals.
- **Molecular breeding:** Employ molecular markers techniques to supplement a classical breeding program, thereby reducing the time required for developing varieties. Available data/resources would be used to fine map and tag QTLs for future use in marker assisted breeding.

\textsuperscript{23} Yu et al. (2006) and Yu et al. (2007)  
\textsuperscript{24} Bai et al. (2000) and Yu et al. (2006)  
\textsuperscript{25} Bai et al. (2000)
- **In vitro breeding**: Enables researchers to create different breeds and increase genetic diversity.

  In vitro is a laboratory process that develops pre-breeding material. The process grows a tissue culture, called an explant, from the cells of a plant. The culture grows on a source of food called agar, and becomes a plantlet. In vitro or micro-propagation plant breeding also requires careful temperature and lighting control as well as sterile conditions. The harvested tissue cells from the mother plant must be healthy or the plantlet will not form normally. In light of this, tef varietal development efforts can be complemented using in vitro breeding techniques.

**Intervention 5: Enhance applied research in areas such as socioeconomics, soil, physiology, food chemistry, crop protection, and mechanization**

**Socioeconomics**: Ensuring a rapid and continued adoption of technologies can be achieved in a number of ways, among which the following are key: entire production system should have a clear, farmer focused and problem oriented approach; should be innovation-led; and should focused on sustainability. Recently, embarking on revenue generating enterprises has been earmarked as a pathway for sustainability. Inappropriateness of technologies or inputs to the specific agro-ecology and/or the navailability of inputs that go along with technologies will lead to unsustainable outcomes.

Input suppliers and credit providers sometimes demand unreasonable preconditions which individual farmers may not fulfill, resulting in low productivity even if the right agricultural inputs and cultural practices are used. The outcomes will be measured through indicators that are a few steps closer to the farmer than the output indicators. Finally, the outcomes should contribute to the actual adoption, impact, and cost-value ratio for inputs at the farmer-level, in a much wider geographic area, and on a broader scale.

**Agronomy**: Investigate appropriate agronomic practices for different agro-ecologies and purposes to reduce production costs and increase production and productivity.

**Physiology**: Explore drought and other abiotic stress resistance mechanisms and establish water requirements for tef.

**Food chemistry**: Investigate the physical properties (seed weight, seed size, seed color, WAI, WSI), chemical composition (protein, starch, amylase, amylopectin, presence of tannin), pasting properties (peak viscosity, hot paste viscosity, breakdown viscosity, cold paste viscosity, setback viscosity), and nutritional quality (lysine, iron) of tef. The results of these parameters will be correlated to their food making qualities.

**Crop protection**: On tef 24 fungal, two nematodes, 38 insect pests, and 91 weed species have been recorded. Among the diseases, tef rust (*Uromyces eragrostidis*), head smudge (*Helminthosporium miyakei*), damping-off (*Drechslera spp*), and helminthosporium leaf spot (*Helminthosporium spp*) are occasionally important. Although tef rust infects tef after flowering, yield losses of 10-40% have been reported. The loss due to head smudge can reach 50%.

Similarly, among the insect pests, the tef grasshopper (*Aiolopus longicornis*), Degeza/Wello bush cricket (*Decticoides brevipennis*), tef red worm (*Mentaxya ignicollis*), and tef shoot fly are sporadically important pests in different tef growing areas of the country. Weeds are another group of tef pest, and
more than 91 species are known to occur in association with tef. The parasitic weed *Striga hermontica*, for example, parasitizes tef in western Tigray.

The current “pest status” of tef pests is based on observations or on-station loss assessments done on research plots in the late 1960s and early 1970s. The tef grasshopper and diseases such as damping off, which were once major pests of tef, have since been relegated to minor status, but they are still classified as major tef pests. Therefore, aside from its use in decision making and prioritizing tef pest research, undertaking loss assessment studies will help to update the current “pest status” which is used as a basis for insurance coverage and other purposes.

Compared to diseases and insect pests, weeds are even more important tef pests. For example, when hand weeding, which is the dominant method of weed control in tef, weeds have to grow to a height that can be seized by hand, in order to be effective. But by the time the weed has reached this height, the critical weeding time has passed and losses are incurred. Moreover, the morphological resemblance of grass weeds with tef at its early stage increases the difficulty of controlling grasses by hand. In some tef growing regions, grass weeds also get a selective advantage from repeated use of broad-leaf herbicides. Therefore, devising grass weed management methods, including herbicides, is of paramount importance.

**Pre-harvest mechanization:** Different recommendations and best practices being promoted by the research system, individually or as part of technology packages, require new or better agricultural mechanization technologies. With existing farm implements or bare hands, many of these practices are simply not possible, or not economically feasible enough to execute.

Row planting of tef is one best practice for improving agricultural production and productivity in Ethiopia. Like other small seeds, tef seed can be sown in rows by drill planters, where there is no need to place plants equidistant down the rows. In order to introduce mechanical row planting of tef, different organizations/institutions (MARC, JICA, QSP experts, My-media, and other manufacturers) have tried to develop initial prototype seed drills. Recent preliminary tests of these prototypes showed that further extensive testing, improvement, and promotional work has to be carried out in order to deliver viable planting implements.

Given tef’s status as an “orphan” crop that receives relatively little global attention, a shortage of work has been done in non-breeding research areas. With the government’s interest and commitment to tef, it is expected that the number of stakeholders and amount of support will increase, providing tef with the attention it deserves. In particular, activities should be undertaken to strengthen the following: systematic research of tef mechanization; crop, pest, and soil management; processing; storage; plant and human nutrition; marketing; trading; and other critical non-input areas.

**Intervention 6: Strengthen research related to other value chain steps**

Although listed as a distinct and first step in the tef value chain, research is also relevant to each subsequent step of the value chain and should therefore be considered a priority for advancement of each value chain step. Below are some key examples of necessary research functions related to other value chain steps.
Research on tef food recipe development

In Ethiopia, the use of tef is limited to a few traditional food products that are staple items in the Ethiopian diet, such as injera. The development of new tef-based food products could be developed locally, through research or through the adaption and testing of recipes developed elsewhere, for value-addition and income-generation purposes. In Europe, for example, different baked food products were developed from tef to serve the European gluten-intolerant population, which made tef increasingly popular.

Research on tef standardization and grading

Although an effort has been undertaken by the Quality and Standard Authority of Ethiopia to create and popularize a tef standard and grading system, it has noted shortcomings. One of the problems is that it does not consider and reflect the vast geographic variations and origins of tef. For example, this means that the standards and grading applied to “white tef” that originates from Gojam will not be the same as “white tef” that originates from Becho area, rendering the system somewhat invalid until it is fully comprehensive and updated.

3.2 Inputs production

3.2.1 Vision

Overall vision for inputs production: Agricultural inputs, including seed, lime, farm implements, and pesticides, are produced in sufficient quantity to meet smallholder tef farmer demand.

3.2.2 Systemic challenges

Inputs required by tef farmers include seed, lime, farm implements and herbicide. Note that this section intentionally omits fertilizer even though it is also an important agricultural input because inorganic fertilizer is not produced domestically but rather procured from international sources. Therefore, the next section, Inputs Supply and Production, addresses fertilizer in detail, including international procurement and supply as well as domestic distribution of fertilizer.

This Strategy primarily focuses on seed and fertilizer as they are believed to have the greatest potential impact on productivity in the near term. Though numerous improved tef varieties have been released, farmers have complained about the availability of the right quantity and quality of seed, at the right time and place, from both the formal and informal seed sectors.

The formal and informal seed sectors are the two key sources of tef seeds for farmers in the country. In the formal seed sector, the supply of open- and self-pollinated seeds, including tef, has been dominated by the Ethiopian Seed Enterprise (ESE) (more than 85%) over the past three years.

As depicted below, over the past few years, about 55% of the total area cultivated for tef has had some fertilizer applied, yet the reported area covered by improved seeds has been less than 1%26. The second

26 Bekabil et al. (2011)
figure, however, is likely to be an underestimate as it does not take into account varieties developed by research stations that have been distributed in previous years and adapted by farmers who now consider them as local varieties or seed recycling.

Exhibit 14: Use of improved technologies in tef

<table>
<thead>
<tr>
<th>Year</th>
<th>Area cultivated (ha)</th>
<th>Improved seeds (t)</th>
<th>% share</th>
<th>Fertilizer (t)</th>
<th>% share</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003/04</td>
<td>1,989,068</td>
<td>1,215</td>
<td>0.61</td>
<td>99,685</td>
<td>50.12</td>
</tr>
<tr>
<td>2004/05</td>
<td>2,135,553</td>
<td>1,545</td>
<td>0.72</td>
<td>113,805</td>
<td>53.29</td>
</tr>
<tr>
<td>2005/06</td>
<td>2,246,017</td>
<td>2,471</td>
<td>1.1</td>
<td>131,960</td>
<td>58.75</td>
</tr>
<tr>
<td>2006/07</td>
<td>2,404,674</td>
<td>1,317</td>
<td>0.55</td>
<td>142,514</td>
<td>59.27</td>
</tr>
<tr>
<td>2007/08</td>
<td>2,565,155</td>
<td>1,760</td>
<td>0.69</td>
<td>153,098</td>
<td>59.68</td>
</tr>
<tr>
<td>2008/09</td>
<td>2,481,333</td>
<td>1,661</td>
<td>0.67</td>
<td>121,456</td>
<td>48.95</td>
</tr>
<tr>
<td>2009/10</td>
<td>2,588,661</td>
<td>1,930</td>
<td>0.75</td>
<td>126,503</td>
<td>48.87</td>
</tr>
<tr>
<td>2010/11</td>
<td>2,761,190</td>
<td>3,192</td>
<td></td>
<td>145,039</td>
<td></td>
</tr>
<tr>
<td>2011/12</td>
<td>2,731,112</td>
<td>7,391</td>
<td></td>
<td>143,459</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>2,433,640</td>
<td>1,700</td>
<td>0.73</td>
<td>130,835</td>
<td>54.17</td>
</tr>
</tbody>
</table>

Source: CSA (various years)

Improved seed usage was low in the past, yet recent production and adoption of improved seed in the country has grown substantially. This surge in production is partly attributed to new developments including the emergence of regional seed enterprises (RSEs) which have created an opportunity to address location-specific needs. The other advancement is in farmer-based seed multiplication schemes implemented by specialized local seed producer cooperatives.

Lime is another critical input that is required for increased productivity for areas with acidic soils. When the pH of the soil falls below 6.0, the prevalence of nutrients in the soil, such as phosphorus, potassium, calcium, and magnesium, is decreased. The availability of the metallic micronutrients, however, such as zinc, manganese, copper, and iron, increases as the pH decreases. The main determinant of soil acidity levels is rainfall. Water passing through the soil leaches basic cations from the soil, such as calcium (Ca2+), magnesium (Mg2+), and potassium (K+), and pulls them down into drainage water. These basic cations are replaced by acidic cations in the soil, such as aluminum (Al3+) and hydrogen (H+). For this reason, soils formed under high rainfall conditions are more acidic than those formed under arid conditions.

The majority of tef-producing areas of Ethiopia are in the central highlands, where the rainfall intensity is medium to high. Lime is used in the soil to combat the acidity levels, to reduce the harmful effects of
low pH (aluminum or manganese toxicity), and to add calcium and magnesium to the soil. The amount of lime needed to achieve a certain pH depends on the existing pH and the buffering capacity of the soil. The buffering capacity is related to the cation exchange capacity (CEC). The higher the CEC, the more exchangeable acidity (hydrogen and aluminum) is held by the soil colloids. Despite the great benefits of from treating soil with lime, its lack of timely availability, low production, and high price (making it costly for farmers) are among the challenges to be addressed.

The third input discussed in this section is farming implements, which includes any type of machinery or instrument that aids in increasing productivity for the farmers in pre-farming and farming activities. Implements can be procured from international sources or manufactured locally using basic materials such as water bottles and wood. These implements are used to prepare the land before planting and also to enable efficient planting methods, such as planting in rows by first using an implement to create rows in the soil.

A final input to be considered is pesticides. Pests are a major concern in tef production, as pests have the capacity to damage large area of crop when they occur. Commonly occurring pests in Ethiopia include the armyworm and the locust. In particular, herbicides, such as 2-4-D, should be considered, given that tef is grown under a wide range of farming systems and therefore is exposed to a wide range of weeds that can affect production.

**Challenge 1: Production of seed is inconsistent, containing a high variability in the quality and quantity produced**

The first priority of seed multiplication is to produce high-quality seeds for the next planting season. Since high-quality seeds – Basic Seed (BS) and Certified Seed 1 (C1) – are in short supply, the Government of Ethiopia has designed a policy to support the multiplication and distribution of a second-tier quality seed, called Certified Seed 2 (C2), which is intended to fill the gap of quality seed in the market. Farmers that lack access to BS or C1 seed often self-multiply using their previous year’s grain, however maintaining quality standards in this manner is challenging. Often, these seeds are local varieties of lower quality, exhibiting lower potential yield, greater exposure to diseases, poor germination, and contamination during post-harvest processing.

The major challenge facing seed production is an insufficient supply of seeds. This is partly due to the absence of efficient seed demand assessment systems and processes. One cause for this mismatch between supply and demand is the fact that most seed producers do not assess their markets; rather they rely on national demand assessments by the government.

The national demand assessment is a bottom-up process that begins with the DA surveying farmers at the kebele level, which is then aggregated to the woreda, zonal, regional, and finally the national level. Based on these statistics, the MoA and RBoAs then engage public and private sector seed producers to develop seeds for the farmers stated demand. Finally, the seeds produced by public and private seed companies are channeled through the RBoAs to cooperatives for distribution to farmers.

Unfortunately, this system has a built-in lag that frequently creates a mismatch between supply and demand. While the farmer may have requested a certain type of seed, the actual delivery of that seed is often delayed by a full year due to production. This means that the “actual” demand at the time of
purchase may change, due to seasonal climate factors (i.e., later rains that change the needs of a farmer from longer maturity to shorter maturity varieties) or lack of funds. And these changes are not reflected in the demand assessment or the eventual supply\textsuperscript{27}. Absence of real-time market assessment mechanisms have forced seed producers to plan production based on the previous year’s sales, leading to sharp annual changes.

A scan of woredas across 3 of the 4 priority regions (Amhara, Oromia, SNNP, and Tigray) was done to determine the demand and supply of improved seed varieties for tef. Across the regions, 25 woredas experienced a shortage of seed while only 5 received a surplus. This scan suggests that the current gap between demand for improved varieties and local supply is also location specific.

An analysis of the last four years of improved variety supply and demand in the four priority regions reveals a disparity, both across years and regions. As Exhibits 15 and 16 show, supply and demand in recent years exhibited a consistent problem with seed shortages, especially in Oromia and Tigray.

Exhibit 15: Count of seed imbalances by region

\begin{center}
\begin{tabular}{|c|c|c|c|}
\hline
Region & Shortage & Surplus \\
\hline
Amhara & 9 & 3 \\
Oromia & 12 & 1 \\
Tigray & 4 & 1 \\
\hline
\end{tabular}
\end{center}

Source: ATA interviews with Zonal Bureaus of Agriculture (2012)

\textsuperscript{27} Five Year Strategy for the Transformation of the Ethiopian Seed System (2012)
Timely processing, cleaning, packaging, distribution, and delivery to farmers before tef planting time are also critical areas in need of improvement.

**Challenge 2: Lime, which is used to treat highly acidic soil, is both in limited supply and costly to farmers**

Available information indicates that 13% and 27% of the land area is roughly classified as strongly and moderately acidified respectively\(^{28}\). The extent of acidity is believed to increase from year to year due to anthropogenic or manmade activities, and agricultural productivity in areas with high soil acidity is generally very low. Because high-quality, finely ground limestone is very dusty and difficult to spread, a "prilled" or "granular" limestone application will alleviate this problem and make application easier and more effective for smallholder farmers. In order to form these small "prills," a small amount of clay or a polymer is added to the ground limestone to avoid dustiness in application. This makes it easier to spread by hand or with a garden fertilizer spreader. Once applied, soil moisture will cause the "prills" or "granules" to dissociate and disperse the limestone particles. Additional constraints facing lime application include the high quantity of lime required (and therefore the high costs to farmers), lack of lime application rates tailored to specific agro-ecologies, and the absence of lime application in the use of row planting.

**Challenge 3: Existing farm implements (e.g., row planters, broad-bed makers, and ploughs) are inadequate and not readily available to farmers**

A number of farm implements have been designed and created within the last two decades, including the “Erfo” and “Mofer” attached moldboard ploughs, winged plough, broad-bed maker (BBM), tie-ridger, and mechanical broadcaster. These technologies play a significant role in improving labor and land

\(^{28}\) MoA (2012)
productivity for farmers, particularly given the labor-intensive nature of tef farming. Some efforts have been made to mass produce and introduce these technologies to the user community, through the research extension system, third-party partner organizations, and public-private partnership models. However, excluding very few implements, such as the BBM, minimal efforts have been successful at the large-scale mass production and introduction of farm implements, beyond small groups of farmers or kebeles. This is driven in large part by a lack of awareness of the value of using such implements, the initial start-up costs required to develop and produce machinery, and difficulty in reaching farmers across a widespread geographic area, among other reasons.

**Challenge 4: Pesticides are currently costly and are not widely accessible for farmers**

The availability and affordability of pesticides in tef production is a major constraint for tef producers. Ethiopia enacted the Pesticide Registration and Control Special Decree 20/1990 in September 1990. Since then, very few pesticides have been registered for use on tef production. For instance, in 1999 only two active ingredients (although there are several different trade names), one for fungicide and one for herbicide, were registered. Insecticide was not registered at all, but ten active ingredients were registered for use on cereals and pastures in general, for armyworm (*Spodoptera exempta*) and locust (*Schistocerca gregaria* and *Locusta migratoria*) control. This limited supply has not grown since, given the perceived low rate of return on investments in pesticides, especially when coupled with an investment in spraying equipment. The low active demand for pesticides ultimately discourages pesticide dealers and equipment suppliers.

One pesticide that is particularly important to tef is the herbicide 2-4-D. A review of literature shows that countrywide, tef yield losses due to weeds (if there is uncontrolled weed growth) range between 23% around the Debre Zeit area to 56% in Eastern Shoa. The use of 2-4-D herbicide at a recommended rate of 1 liter per hectare can help control broad-leaf weeds, yet this is not always effectively practiced. Focus group discussions with farmers reveal that farmers in the Ada’a area use the recommended rate of herbicide while farmers in Becho and Shashemene reported application of about 0.5 liters of 2-4-D per hectare, which is only half of the recommended rate. In the Dejen area, the use of herbicide is uncommon, as farmers have found that the application of the chemical can make the tef inflorescence sterile and produce no grain when the herbicide is applied at the wrong time, such as the jointing stage and beyond. Thus, the farmers prefer to use hand weeding and only rarely use chemicals while under the supervision of extension workers²⁹. In addition, 2-4-D has been banned in many countries and its continued use in Ethiopia has produced a new generation of 2-4-D-tolerant broad-leaf weeds. Thus, new types of herbicides are urgently required, together with new types of knowledge dissemination on the appropriate application rates. It should be clear that the use of the chemical was found to reduce the need for tef weeding, however, the chemical does not kill grass weeds, making hand weeding essential even for those farmers who do apply herbicide.

### 3.2.3 Interventions

**Intervention 1: Strengthen capacity of public and private enterprises to improve seed production efficiency**

²⁹ Bekabil et al. (2011)
Strengthening of the formal sector requires a deep look at the currently operating model and processes employed by the public seed enterprises, from demand assessments (addressed in the following intervention) to annual planning to collection of seed. Efforts must be made to work closely with leadership of each of the seed enterprises to determine specific ways to improve processes and thereby improve seed production efficiency. For example, it may be possible to better formalize the pre-planning process that the seed enterprises undertake in collaboration with the regions so that the appropriate varieties are prioritized for production, such as Quncho and Cross-37.

In addition, there are several targeted ways to strengthen private sector enterprises. As the bridge between activities of the formal and informal seed systems, community-based and cooperative seed producers have the advantage of being more closely linked with smallholder farmers and their needs. Community-based seed system empowerment encourages promotion of new tef seed varieties and will contribute to the effectiveness of improved seed based technology promotion. Participating farmers in a community-based seed production will serve as sources for seed, knowledge, technology transfer, and experience in deploying high yielding, adaptive to biotic and abiotic stress tef seed varieties. To formalize and ensure quality seed output from this intermediate system, community-based and cooperative seed producers require appropriate resources and capacity-building efforts to support their activities, including:

**Early-generation seed:** Community-based and cooperative seed producers experience difficulties in securing adequate quantities of early-generation seed of improved varieties, which is allocated only to public enterprises, and are often forced to conduct multiplication activities using certified seed. It is important to link these producers with early-generation seed producers to create sustainable access to early-generation seeds.

**Technical assistance and oversight:** Community-based and cooperative producers need to be more strongly linked with the formal seed sector through the research and extension systems, in order to build their ability to produce quality tef seed through access to guidelines, technical assistance and oversight, and training on topics including tef seed production techniques and business management.

**Adequate processing and storage capacity:** Adequate processing and storage capacity is required to maintain the quality and productivity potential of seed. In particular, seed cleaners and specialized storage for seed require significant capital investment, and community-based and cooperative producers will need support in securing the required investment capital.

**Financial resources:** Given their limited collateral and risky seasonal revenue streams, agricultural cooperatives require a dedicated source of financing capital. A dedicated revolving cooperative fund should be developed, such as the Oromia Cooperative Bank (OCB) and Addis international Bank (AIB) which were established by cooperatives to serve the cooperatives. Microfinance Institutions (MFIs) and Rural Savings and Credit Cooperatives (RUSACCOS) should be strengthened and their mandates expanded to serve the role of semi-dedicated financing institutions for the cooperatives sector, and to draw on the dedicated Cooperative Fund to lend to cooperatives at low interest rates. The Commercial Bank of Ethiopia’s roles should also be considered for credit guarantees so that cooperatives can access financing from a semi-dedicated institution with sufficient reach, capitalization, and mandate to reliably serve their financial needs.
Intervention 2: Develop a system to accurately predict demand for seed

Public Seed Enterprises (PSEs) are mandated to deliver seed to high-priority areas and also to address gaps in underserved areas, both in terms of crop varieties and geographies. PSEs at both national and regional levels need to be strengthened and positioned to understand where gaps exist and to apply financially sound business models to fill them. This should be done through the following efforts:

- **Strengthen national demand estimation.** While a precise estimation of national seed demand is challenging to calculate, due to factors such as weather and socio-economic conditions that influence farmers’ decisions in choosing the type of crops and improved seed varieties they desire, a national demand assessment should adequately approximate actual demand. The envisioned role of a national seed demand assessment system is to serve as a guide. Beyond estimating national demand, the government should ensure preparedness for emergency situations – such as natural disasters that destroy young crops – by leading the design and execution of an emergency reserve strategy.

- **Strengthen and tailor local market assessment.** The demand assessment should include detailed and localized considerations, such as demand for specific improved varieties, willingness to pay, and package sizes. Seed producers and distributors should actively forecast demand by leveraging national demand assessments that are tailored to local markets. Seed producers and distributors should also work with the research and regulatory systems to access data on trends in farmers’ choices and purchases of certified seeds. It is expected that the regulatory system will be a key partner in collecting this data because inspectors will document the amount of seed that has been approved from multiplication through distribution and storage.

- **Design a process to estimate and correct for potential shortages and surpluses.** Finally, once national and local demand assessments are completed, there must be a process in place by which PSEs compile this information and propose an action plan. Specifically, with support from the Regional Bureaus of Agriculture, seed producers should look to identify key gaps by geographic area and enact plans to bridge this gap by delivering seed from other areas that have an abundance.

When designing the system of demand assessment to adopt going forward, Ethiopia can leverage the models used in other countries. India, for example, faces similar challenges as Ethiopia in understanding farmers’ demand for certified seeds. India’s demand assessment resembles Ethiopia’s approach in the sense that it is collected at local levels and aggregated to the national level. Indian public seed companies, which include the National Seed Corporation (NSC) and State Seed Corporations (SSCs), work closely together to coordinate the seed demand forecasting process. Based on feedback from dealers and end-users, public sector seed companies and state governments forecast seed demand for various crops three years in advance. They then forward the amount of breeder seed they need to the MoA and public agricultural research institutes. This data is then used for the production of basic seed. The basic seed are further multiplied in contract farmers’ fields the following year, for use as certified seed for commercial distribution.

It has been reported that this system faces the main challenge of inaccuracy, as does Ethiopia’s demand assessment system. However, Ethiopia can draw lessons from some of the key differences India applies.
in its system to improve the way demand assessment is conducted here. For example, the assessment takes into account growth rates adjusted for new technology adoption, by considering the level of new technology uptake and likely speed of change. Each region or district could then be categorized as “low”, “medium” or “high.” In addition, it uses sampling techniques, measuring anticipated seed demand of groups of representative farmers sampled from each region. These and other practices allow the approach to combine actual data collection with an understanding of trends and sampling. Finally, seed producers directly market seed to farmers and thus use the national assessment only as a gauge to determine the appropriate amount of seed they produce for their target market.

**Intervention 3: Increase the availability and affordability of lime to treat acidic soils**

Treating acidic soil with lime can reduce the soil’s acidity levels (and increase pH levels) by converting hydrogen ions into water and carbon dioxide (CO$_2$). The most common materials that are used for liming are calcitic or dolomitic agricultural limestone. These are naturally occurring products that can be made by finely grinding natural limestone.

The most important consideration is lime placement. Ground agricultural limestone is relatively insoluble in water so maximum contact with the soil is necessary to neutralize the soil acidity. To maximize the effectiveness of lime treatment, the recommended application rate should be thoroughly mixed with the top 15 to 20 cm of soil. In addition, because very fine lime particles react more quickly than coarse particles, a finely ground limestone mixture must be used to achieve the desired soil pH change within a few months.

In order to increase the availability and affordability of lime, efforts should be focused on establishing new lime crashing sites to increase the overall supply of lime. Moreover, work must be done to enhance the efficiency of existing lime crashing centers with equipment and technical support. In parallel, new distribution systems must be developed to appropriately package and market the use of lime. Finally, specific application recommendations must be revised or developed to reflect specific soil pH levels and various planting methods (e.g., need to design new method for row planting versus broadcasting).

**Intervention 4: Facilitate the development of improved farm implements by public and private enterprises**

The main challenge in agricultural mechanization research is the effective and rapid transfer of validated technologies to the user community at an affordable cost. This requires mass production and scale-up of viable pre-harvest and harvest (post-harvest to be covered in a later section) implements by trained public and private enterprises. In order to accomplish this, specification descriptions, working drawings, and operation manuals must be created and disseminated via targeted trainings, in order to facilitate easy adoption by farmers and to provide operators and other facilitators (such as extension agents) with adequate content to train farmers. To ensure that farm implements reflect the most effective, innovative solutions that exist, a global scan of existing models must be undertaken, particularly focused on countries with similar agriculture sectors. In addition, quality control mechanisms should be developed and conducted by the agricultural mechanization research centers and MoA.

---

30 Five Year Strategy for the Transformation of the Ethiopian Seed System (2012)
Intervention 5: Disseminate knowledge on integrated pest management and encourage pesticide production

Changes in tef agronomic practices (row planting, reduced seed rate, use of improved varieties, fertilization, etc.) will impact the type and prevalence of pests, such as diseases, insects, and weeds. It is possible that pests which were previously of minor significance may become larger problems, and vice versa. Additionally, new pests may arise due to changes in the entire farming system, introduction of tef to new areas, climate change, shrinkage of natural forests and wilderness, or inadvertent introduction of pests. Therefore, the following activities must be undertaken:

- Survey and monitor pests and their natural enemies throughout tef growing regions of the country
- Explore indigenous farmers’ tef pest management knowledge and practices
- Undertake nationwide yield loss assessments for sporadically occurring pests

Research on tef pest management has been conducted in great detail and many specific recommendations based on research trials have been made. However, these recommendations have not yet been fully evaluated under farmers’ conditions. Thus, work must now be done to:

- Verify and demonstrate currently available chemical and cultural tef pest management practices on farmers’ fields
- Test pest management with new agronomic practices and varying inputs (e.g., new improved tef varieties) to understand where new pest-related challenges may emerge
- Assess the impact of new tef agronomic practices on pests of tef in general, and on weeds and rust in particular

At this point, research has uncovered several areas related to pest management that should be further investigated. One area is tef shoot flies, which are known pests found in tef growing regions of the country; however, their species identity is not yet known. A clear identification of pests down to the species level is a prerequisite for devising management methods and understanding pest dynamics. Another area to further investigate are cultural practices, such as time of planting, host plant resistance, seed rate, and frequency of plowing, etc., which can be used to hinder pest development and reduce associated yield losses. Unlike pesticides, such pest management methods do not involve additional cost as they are done as part of normal agronomic practices.

Finally, focus must be placed on expanding the availability, production, and marketing of effective pesticides. Although many pesticides have been tested against pests that harm tef, only a few of them have been registered for use on tef. In fact, some of these pesticides have been banned or are out of production. On the other hand, new pesticides (includes insecticides, herbicides, and fungicides) that are safer and more efficacious than the older generations are now available and must be tested against the current major pests of tef.
3.3 Inputs supply and distribution

3.3.1 Vision

Overall vision for inputs supply and distribution: Inputs producers are able to supply farmers with affordable, reliable, and high-quality inputs, through effective use of existing and new distribution channels.

Inputs supply and distribution is defined as the availability of agricultural inputs and the transportation of these inputs between the producer or supplier and their end-users, smallholder tef farmers. This section will cover fertilizer in detail, as fertilizer supply and distribution have domestic relevance, whereas fertilizer was omitted from the previous section on Inputs Production, given that the production of fertilizer takes places internationally and therefore is outside of the realm of feasible interventions. In Ethiopia, the supply and distribution of major agricultural inputs has been primarily owned and operated by the public sector. While there have been changes in distribution channels, policies, and systems that have led to more privatization in recent years, the public sector remains the main supplier and distributor for inputs.

For seed, certified seed should be distributed through efficient and effective distribution systems with multiple channels that meet the needs of farmers and ensures that they have a choice of service providers. The channels should also provide timely access to high quality seeds of improved varieties at sufficient quantities. The current seed distribution system relies heavily on cooperative unions as the main distribution points between public seed enterprises and primary cooperatives that interact directly with farmers. In evaluating the effectiveness of distribution channels, there are three main challenges: too many transactions, a reliance on cooperatives that are under-resourced, and a lack of awareness among farmers regarding the benefits of improved inputs use.

For fertilizer, there are also adjustments that can be made, although arguably these levers are more challenging to change than those related to seed. As described in a recent IFPRI report on fertilizer, while private retailers held a majority share of the fertilizer market in the early 1990s, the public sector and cooperative unions have become almost the sole supplier and distributor of fertilizer since 2000\textsuperscript{31}. According to Spielman, et al., while the Agricultural Input Supply Enterprise (AISE) had a market share of less than 50% during the mid and late 1990s, it regained the majority share by 2001 when private sector wholesalers, except for holding companies, disappeared from the scene. As of 2004, the public sector accounted for over 70% of supply and distribution, with private dealers accounting for only 23% of sales nationwide\textsuperscript{32}. According to the report, public sector supply channels have also changed; whereas extension agents previously managed distribution, responsibility was shifted to woreda input supply offices and cooperatives. Currently, cooperative unions supply and distribute fertilizer in the country with AISE acting on the union’s behalf in aggregating annual demand and importing. This is done to overcome collateral requirement problems in importing fertilizer that have hindered private sector involvement.

\textsuperscript{31} IFPRI (2012)
\textsuperscript{32} EEA/EEPRI (2006)
Lime, which is used to treat acidic soil, is another input to consider. Farmer demand for lime has steadily increased and there are numerous benefits to increasing the availability and affordability of lime for farmers. RBoAs assign quotas for cooperatives to distribute from lime processing plants. Other inputs that are addressed in this section include farm implements and pesticides, both of which are largely supplied and distributed by private sector individuals and enterprises.

### 3.3.2 Systemic challenges

**Challenge 1: Current complexities in the seed distribution process cause delays and supply shortages**

The current seed distribution system contains many unnecessary complexities. This has two debilitating effects on the distribution of inputs, and ultimately impacts farmers by limiting their access to inputs that can improve yields, particularly certified seed and fertilizer. For seed, there are four key characteristics that should be addressed to improve distribution effectiveness:

- **Transportation system involves multiple transaction points that can be streamlined:** As the below exhibit illustrates, the process starts from out-growers. Seed that is sold to PSEs is unprocessed tef seed while seed sold to unions and primary cooperatives is cleaned and processed. PSEs must route the certified seed produced through union cooperatives who, in turn, will distribute seed to primary cooperatives. Finally, primary cooperatives will market and distribute seed to farmers. Given the number of transactions in the process, there are often delays, quality risks, and mismanagement in actual supply and demand of type and quantity of seed.

Exhibit 17: Overview of seed distribution process

- **Lack of capacity of cooperatives:** Another cause of delays and inefficiency in distribution of seed is driven by a lack of capacity of cooperatives. In Ethiopia, certified seeds are marketed almost
exclusively through cooperatives under the guidance of the MoA and RBoAs. In addition, the RBoAs allocate targets to seed producers and direct them to deliver seeds to specific cooperatives. This limits the ability of cooperatives and farmers to procure seed on a competitive basis from seed producers that provide high-quality and affordable seeds. The reverse is also true: this arrangement weakens the incentives of producers to invest in quality and brands in order to win market shares. Additional capacity aspects that cooperatives lack include adequate storage facilities for seed and fertilizer, seed cleaning facilities, and processing plants. In addition, cooperatives also have limited organizational, financial, and human resources capacity to effectively manage input distribution.

- **Reliance on the standard demand assessment system:** Similar to seed producers, cooperatives do not conduct market assessments. Instead, they receive the certified seed allotted to them from the RBoAs and engage in retail distribution. Thus, their supply levels are fully dependent, and therefore vulnerable, to any limitations or errors in the RBoA demand assessments (discussed in the previous section). Some of these limitations include: the lead-time of one year (during which actual demand of the farmer may change), grain price volatility, and other factors, such as disease occurrence which can strongly influence farmers’ varietal preferences. This results in excess inventories for some varieties and insufficient supply for others, which increases storage costs for the cooperatives and financial costs on the invested capital for the inventories.

- **Limited alternative distribution models:** There are limited alternative distributors beyond cooperatives. By comparison, in recent years, the horticulture and vegetable sectors have made substantial achievements in this regard and are relatively better positioned in distributing inputs, with multiple distribution channels. In the last few years, an increasing number of local and international companies distribute vegetable and horticultural seeds and fertilizers, using multiple channels, such as through direct marketing, cooperatives, and NGOs, etc.

**Challenge 2: Fertilizer prices remain high for farmers, partly due to importation and domestic distribution processes**

One of the main drivers of increased productivity is the application of the appropriate type and rate of fertilizer. Given that – so far – all fertilizer is manufactured internationally and transported to Ethiopia, not much can be improved on the production process itself. However, there are domestic factors that cause the price of fertilizer to remain costly for farmers which may be able to be improved. These changes, however, will likely be small, given that the fertilizer distribution processes in Ethiopia have already seen significant improvements in the last ten years.

To pinpoint specific areas where there may be opportunities for small improvements in distribution costs, it is important to understand the process, from the point of delivery at port to reaching the farmer. According to a 2012 IFPRI fertilizer report, fertilizer is more expensive in Africa than in developing countries in Asia, partly because domestic transport costs are much higher in Africa than in Asian countries. At the country level, a national government can directly influence domestic transportation costs through improvement in infrastructure, institutions, and policy environment.
Below is an overview of the fertilizer importation and delivery process (carried out exclusively by AISE) that has been in place since 2008:

- Once imported fertilizer arrives at the Djibouti port, AISE ships the consignment to central warehouses and informs the cooperative unions to get their supplies.

- If the unions do not have storage capacity or are not ready to receive shipments directly from the port, AISE stocks the fertilizer in its central warehouses until the cooperative unions can collect the stocks.

- Once the fertilizer is in their warehouses, the cooperative unions distribute to the primary cooperatives, where farmers have direct access to the fertilizer to purchase or, in some cases, obtain on credit terms (AISE transports directly in areas where there are no cooperative unions).

The fertilizer supply chain includes some transaction points which may increase the retail price while adding little value. For example, it may be possible to route fertilizer directly from the Djibouti port to cooperative unions. Or, it may be possible to reduce the costs of materials required for distribution, such as using slightly cheaper bags to package and repackage the fertilizer. The below exhibit provides a detailed look at the price mark-up of fertilizer at various stages in the supply chain in Ethiopia. This indicates that there are opportunities to better streamline the process, in order to avoid unnecessary price premiums that are added on between import and farm gate.

---

33 IFPRI (2012)
Exhibit 18: Fertilizer cost build-ups by region (in USD per MT)

<table>
<thead>
<tr>
<th>No.</th>
<th>Cost element</th>
<th>Tigray Dap</th>
<th>Urea</th>
<th>Amhara Dap</th>
<th>Urea</th>
<th>Oromia Dap</th>
<th>Urea</th>
<th>SNNP Dap</th>
<th>Urea</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CFR ex Djibouti</td>
<td>701.2</td>
<td>558.4</td>
<td>701.2</td>
<td>558.4</td>
<td>701.2</td>
<td>558.4</td>
<td>701.2</td>
<td>558.4</td>
</tr>
<tr>
<td>2</td>
<td>CFR local price due to pre-fixed exchange rates</td>
<td>725.4</td>
<td>577.6</td>
<td>725.4</td>
<td>577.6</td>
<td>725.4</td>
<td>577.6</td>
<td>725.4</td>
<td>577.6</td>
</tr>
<tr>
<td>3</td>
<td>Margin due exchange rate differentials</td>
<td>24.2</td>
<td>19.2</td>
<td>24.2</td>
<td>19.2</td>
<td>24.2</td>
<td>19.2</td>
<td>24.2</td>
<td>19.2</td>
</tr>
<tr>
<td>4</td>
<td>Insurance</td>
<td>1.1</td>
<td>1.1</td>
<td>1.1</td>
<td>1.1</td>
<td>1.1</td>
<td>1.1</td>
<td>1.1</td>
<td>1.1</td>
</tr>
<tr>
<td>5</td>
<td>Clearing and transit</td>
<td>2.8</td>
<td>2.8</td>
<td>2.8</td>
<td>2.8</td>
<td>2.8</td>
<td>2.8</td>
<td>2.8</td>
<td>2.8</td>
</tr>
<tr>
<td>6</td>
<td>Bank charge/commission for LC</td>
<td>9.4</td>
<td>7.8</td>
<td>9.4</td>
<td>7.8</td>
<td>9.4</td>
<td>7.8</td>
<td>9.4</td>
<td>7.8</td>
</tr>
<tr>
<td>7</td>
<td>Inspection and bagging (0.2% on c. &amp; f.)</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>8</td>
<td>Re-bagging</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>9</td>
<td>Overhead cost/profit margin for AISE</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>10</td>
<td>Bank interest</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>11</td>
<td>Spoilage</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>12</td>
<td>Transport (Djibouti to Central Warehouse)</td>
<td>63.6</td>
<td>63.6</td>
<td>62.8</td>
<td>62.8</td>
<td>51.4</td>
<td>51.4</td>
<td>51.3</td>
<td>51.3</td>
</tr>
</tbody>
</table>

Source: IFPRI (2012); Authors compilation from the AISE, Cooperative Unions, and MoARD, 2012

The above table depicts that there are huge price increases at each step of fertilizer distribution. Both DAP and Urea fertilizer prices at the Djibouti port are fixed, while price increases will start when shipping to the AISE warehouse and unions. For example, in Amhara, the price of DAP will increase when it reaches the AISE central warehouse from 701.20 ETB to 804.4 ETB per quintal. Again, another price increase will be added when the fertilizer reaches the unions, this time from 804.4 ETB to 811.70 ETB. At the final distribution point of primary cooperatives, the final cost is 885.7 ETB and farmers will pay a retail price of 861.30 ETB.

In some cases, the farmer purchase price is actually lower than the IPP at primary cooperatives. The RBoAs determine fertilizer prices at the unions and primary cooperatives based on ex-AISE warehouse prices and whether or not a subsidy can be applied. Sometimes a subsidy can be applied in regions that...
have large carry-over stock that was acquired at a lower price. In these cases, (e.g., for Amhara and Oromia here), the regions are able to charge a lower price to farmers because they have sufficient carry-over stock that was cheaper for them to procure initially.

In addition to the complications caused by a supply chain with many players and transactions, trucking companies are required to meet a fertilizer discharge rate off of the ships of 2,000 tons per day, to avoid demurrage costs. This means 50-65 trucks are required daily when a fertilizer shipment is being offloaded, causing an increase in costs as trucks maintain on-time ship unloading, but often return to Djibouti empty.

Through all of these transactions between AISE, unions, primary cooperatives, and other players, many costs are incurred. These include loading and unloading costs, warehouse rent, bank interest rates, and other administrative costs that increase retail prices at which the fertilizer is sold at primary cooperatives.

The below process also provides an overview of the product and cash flow in the fertilizer procurement and distribution process in Ethiopia. As the chart depicts, both the product and cash flow processes involve many touch points that may include waste and redundancy.

Exhibit 19: Process flow of both product and cash for fertilizer distribution

Source: IFPRI (2012)
**Challenge 3: Institutional constraints limit the effectiveness of inputs suppliers and distributors**

As discussed earlier, unions and primary cooperatives are major distribution channels for inputs. However, capacity limitations restrict their ability to actively engage in the supply and distribution of much-needed inputs. These limitations include financial, transportation equipment and logistics, and storage facilities, etc.

In addition, the public seed enterprises (ESE, RSEs) and the AISE face similar constraints. The rapid growth in seed production in recent years, led by the Regional Seed Enterprises and their networks of out-growers, has not been accompanied by a commensurate investment in internal quality control systems. The ATA’s capacity assessment conducted on 8 research centers and 10 seed producers (focused on hybrid maize), held during 2011 suggests that neither lab facilities nor the number of trained and experienced staff are adequate to ensure the supply of quality seed. Seed enterprises currently have inadequate production facilities, in terms of farm machinery and implements, seed processing and storage facilities (cold rooms), seed testing labs, and vehicles for transportation. Gaps in skilled staff areas include plant breeders, seed technologists, pathologists, and entomologists, among others.

### 3.3.3 Interventions

**Intervention 1: Enhance the efficiency of the seed distribution process by improving existing channels and creating new alternative channels**

As explained above, the primary inputs distribution channel that exists today is through the public sector, which relies heavily on cooperative unions. Given that this system contains much inefficiency, there is a need to redesign the system and incorporate alternative models into Ethiopia’s input distribution channels. In order to create a more efficient inputs distribution system, two main activities must be undertaken:

- Expand its channels to include alternate modes of distribution
- Shift the fertilizer transportation system to move directly from port to regional destinations, versus routing through central locations

Firstly, Ethiopia must explore alternate modes of distribution by leveraging the private sector in partnership with public sector players, such as ESE and RSEs. Multiple distribution channels (public and private) that meet regulatory standards should be set up to ensure that farmers have access to their preferred variety/type that is both high-quality and affordable. In addition, multiple sources will create competition and maximize the choices of crops, varieties, brands, and prices for farmers. These alternate channels need to be designed to meet the gaps and needs faced by farmers. They will also need to complement existing distributors, particularly cooperatives. For example, they may be contracted by cooperative unions to serve targeted farmers and crop varieties, and meet clearly defined objectives, mainly increasing the reach of distribution. One specific change that could be made is to link seed enterprises directly with primary cooperatives at the kebele level, to ensure timely distribution of seed that does not pass through union cooperatives.
Moreover, since the early 2000s, growing networks of agro-dealers are being engaged in Ethiopia’s horticulture sector, including the delivery of inputs, such as seed, fertilizer and pesticides. As a result of the government’s incentive packages aimed at making inputs production and supply more attractive, the number of private inputs suppliers at the import, distribution, and retail levels increased to serve the growing need (about 40 private companies, to date). While certain components of the success seen in the horticulture sector may be applicable to the tef sector as well, mixed results and emerging challenges indicate that caution should be taken when drawing lessons to be applied to the distribution of inputs for staple crops. For example, a more systematic approach to train and certify the multitude of emerging private sector distribution networks would enable the government to ensure that farmers have access to a consistent supply of the highest quality inputs from these varied distribution networks.

Recently, some domestic public and private seed producers have also experimented with alternate distribution channels that directly engage privately-run enterprises. The ESE as well as RSEs has piloted the use of agent distributors. These agents of public enterprises are now active in three pilot woredas.

**Intervention 2: Enable flexibility in the fertilizer shipping, inland transport and distribution process to lower costs**

In addition to exploring alternate channels, Ethiopia must alter its existing fertilizer distribution system to become more efficient. The current fertilizer distribution system involves moving product from the Djibouti port to central locations in Ethiopia, then transporting the fertilizer from these central aggregation points to their localized unions, and then moving it again to primary cooperatives. Through this process, unnecessary storage and transportation costs are incurred by AISE, which cause the price of fertilizer to be inflated. To remedy this, AISE must work hand-in-hand with the MoA and the Regional Bureaus of Agriculture to anticipate regional demand, thereby enabling a redesign of transportation channels so that fertilizer is delivered directly from the port to its local destinations. This will save time and transportation costs and has the potential to reduce the retail price of fertilizer for farmers by incentivizing suppliers to pass on a portion of the savings to end-consumers.

Another aspect that could be improved is the fertilizer packaging process. Work should be done to incentive inputs producers and suppliers to change inputs packaging to be more efficient and attractive for farmers. Current packaging of inputs, particularly for fertilizer and seed, supplies too large of a volume to farmers, making the use of inputs more costly than necessary. In addition, there is redundancy in the process that causes inputs to be packaged and re-packaged several times, driving up production costs. To resolve this, AISE and the national and regional seed enterprises should work to repackage inputs into smaller, more marketable sizes.

**Intervention 3: Provide policy, financial, and organizational support to promote the use of inputs**

One characteristic that is common among inputs suppliers and distributors is a lack of capacity across several dimensions, including policy, finance, and organizational resources and capabilities. Some key examples of support provision that are required by main stakeholders include the following:

- Articulation of seed proclamation and provision of policy support for implementing multiple input distribution channels
- Policy support to intermediate and informal seed exchange (farmer-to-farmer) is also essential, as the majority of improved varieties are supplied through the informal seed sector.

- Establishing a credit facility scheme or other financial instruments in collaboration with Ethiopian finance institutions for addressing financial constraints facing farmers that prohibit necessary actions (e.g., lack of farmer liquidity to purchase chemical fertilizer).

- Enhancing management and organizational capacity of primary cooperatives through the hiring of additional human resources (e.g., agronomic experts on staff) or provision of needed materials (e.g., data management software to track spending and budgetary activities).

Provision of support is certainly not limited to the above examples; an overall scan of the sector must be done to determine the most impactful areas in which political, financial, and organizational support can be given to accelerate change.

**Intervention 4: Promote use of organic fertilizer as a cost-effective alternative to inorganic, internationally-sourced fertilizer**

Organic fertilizers have a number of advantages, both environmental and economic. Organic fertilizer can build a soil environment that is optimal for soil organisms to flourish, such as earthworms, which can help to aerate and loosen the ground. Organic fertilizers can also improve the nutrient and water capacity of the soil. As a result, unlike chemical fertilizers, nutrients are released to the plant in a sustainable, slower manner, and there is little to no risk of the plant "burning" on an overdose of nutrients. Furthermore, chemical fertilizers may also release other biodegradable elements that may not only harm helpful microorganisms living in the soil but also pollute lands and waters. In order to provide a more cost-effective alternative for farmers that find it difficult to purchase chemical fertilizer, promoting the efficient use of organic fertilizer will make fertilizer use possible for more farmers.

Organic fertilizers can be produced at home or on farms by using a mix of different animal manure along with other waste sources, such as leaves or plant remains. This is an efficient way to leverage the waste from a garden or farm and is also clearly a cheaper alternative to purchasing chemical fertilizers.

**3.4 On-farm production**

**3.4.1 Vision**

**Overall vision for on-farm production:** Farmers have knowledge of and access to yield-enhancing agronomic practices in order to further enhance the yield increases achieved from use of improved seeds, fertilizer, and other inputs.

To realize the highest rate of return on investment from inputs such as improved varieties and fertilizer, appropriate on-farm production practices must be used. This section considers the agronomic practices that affect tef productivity, including appropriate use of inputs.
3.4.2 Systemic challenges

Challenge 1: Farmers have insufficient knowledge of and a lack of financial ability to purchase and use inputs, such as fertilizer and seed

Actual demand for and adoption of improved varieties is low, which is driven, in large part, by a lack of awareness of the value that can be gained by using inputs. According to the CSA Farm Practices Survey\(^\text{34}\), only 17% of smallholder farmers have bought any type of seed, including those who have bought seeds from the informal system, such as village markets. Another estimate suggests that only about 5% of cultivated hectares are planted with seeds of improved varieties. This figure represents farmers who have bought a new batch of certified seed in the given planting season, however it is expected that figure would be significantly higher if farmers who recycle improved varieties were counted, since self-pollinating varieties (SPVs) can be recycled for several generations without any yield loss. Seed replacement of SPVs should be done only because farmers have mixed the seed of multiple varieties or it has become contaminated with weed seeds, etc., but rarely because of yield losses due to genetic drift. By any measurement, adoption of improved varieties is low in Ethiopia for two main reasons: knowledge dissemination of the benefits of inputs happens through limited channels, and limited seed varieties are available to market to farmers.

Firstly, popularization of improved varieties and creation of demand for certified seeds is done almost entirely by the public sector – particularly the extension system. While almost all domestic private seed companies multiply publically-available varieties, very few of them are engaged in popularization. Therefore, farmers’ knowledge of improved varieties and best practices comes from limited sources.

Secondly, there is a limited choice in seed varieties, which contributes to a lack of awareness. Most improved varieties are targeted for high-rainfall areas. Consequently, farmers, particularly in lower-rainfall areas, have a limited selection of improved varieties. Furthermore, the majority of improved seed within high-rainfall areas is also limited to maize. Hence, even if they are aware of the value of investing in certified seeds, farmers are often unable to adopt because they do not have access to certified seeds of improved varieties that will increase yields for their particular agro-ecologies or crops of interest\(^\text{35}\). Adoption of improved seed varieties is low, especially when compared to the adoption of other agricultural inputs, such as fertilizer.

Fertilizer has been applied to about half of the area planted with cereals in Ethiopia. While this prevalence of use is good, it is also concerning because the full potential yield gain of fertilizer cannot be harnessed unless it is applied in combination with improved seed varieties that also have greater yield potential.

With the exception of virgin land (not yet open to the plow), arable soils in Ethiopia require the use of plant nutrients (chemical fertilizers or organic sources) since they are depleted from essential nutrients. The two main nutrients that are required are nitrogen (N) and phosphorous (P). In Ethiopia, P nutrient is provided by the application of DAP (Di-ammonium phosphate), although some other sources are

\(^{34}\) Bekabil et al. (2011)
\(^{35}\) Five Year Strategy for the Transformation of the Ethiopian Seed System (2012)
available in the international markets, such as SSP (single super phosphate), TSP (triple super phosphate), MAP (mono-ammonium phosphate), and others.

The phosphorous nutrient has a very specific role in plant physiology: it is involved in the energy storage and transfer requirements during the respiratory process, and energy electron transfer of all chemical processes. Phosphorous enriches plant nutrition, however grain yield is driven by nitrogen. In Ethiopia, N is provided by Urea fertilizer.

Understanding this knowledge of fertilizer can enable extension staff and farmers to properly apply the correct type and dose of fertilizer. Unfortunately, knowledge of mineral nutrient roles in the plant system is very limited, and most times, farmers apply the incorrect fertilizer formulas, due to insufficient information. When farmers apply unbalanced nutrient levels, the yield gain is often insignificant, making the use of fertilizers appear very costly, with little or no return on investment. Ultimately, in these cases, farmers experience a lower rate of return than envisioned when they decide to purchase fertilizer.

Thus, it is of primary importance for farmers to understand the accurate application of balanced fertilizer nutrient formulas, in order to increase their grain yield and reduce their production costs. In addition to the N and P nutrients discussed above, there are other nutrients that may be required, as they may have become deficient in the soil. Usually, the sequencing of nutrient needs follows this pattern: N + P are considered the major nutrients; followed by potassium (K), sulphur (S), magnesium (Mg), and calcium (Ca).

Micronutrients also are to be considered, such as zinc (Zn), manganese (Mn), copper (Cu), boron (Bo), and molybdenum (Mo). Fertilizers containing N + P + K + Zn + Mo can be considered ideal combinations, since the other nutrients may still be present in enough quantities in the soil. In acidic soils, fertilizers may also need to contain some amount of Ca (as CaCO₃) to reduce soil acidity. However, soil analysis is required in order to recommend the most correct fertilizer formula and dose.

Exhibit 20: Use of fertilizer by type and region

---

<table>
<thead>
<tr>
<th>Use of improved fertilizer types in priority tef areas</th>
<th>Kg/hectare</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recommended and Adaa and Dejen</td>
<td>DAP</td>
</tr>
<tr>
<td>Bechoo</td>
<td>50</td>
</tr>
<tr>
<td>Shasmene</td>
<td>25</td>
</tr>
</tbody>
</table>

Source: Bekabil et al. (2011)
The currently recommended rate of fertilizer application in tef production is 100 kg of DAP/ha and 100 kg of Urea/ha, as set by the MoA. During a series of field visits conducted in 2011, it was learned that in Ada’a and Dejen, the farmers use the recommended rates of fertilizer application (i.e., 100 kg of DAP and 100 kg of Urea per hectare). However, in Becho and Shashemene, farmers’ actual fertilizer usage was found to be below the recommended rate. On average, in Becho, farmers only apply 90 kg of DAP and 50 kg of Urea per hectare. According to farmers’ responses, this is due to the fertility level of the soils in the area, with claims that higher fertilizer application rates result in increased lodging. On the other hand, in Shashemene, farmers apply only 50 kg of DAP and 25 kg of Urea per hectare, on average.

As mentioned earlier, the inaccurate application of fertilizer is believed to be driven by the low rate of return, which makes fertilizer appear very costly, causing farmers to ration their use, which in turn leads to lower productivity than anticipated (lower rate of return on input use). Major problems limiting the use of fertilizer include ever-increasing prices, lack of availability of the right quantity, lack of timely supply, and credit constraints (particularly in 2011 as the farmers were asked to buy on cash versus credit, as reported in the Shashemene area). Furthermore, farmers in the Dejen, Shashemene, and Ada’a areas reported that fertilizer costs account for about 23% of the total cost of tef production (see Exhibit).

**Challenge 2: Yield-enhancing farming practices are not well utilized or applied**

Despite tef’s importance as a preferred domestic cereal crop, average yields remain low, at 1.2 ton/hectare, and production has not kept pace with increasing consumer demand. Moreover, growth in tef production has mainly come from expansion of land under cultivation, but this growth is not
sustainable, and in some areas it has had a negative environmental impact, as some unsuitable areas that are highly prone to soil erosion have come under the plow. One major challenge impacting tef productivity is the use of unsustainable, traditional methods of land preparation, sowing, and planting. Results from research conducted in 2011 in Debre Zeit and at 1,400 FTCs and farmer trials indicate that there are several yield-enhancing practices that farmers should employ to increase productivity in a sustainable manner. As the exhibit below indicates, there is opportunity to improve yields through specific changes to agronomic practices.

Exhibit 22: Maximum tef yields obtained by technology implemented during 2009-2011

<table>
<thead>
<tr>
<th>Yield by technology use</th>
<th>Quintals per hectare</th>
</tr>
</thead>
<tbody>
<tr>
<td>National average</td>
<td>12-15</td>
</tr>
<tr>
<td>Row planting</td>
<td>50</td>
</tr>
<tr>
<td>Transplanting</td>
<td>60</td>
</tr>
<tr>
<td>Fertilizer blends</td>
<td>35-66</td>
</tr>
</tbody>
</table>

Traditional on-farm production methods (e.g., broadcasting, 30 kg/ha seed rate)

New row planting technology with reduced seed rate (5-10 kg/ha)

New transplanting technology: raise seedlings in contained space and transfer to plots after ~25 days

Use of fertilizers with micronutrients (e.g., DAP + Urea, DAP + Zn + Cu, DAP + Boost ext.)

Note: Yields are average for National average and maximum for Row planting, Transplanting, and Fertilizer blends

Source: SAA Tef Project Final Report (2010); MoA/ATA Tef Demonstration Results (2011)

Specific agronomic practices that should be changed or addressed include the following:

**Reduce plant competition through reduced seed rate:** Farmers traditionally plant tef using a high seed rate of 30-50 kg/hectare to ensure that the small seeds are able to establish strong seedlings. However, recent on-farm and on-station trials using lower seeding rates of 3-5 kg/hectare have shown that tef responds well to intensification agriculture. Tef grain and straw yields can be doubled and even tripled by drastically reducing plant population and applying fertilizers that contain micronutrients such as zinc and copper. The highest yields of 6.6 tons of grain and 25.8 tons of straw were obtained with complete fertilizer treatment. The average traditional yields (planting by broadcasting; without fertilizer) were 1.9 tons of grain and 9 tons of straw. Hence, the double and three-fold increases in productivity apply to both grain and straw.

**Planting method:** Plant competition can be further reduced by row planting instead of broadcasting. The traditional practice of broadcasting at high seed rates leads to a high plant population density, with

---

37 SAA (2010)
plants competing for water, sunlight, and other nutrients. Broadcasting also creates uneven distribution of plants and causes extreme difficulties during weeding. Row planting, on the other hand, may improve yields by allowing for lower seeding rates, reducing the risk of crowding, and providing a border effect for all plants. Currently, very few farmer are aware of the practice, as row planting technology has only recently been introduced in Ethiopia. Row planting has, however, long been used in other countries, such as Holland and USA, on commercial, mechanized tef production. Unfortunately though, the adoption of row planting tef in Ethiopia is likely to be slowed by technical challenges, including lack of mechanical row planters, the small size of the tef seed, and the labor-intensive nature of row planting by hand.

**Tillage frequency should be decreased to reduce soil erosion and labor-intensity:** Land preparation is one of the most labor-intensive tasks in tef production. In most areas, tef plots are usually plowed at least five and sometimes up to seven times using the traditional plough (Maresha), as farmers believe it is necessary to break up the soil in order to facilitate germination of the very small tef seeds. This however, is not fully correct since tef has been planted under no till or minimum till for several years by some farmers in Ada’a, Lume, and Ambo woredas. Too many tilling operations may destroy soil aggregates and make the soil prone to water and wind erosion. In vertisol areas, waterlogging during early plant development constrains healthy crop establishment and development due to oxygen deprivation to the root system because of anaerobic conditions prevailing in the soil.

Excess tillage results in high costs for farmers (in time and labor) and can lead to soil organic matter loss and erosion over time, especially if conservation practices (e.g., contour plowing) are not followed. Research has yet to develop better soil management alternatives, which may include minimum tillage in place of several plowing operations. To enhance drainage, tef may be planted with the establishment of cambered beds or use of broad-bed maker technology to drain the excess water.

**Weeding is labor intensive and requires appropriate use of tools:** Another major cost driver in the tef production process is weeding. Weeds are a major hindrance in tef plant development, and removing them is likely the most labor-intensive task. Given the high costs involved, most farmers use a combination of chemicals and hand weeding to control weeds. By example, from the total cost of tef production, the percentage share of tef weeding costs ranged from 14% in the Ada’a area to 23% in Shashemene.

The method of weeding depends on several factors, including: the availability of cash, labor and herbicides; the weed type and its degree of infestation; and whether the weeds are used for animal feed. Furthermore, herbicides are effective against broad-leaved plants, but other grasses must be removed by hand. The herbicide that is currently the most available for weed control is 2,4-D, which was originally used to control only broad-leaved weeds. However, local weeds have developed resistance to 2,4-D meaning that the herbicide is no longer eliminating weeds effectively. As a result, farmers are now forced to do hand weeding in situations where the herbicide normally would have been applied. Another challenge with the use of 2, 4-D is that the chemical is a hormonal herbicide which needs to be applied at just the right time, before the tef crop enters into the joint stage (at the end of the tillering

---

38 Dr. Marco Quinones interview (2012)
stage). If applied at incorrect times, it can produce flower sterility in the tef crop, thus reducing grain yield.

Exhibit 23: Estimates of farm-level production costs in Ada’a area

<table>
<thead>
<tr>
<th>Activity</th>
<th>Amount of the input required/ha</th>
<th>Price (Birr/unit)</th>
<th>Total cost/ha</th>
<th>% share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land preparation (man-days)</td>
<td>20</td>
<td>30</td>
<td>600</td>
<td>10.8</td>
</tr>
<tr>
<td>Seeding rate (kg)</td>
<td>30</td>
<td>15</td>
<td>450</td>
<td>8.0</td>
</tr>
<tr>
<td>Fertilizer (DAP in qts)</td>
<td>1</td>
<td>1,100</td>
<td>1,100</td>
<td>19.8</td>
</tr>
<tr>
<td>Fertilizer (Urea in qts)</td>
<td>1</td>
<td>900</td>
<td>900</td>
<td>16.2</td>
</tr>
<tr>
<td>Weeding (person-days)</td>
<td>24</td>
<td>30</td>
<td>720</td>
<td>13.0</td>
</tr>
<tr>
<td>Herbicide (lts)</td>
<td>1</td>
<td>77</td>
<td>77</td>
<td>1.4</td>
</tr>
<tr>
<td>Harvesting (person-days)</td>
<td>30</td>
<td>30</td>
<td>900</td>
<td>16.2</td>
</tr>
<tr>
<td>Gathering and piling (person-days)</td>
<td>3</td>
<td>30</td>
<td>90</td>
<td>1.6</td>
</tr>
<tr>
<td>Threshing (person-days)</td>
<td>24</td>
<td>30</td>
<td>720</td>
<td>13.0</td>
</tr>
<tr>
<td>Total cost (birk)</td>
<td></td>
<td></td>
<td>5,557</td>
<td>100.00</td>
</tr>
</tbody>
</table>

Source: Bekabil et al. (2011)

Exhibit 24: Estimates of farm-level production costs in Shashemene area

<table>
<thead>
<tr>
<th>Activity</th>
<th>Amount of the input required/ha</th>
<th>Unit price (Birr)</th>
<th>Cost/ha (Birr)</th>
<th>% share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land preparation (person-days)</td>
<td>24</td>
<td>35</td>
<td>840</td>
<td>17.61</td>
</tr>
<tr>
<td>Seed (kg)</td>
<td>48</td>
<td>11</td>
<td>528</td>
<td>11.07</td>
</tr>
<tr>
<td>DAP (kg)</td>
<td>50</td>
<td>10.5</td>
<td>525</td>
<td>11.00</td>
</tr>
<tr>
<td>Urea</td>
<td>25</td>
<td>6</td>
<td>150</td>
<td>3.14</td>
</tr>
<tr>
<td>Weeding labor (person-days)</td>
<td>30</td>
<td>35</td>
<td>1,050</td>
<td>22.01</td>
</tr>
<tr>
<td>Herbicide (lt)</td>
<td>0.5</td>
<td>80</td>
<td>40</td>
<td>0.84</td>
</tr>
<tr>
<td>Harvesting (person-days)</td>
<td>20</td>
<td>35</td>
<td>700</td>
<td>14.67</td>
</tr>
<tr>
<td>Piling (person-days)</td>
<td>12</td>
<td>35</td>
<td>420</td>
<td>8.80</td>
</tr>
<tr>
<td>Gathering (person-days)</td>
<td>2</td>
<td>35</td>
<td>70</td>
<td>1.47</td>
</tr>
<tr>
<td>Transportation of the harvested tef (donkey-days)</td>
<td>1</td>
<td>48</td>
<td>48</td>
<td>1.01</td>
</tr>
<tr>
<td>Threshing (thresher hours)</td>
<td>4</td>
<td>100</td>
<td>400</td>
<td>8.38</td>
</tr>
<tr>
<td>Total Cost</td>
<td></td>
<td></td>
<td>4,771</td>
<td>100.00</td>
</tr>
</tbody>
</table>

Source: Bekabil et al. (2011)

In order to take full advantage of gains that are experienced through the use of these agronomic practices, various awareness-raising events should be conducted once the plants have fully matured. For example, local and regional farmer field days which bring together large groups of farmers and extension staff to see the improvement of these practices on a farmer’s field can serve to motivate farmers to try these practices themselves the following year. Finally, materials which explain how to implement these agronomic practices in detail (e.g., production manuals, instruction leaflets, etc.) should be distributed to farmers in high-potential tef areas.
Challenge 4: Cropping systems (rotation, double cropping, relay cropping, and agroforestry) are not efficiently practiced

Since tef has a relatively short season, it can be produced both during the main (Kiremt) and short (Belg) seasons. However, the traditional cropping practice used by by tef farmers can cause delays, forcing them to harvest tef beyond its physiological maturity. When this happens, farmers are not able to plant pulse crops in rotation to leverage residual moisture.

In monocultures, increases in crop-specific weed infestations, pests, and diseases are often observed over time. Continuously growing the same crop will tend to exploit the same soil root zone, which can lead to a decrease in available nutrients for plant growth and to a decrease in root development.

Rotation is most effective when combined with practices such as manuring and composting. Together, these practices create soil quality improvements, such as increased soil aggregate stability, decreased crusting of soil surfaces, and increased granular structure and friable consistency. Simply put, management systems that maintain or increase soil organic matter have the potential to increase soil productivity for all cropping systems, including organic systems.

Multiple cropping

There are two forms of multiple cropping: double cropping and relay cropping. With double cropping, the second crop is planted following harvest of the first. By contrast, relay cropping consists of inter-seeding the second crop into the first crop well before it is harvested. The relay technique enables the production of a second crop in areas where there is not enough time for a second crop following the tef harvest.

There are two primary requirements for profitable multiple cropping. Firstly, there must be adequate time for the production of a second crop. Secondly, there must be adequate water to produce two crops, whether from stored soil moisture, rainfall, or irrigation. In addition, crops have to be planted in rows (using a mechanical row planter, if possible).

The practice of double-cropping pulses after cereals has grown in popularity and feasibility for many smallholder farmers who have limited plot sizes. This cropping system has several advantages, including control of soil erosion by growing crops on the land all year.

A successful cereal-pulse double crop depends on management and weather conditions. Knowing the conditions to which double cropping is best adapted will provide for a successful second crop. It will also permit farmers to avoid high-risk years.

A successful double-crop system begins with proper management of the main season crop. This includes a good, fully tilled planting that is 2-3 weeks earlier than the usual planting time, use of row planting, covering the seed at 2-3 cm with soil, and adequately fertilizing the tef to suppress weeds until harvest. An ideal tef variety in a double-crop system consistently produces high yields of high-quality grain, yet matures early enough to permit timely establishment of a pulse crop (usually chickpea). Fertilizing for both crops at once is more practical than trying to make an additional application after tef harvest, saving time at a critical period. Also, if the chickpea will not be tilled, the fertilizer will already be in the soil.
3.4.3 Interventions

At farm-level, the most important challenge facing tef production is its labor requirement and the associated costs. Thus, immediate demonstrations of available technologies and practices that help reduce the work burden on farmers are essential. This includes the testing and promotion of technologies, promotion of row planting (either by hand or with a machine), training on reducing seed rate, and the research and development of other practices and technologies that will reduce weed infestation, curb soil erosion, reduce labor, and increase yields.

Specifically, emphasis should be placed on introducing research-approved pre-harvest equipment, such as mechanical row planters and broad-bed makers. In order to do this effectively, machinery must be tested directly with farmers, in various agro-ecologies. This will ensure that the machinery will be effective and practically applicable. In addition to the introduction of research-approved equipment, there is a strong need to identify new and emerging technologies to rigorously test. For example, little work has been done to adapt agronomic practices for tef by agro-ecology, which could lead to yield improvements through better management of diverse soil types. By identifying potential agronomic practices and technologies to further explore, priority can be given to the highest-potential activities.

**Intervention 1: Support scale-up of proven yield-enhancing technologies**

The perception and consensus of a common goal, and frequent interaction, are the cornerstones of effective linkage among research, extension services, and farmers. Work must be done to create formal linkages between researchers and extension staff to work together on how to transfer new technologies and conduct demonstrations for the benefit of smallholder farmers.

In addition to strengthening farmer’s capabilities, a new technology information sharing system must be promoted at all levels, using different communication pathways, such as manuals, leaflets, brochures, media, and facilitating farmer-to-farmer communication.

Effective linkage and collaboration encourages farmers, extension workers, and researchers to jointly organize and implement farmer field days and field visits/tours. In order to strengthen farmer-orientation support services, working with farmer groups, researchers, and extension workers can better address farmers’ needs and problems, and enable proper implementation of on-farm experimentation, adaptation, and uptake of proven technological options by farmers, helping them to develop sustainable systems.

In order to reap the benefits of research and technology developments, yield-enhancing agronomic practices should be introduced to farmers via training and demonstration activities. The tef productivity-enhancing technologies include the following practices:

- **Reduced seed rate**: depending on the method of planting used, farmers should reduce seed rate from 30-50 kg/ha to 3-5 kg/ha for row planting, and to as low as 0.5 kg/ha for transplanting. By doing this, versus traditional broadcast planting, seedlings will be less crowded and suffer from less competition for sunlight, water, and other nutrients, which will enhance tillering capacity and tiller survival, thus increasing the grain yield and total biomass production.
- **Proper seed spacing for row planting**: seeds should be planted or drilled in uniformly with 20 cm between rows. This provides ample space for seedlings and enables easier weeding.

- **Proper seed depth**: preliminary tests indicate that seeds planted 2-3 cm below soil surface germinate and develop well (this can and should be verified later under planned research). Seeds are currently broadcasted on top of soil and the weak roots fail to properly anchor, which may cause lodging. By planting seeds below the surface, they will reap the benefits of moisture-rich soil while also still being shallow enough to germinate.

- **Optimum fertilizer formulas and rates**: complex fertilizers with major and minor elements (e.g., N:P:K:S + Zn + Cu) have been shown to increase both grain and straw yields. Proper types and rates of fertilizer application will promote fertile soil that supports healthy growth of tef plants.

- **Land preparation techniques**: minimum tillage practices have shown promising results and therefore need to be promoted.

- **Transplanting**: improved seedling management should be conducted, including transplanting seedlings from plots to field after ~25 days. This has been shown to boost yields even more than row planting, depending on methodology implemented. Preliminary tests indicate positive results when tef is transplanted at 20 cms between rows and at 10-12 cms between plants within the row.

In order to effectively scale-up these practices, knowledge must be disseminated through multiple channels. Firstly, theoretical and practical training of farmers must be conducted by development agents at farmer training centers with the support of woreda, zonal, and regional level administration. In addition to training, farmers should conduct demonstrations of these “core” technologies, either on demonstration plots at farmer training centers or via model farmers on a portion of their own land.

**Intervention 2: Create financial mechanisms to support farmers in purchasing inputs, such as fertilizer**

In order to ensure that farmers benefit from the full range of yield-enhancing technologies, it is necessary that farmers are financially capable of securing the right inputs and technologies. To do this, work must be done to create financial mechanisms that make purchase and/or rental of inputs and other technologies possible. Only through this will it be possible to promote the widespread adoption of new technologies and practices to accelerate gains in productivity.

One example of a financial mechanism that could be created for this purpose is a revised credit-input system. Through mechanisms like this, farmers will increase their ability to purchase and apply inputs that can lead to enhanced productivity. Some potential design elements of an improved input credit system include:

- Remove regional governments from the role of guaranteeing input credit, so that regional governments are not forfeiting significant quantities of their budgets each year to pay for uncollected fertilizer loans.

- Establish a partial-credit guarantee fund leveraging funding from the government and development partners to encourage creditors to provide input credit while creating incentives for them to make an effort to collect outstanding loans.
- Relieve the cooperatives from the credit issuing and loan collection responsibility. However, the cooperatives would still continue their core business of input retailing to farmers.

- Establish cooperatives as the parties responsible for demand estimation and therefore for any unsold fertilizer.

- Minimize the use of cash in the credit system by introducing a voucher system.

- Channel input credit through microfinance institutes (MFIs) or other appropriately placed institutions that have historically low default rates in the input credit disbursement and loan collection process.

- Link input financing to output marketing through contracts, where cooperatives would sign a contract with an end market buyer and generate a letter of credit that could be extended to receive input financing.

**Intervention 3: Promote efficient cropping systems (crop rotations, double, relay, agroforestry)**

Improved cropping systems of various kinds will enable farmers to achieve higher yields and lead to a higher earned income, both through increased tef yields and also, in some cropping systems, through harvest of double crops in one season. Cropping systems include double cropping (two consecutive plant productions in one harvest season), inter-cropping (mixing of plants on same plot of land), crop relaying (start one crop, then plant the other crop when the first has reached harvest period), and crop rotation (switch crops each new season).

In particular, tef can benefit hugely from the practice of crop rotation, specifically with legumes such as chickpea or faba (or fava) bean. The best nutrient management practice is achieved when legumes are used in crop rotations to supply biologically fixed, atmospheric nitrogen as a replacement or supplement for inorganic nitrogen fertilizer.

Legumes in the rotation can be used to increase the available soil nitrogen. Symbiotic nitrogen-fixing bacteria called rhizobia form nodules on the roots of legume plants and convert or fix atmospheric nitrogen to organic nitrogen. The amount of nitrogen fixed varies by species, available soil nitrogen, and many other factors. Fixed nitrogen not removed from the land by harvest becomes available to succeeding crops as the legume tissues undergo microbial decomposition. When the legume crop is seeded, rhizobia inoculum should always be applied to the seed to ensure the most productive commercial strains are available to form nodules and that inoculating bacteria are always present. Even though indigenous bacteria may be present in the soil, research shows improved commercial strains of rhizobia have more capacity to fix nitrogen. In general the advantages of crop rotations can be stated as:

- Rotations are used to reduce pests and diseases in the cropping system and to control weeds by including smothering crop species (e.g. cowpeas) or green manure cover crops.

- Rotations provide improved soil quality (more or deeper roots, root exudates), better distribution of nutrients in the soil profile (deep-rooted crops bring up nutrients from below), and increased biological activity.
- Crop rotations can balance the production of residues by alternating crops that produce few and/or short-lived residues with crops that produce a lot of durable residues.\(^3\)
- The best economic returns from rotations can be expected if legumes are included, because of the nitrogen they add to the system.

In order to achieve this, training material should be created to disseminate knowledge on the benefits of crop rotation through the use of harvesting tef crops at their physiological maturity. This practice will permit farmers to plant pulse crops in rotation, using the residual moisture created by the tef.

### 3.5 Post-harvest processing and utilization

#### 3.5.1 Vision

**Overall vision for post-harvest processing:** Farmers have knowledge of and access to machinery and techniques that can significantly reduce post-harvest loss rates and increase yield quality.

#### 3.5.2 Systemic challenges

A significant driver of yield loss in tef production is grain shattering, both during and after harvesting. This is primarily due to the small size of tef seeds and the challenge in handling grain mechanically at each step of the post-harvest processing and handling phase (drying, threshing, and transporting). In total, tef production loss is estimated to be 30% across the value chain steps, and the improvement of post-harvest processing through the use of appropriate technologies could save up to 50% of this loss. Improved post-harvest processing also results in high-quality grain and straw that can be sold at more competitive market prices to increase farmers’ incomes. In short, enhanced mechanization in tef can drive sustainable development that Ethiopian smallholder agriculture needs.

**Challenge 1: Traditional post-harvest activities incur large quality and quantity losses**

Traditional post-harvest activities are time-consuming, labor-intensive, and often damage the final product through unintended adulteration of the grain and straw. The process begins when farmers cut the tef and leave it on the soil for drying. After several days of drying in the sun, farmers usually collect the cut crop and pile it up once or twice before it is transported to the threshing ground where the final pile is made.

Most tef producing farmers use traction animals (donkey or oxen) or family labor to transport harvested tef from the harvesting field to the threshing plot (called ‘awdma’). In addition, farmers may also use communal labor for activities such as transporting un-threshed tef to the awdma, by carrying and winnowing (separating the chaff from the grain) using locally-made fanning systems (‘sefed’- wooven from grass or palm leaves and/or ‘delago’ made of animal skin). For this work, farmers provide food and drink to the laborers involved in these activities.

---

\(^3\) Keith R. Baldwin, Crop Rotations on Organic Farms (undated)
Traditionally, tef threshing is done by trampling the crop using live animals, which is time-consuming and arduous and involves significant losses in quantity and quality. The harvested tef is scattered over the ‘awdma’ and cattle or other pack animals are driven over the tef to separate the grain from the straw. Generally, oxen are used to flatten, or trample, the tef and on dried tef sheaves that are spread over a cow-dung plastered floor. This process requires the assistance of 3-5 men to guide the oxen and feed the trampling ground with more un-threshed crop to ensure that quality and quantity loss remains as low as possible. Animals usually defecate and urinate on top of the threshing ground, further deteriorating the quality of the grain. Also, unless they are mouth-tied, oxen feed on tef sheaves, chaffs, and grain while threshing, which results in even more grain quantity loss. In addition to losses caused by this process, smallholder farmers generally suffer from resource constraints. Timely threshing of tef is often difficult, given limited access to oxen or other animals that can be used for threshing. In some situations, for a small amount of tef, farmers will conduct the threshing themselves by beating the grain and straw with sticks on the floor.

During this process, significant yield losses are incurred. In addition, as the threshing is done on the ground, the quality of the tef grain is affected as it can become mixed with the soil, sand and other foreign matter. This affects the market value of tef significantly as tef becomes contaminated by the foreign matter, particularly minute grains of sand and soil, which are difficult to clean and cause discomfort during the consumption of injera.

A final complication to consider in the post-harvest phase is shattering. Late harvest and poor handling leads to shattering which is another source of significant yield loss in tef production. Shattering occurs even before crop cutting starts, then continues as the crop begins to dry out and until the grain is threshed. Tef shattering can also be exacerbated by the incidence of rain, and by farming practices used in harvesting, gathering, piling and threshing. Some farmers attempt to minimize shattering by harvesting the crop while it is still green, but this practice is reported to affect the grain quality.

Challenge 2: Labor-intensive practices increase processing costs, especially gathering, piling, threshing, and cleaning

The other major challenge in the post-harvest processing step is labor intensity. Traditional threshing can take 20-30 person days of labor and 10 oxen days per hectare. Based on farmer focus group discussions done in three high-producing tef zones, an estimate of human labor days per tef production activity was created. As the table below indicates, post-harvest processing activities comprise 26-27% of human labor days required for tef production. This suggests that there is potential to decrease the labor requirement of post-harvest activities via mechanization. The use of machinery, such as a thresher with tef cleaner, would reduce the work burden on humans and oxen. Furthermore, under conditions where threshing has to be done in short amounts of time, for instance due to the incidence of rain, machinery would help to avoid losses in grain quantity and quality that would otherwise be incurred.
Exhibit 25: Estimate of farm-level labor days by tef production activity

<table>
<thead>
<tr>
<th>Activity (person-days)</th>
<th>Ada’a Days/ha</th>
<th>Becho Days/ha</th>
<th>Dejen Days/ha</th>
<th>% share</th>
<th>Days/ha</th>
<th>% share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land preparation</td>
<td>20</td>
<td>16</td>
<td>20</td>
<td>20%</td>
<td>20</td>
<td>17%</td>
</tr>
<tr>
<td>Weeding</td>
<td>24</td>
<td>18</td>
<td>40</td>
<td>24%</td>
<td>40</td>
<td>35%</td>
</tr>
<tr>
<td>Harvesting</td>
<td>30</td>
<td>18</td>
<td>24</td>
<td>30%</td>
<td>24</td>
<td>21%</td>
</tr>
<tr>
<td>Post-harvest processing</td>
<td>27</td>
<td>20</td>
<td>31</td>
<td>27%</td>
<td>31</td>
<td>27%</td>
</tr>
</tbody>
</table>

Source: Bekabil et al. (2011)

Agricultural mechanization, however, faces a number of challenges. First, the priority that mechanization is given by researchers is limited due to insufficient financial support. There is also a lack of a clear policy on traditional, intermediate, and modern agricultural technologies. In addition, public sector mechanization efforts are rather limited and uncoordinated. The private sector is nascent and marginalized when it comes to supplying the requisite quantity and quality of technologies. For example, only a select group of farmers in the Shashemene area and a few farmers in Dejen have been exposed to mechanical threshers for tef, via the efforts of international organizations such as Sasakawa Global 2000.

The nature of many intermediate technologies has also hindered their use by smallholder farmers. For example, unlike crop varieties or fertilizer, intermediate technologies, such as threshers, tend to be less divisible, requiring relatively large initial investments by the smallholder farmer who is already cash-constrained. Given the scale involved, making optimum use of such technologies can be a challenge unless mechanisms are devised to suit smallholder farmers. Despite these challenges, there are however encouraging opportunities for introducing mechanization to the Ethiopian smallholder sector. One such opportunity is the potential availability of relevant technologies from emerging Asian, Latin American, and African countries, most notably India, China, and Brazil.

**Challenge 3: Improper straw handling and utilization**

Most Ethiopian farmers traditionally store tef straw and crop residue by creating heaps or piles directly in the field, or transporting the heaps to the land near their home for animal feed. Problems identified with these traditional straw handling practices include quality deterioration, such as color fading, bad smell, and fungal growth due to delayed handling, as well as the inconvenience and additional labor needed to transport it. Finally, given the bulk involved, maintaining the straw and crop residue requires ample storage space.

The occurrence of poor weather during the time of conventional handling and storage activities can influence the quality characteristics of the straw. Furthermore, an appropriate level of compaction is important to maintain the initial quality of the straw, and to reduce the transport and space requirements. The introduction of proper technologies that can be used to complete straw handling activities, such as baling, compacting, treating, and transporting the straw, will aid in maintaining high quality straw. Additionally, the methods of transportation, storage, and preparation of feed rations can be improved from the traditional straw conservation and handling practices.
Challenge 4: Limited information available on tef food products development

Studies of twelve Ethiopian tef cultivars from four growing locations have shown differences in their physicochemical characteristics and injera-making qualities\(^{40}\). These differences are probably due to specific genetically-controlled physicochemical characteristics of the grain and growing environments, specifically the soil type. This requires further investigation and remains a knowledge gap for future research.

In Ethiopia, the use of tef is limited to a few, specific, traditional food products, such as injera. New food products made from tef could be developed for value-addition and income generation, either locally, through research, or based on the adaption and testing of recipes that have been developed abroad. In Europe and the United States, for example, different baked and cooked food products have been developed from tef. These products target the gluten-intolerant sector (2-4% of population) which has driven the increasing popularization of, and demand for, tef-based products and tef flour to be used in cooking.

3.5.3 Interventions

Intervention 1: Create awareness of and provide access to proven, efficient post-harvest technologies

There are many benefits that can be observed from the introduction of proven post-harvest technologies. Most notably, the mechanical thresher has been proven to provide significant benefits to farmers based on productivity gains, quality improvement, and reduced labor costs. Mechanical threshers should be promoted through knowledge dissemination practices and increased financial access to machinery for farmers and small enterprises.

In particular, two key activities will help in accomplishing this. First, comprehensive training sessions and manuals should be designed and conducted to disseminate knowledge of post-harvest technology benefits and use (e.g., field days, and woreda-level training events). Training sessions and related materials that will be used to raise awareness and market post-harvest technologies to farmers must include an explanation of how post-harvest technology can be profitable for farmers.

For example, in the Shashemene area, it was observed that almost all farmers use a thresher instead of the traditional techniques mentioned above. As the exhibit below describes, farmers can expect ~30% additional profit, as compared to profit earned from traditional threshing methods. Assuming a yield of about 12 quintals per hectare, the traditional post-harvest loss is ~20%, or 2.4 quintals per hectare. The use of a thresher is reported to reduce post-harvest loss by about 50%, or 1.2 quintals per hectare. Furthermore, the farmers reported that they pay about 110-120 ETB per hour to rent the thresher, and that a hectare of tef crop may take about 3 hours to thresh by machine. Assuming the current price of 1,336 ETB per quintal of tef (per EGTE price data), the total value of loss avoided is about 800 ETB, and the savings from reduced farmer and oxen labor cost (net of machinery costs) is about 1,500 ETB per half hectare. This results in an estimated revenue increase of about 2,300 ETB per half hectare, which is about 30% of total earned revenue using traditional methods.

---

\(^{40}\) Senayit Yetneberk (2012)
This information should be disseminated to farmers through multiple channels. Firstly, the traditional extension system should be leveraged, and detailed, rigorous training should be provided to development agents and other relevant woreda and FTC administration and staff. Secondly, specific events should be designed and conducted solely to provide information to farmers (e.g., farmer field days), demonstrating the positive results of using post-harvest technology. Finally, indirect transmission of information is possible through the development of materials like production manuals, television and radio programs, and other publications that can reach a high volume of farmers.

Exhibit 26: Profitability analysis of mechanical thresher use, based on Dejen trial

The second key activity to undertake is to enhance the production of proven post-harvest technologies. Training and farmer feedback should be provided to manufacturers to improve equipment quality and design, including development of quality certification. There are several Ethiopian manufacturers that produce post-harvest machinery, specifically multi-crop threshers with tef cleaners, but there is opportunity to enhance their product design and also incentivize additional manufacturers to start producing post-harvest machinery. For example, current mechanical threshers have been reported to have a wide difference between theoretical and practical efficiency rates. In order to develop highly effective machinery, farmers’ input on how to improve and modify threshers should be provided directly to manufacturers.

In addition to direct feedback from farmers, local thresher manufactures and Ethiopian farms could also benefit from exposure to international markets. Based on a global scan of threshing machinery, several key international manufacturers have been identified. In China, Zhengzhou Shuily Machinery and Hernan Gelgoog both currently produce multi-crop threshers that work well with small seeds, like tef.
India, Thomas International and Maple Export produce multi-crop threshers. By working with domestic manufacturers, like Selam Hawassa and My-Media, best practices in design and production can be leveraged from international sources.

A final aspect of enhancing existing production activities that should be considered is the implementation of higher quality assurance, via a quality certification program. The quality certification would be awarded to manufacturers that produce post-harvest machinery that meets specific criteria (e.g., a specified theoretical efficiency percentage level) and would indicate to interested parties, such as farmer training centers and private sector operators, that the machinery is of sufficient quality to be promoted to farmers.

In addition to providing design input via farmer feedback and competitor models, incentives could also be developed via policy and financial mechanisms. For example, current production costs of machinery remain high in Ethiopia, but they could be lowered if policies were enacted to reduce the import costs of critical parts. In addition or in place of lowering import costs, the federal government could provide waivers to incentivize greater production levels for specific machinery, such as multi-crop threshers, that will ultimately benefit smallholder farmers and boost productivity. Another mechanism that should be explored is the implementation of financial schemes. For example, setting up contracts between primary cooperatives and private sector operators or manufacturers would ensure a sustainable demand for post-harvest machinery and also provide a profitable model that benefits all parties.

In order to scale up the use of appropriate post-harvest technologies, all potential actors should be considered. There should also be a balance of public and private sector involvement to ensure that the model with the highest likelihood of success, scalability, and sustainably is identified. In particular, there are six main stakeholders to consider: smallholder farmers, entrepreneurs, technical resources, financial resources, private sector manufacturers and suppliers, and operators.

One such approach to promoting the use of post-harvest technologies through innovative models has been undertaken by the ATA. The ATA Technology Access & Adoption team and the Tef Program team have initiated various models with the RBoAs to provide farmers with increased access to technologies. These include delivery via private entrepreneurs, farmer groups, and youth groups organized in the form of micro- and small-enterprise operators. The models designed require that all types of operators provide rental services of multi-crop threshers to smallholder farmers at a standard rate or fee. A portion of the proceeds from this revenue earned is then used to pay back the cost of the machinery over a 2-3 year payback period.
Exhibit 27: Overview of potential operating model to provide farmer access to threshers

In addition to designing new operating models, there is a need to specifically support private sector entrepreneurs and operators in order to ensure that farmer access levels are dramatically increased. For example, training can be provided on various financing mechanisms and ownership options, such as through collective purchase via primary cooperatives, leasing agreements, or direct purchases with a loan.

**Intervention 2: Develop, test, and introduce new post-harvest technology prototypes**

Post-harvest equipment has gained popularity among farmers for their multi-dimensional benefits, such as reduction of operational cost and human drudgery, timeliness of operation, and increased labor productivity and efficiency. It is, however, one of the research areas that is often overlooked in the country.

Given that tef is unique to Ethiopia, it does not benefit from global experiences of post-harvest and handling practices, such as might be the case with wheat or maize farming. Except for mechanical threshers, the use of improved equipment and practices for all post-harvest operations of tef is almost non-existent throughout the country.

To combat these issues, work must be done to identify or design new technologies; ones which will help to reduce qualitative and quantitative losses during post-harvesting, and reduce the labor intensity of the process. To this end, the priority research activities that need to be undertaken from a post-harvest perspective, include: the introduction (or adaptation from foreign designs) of mechanical harvesters; selection and promotion of viable technologies for threshing; development (or adaptation from foreign designs) of cleaning and grading equipment; and the demonstration and evaluation of these
technologies to the farming communities in order to aid their adoption.

**Intervention 3: Support scale-up of proven straw handling methods**

Baling of tef straw by compacting heaps is an important practice that can reduce waste, conserve nutrients, maintain quality levels, and simplify the transport, storage, and preparation of feed rations. In order to accomplish this, it is important to introduce and promote straw baling and chopping equipment to farmers through innovative deployment models, and to provide support to baling and chopping machinery producers and distributors, as necessary.

**Intervention 4: Test and promote tef food products developed in other countries**

While little value-addition and processing activity has been developed within Ethiopia, other countries have taken steps to capture a larger share of the tef value chain. Moreover, given its highly nutritious nature and gluten-free composition, tef is an attractive alternative to wheat and other cereals, particularly in American and Western European markets.

Tef can be used in many kinds of bakery products, such as breads, biscuits, cakes, and cookies, etc., as well as in other food products, such as granola, pancakes, pie and pizza crusts, and so on. In fact, it has been asserted that every product that is currently made from wheat can also be made with tef\(^{41}\). In order to expand value-addition opportunities in Ethiopia, work must be done to test and promote the development of tef-based food products. From here, Ethiopia can begin large-scale development of its ability to create and mass manufacture these products for international export as well as domestic demand.

### 3.6 Market access and growth

#### 3.6.1 Vision

| Overall vision for market access and growth: | Increase efficiency of tef markets to stabilize prices and provide sufficient, high-quality tef to satisfy domestic demand and, in the future, develop a strong export market |

#### 3.6.2 Systemic challenges

**Challenge 1: Market transaction costs are artificially elevated due to a complex supply chain**

This challenge refers to an analysis of supply chain integration, which is measured by how closely producers and consumers are linked; this, in turn, ultimately determines and demonstrates the efficiency and effectiveness of the tef market. In general, it is true that cereal market supply chains in Ethiopia are considered to be long and complex. Similarly, the tef supply chain is characterized by many transactions, with heavy involvement from middlemen and brokers. As depicted below, Debre Zeit, Gojam, Wellega, and West Shoa are the major regional areas that supply tef to the central market. Farmers in these regional “hubs” sell their tef produce to local or nearby assemblers, who in turn pass the produce on to wholesalers in their respective markets.

---

41 Bultosa et al. (2002)
From wholesalers, the produce is channeled to the market in Addis Ababa, known as Ehel Berenda. It is estimated that roughly 70% of the marketed production of tef in Ethiopia routes through Addis Ababa channels and markets. At Ehel Berenda, tef is sold to various public entities (universities, hospitals, etc.), private institutions, processors (millers) operating in Addis, and individual buyers. Addis-based millers and traders sell the tef to urban consumers, while regional traders who buy from this market then route the produce to regional markets that are more removed from Addis Ababa’s operations.

Exhibit 28: Process flow of tef sales between farm-gate and end consumer

![Diagram showing the process flow of tef sales](image)

Source: Bekabil et al. (2011)

Interviews with processors suggest that previous attempts by end-buyers or traders to purchase tef directly from farmers failed due to a lack of trust and transparency in market information, in terms of the price and quality of tef. Lack of trust in the market is identified as the most important reason for the persistence of small grain traders, whose long-term relationships (especially with tef sellers) are the best guarantee that buyers and sellers will not be cheated. Having years of experience, major “power” players in the supply chain (see exhibit above) are local and Addis-based brokers who largely determine price and quality through their own informal standards and grading systems.

---

42 Gabre-Madhin (1999)
At present, some farmers and consumers believe that traders are not fully benefiting farmers, but rather are exploiting them. This is a major driver behind organizing farmers into formal associations, such as cooperative unions\(^{43}\).

The complexities of the tef supply chain are also evident through the price premiums resulting from multiple handovers. As the chart below shows, the price hike in June 2011 for a tef farmer in Debre Zeit was 26% between farm-gate and end-consumer. This price increase is reasonable when compared to other cereals, yet there is opportunity to streamline the process by reducing the number of transactions. There are frequently 5 or more handovers of tef between producers and consumers, with each trader or broker taking a profit margin as well as incurring transport and storage costs.

**Exhibit 29: Price increase and value-addition along tef value chain from farm-gate to end-consumer**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregation</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Packaging</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transporting</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Processing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Bekabil, et al. (2011)

In particular, this is an issue for tef because each handover contains little or no value addition, but simply adds transaction costs until it reaches the consumer. Whereas wheat is often baked into bread and maize is generally shelled, most tef consumers buy the grain directly from a trader or mill, have it milled at their own expense, and then process it into injera at home. The exceptions to this are tef processing cooperatives, mostly in Addis Ababa, who make injera on a moderate scale (up to 5,000 items per day) and sell it to institutional customers, such as schools, hotels, and supermarkets. Estimates suggest that this sector processes less than 1%\(^{44}\) of all tef consumed in Ethiopia, with the rest processed by families in their own homes, or by informal neighborhood processors whose contribution is difficult

---

\(^{43}\) Dr. Marco Quinones interview (2012)

\(^{44}\) Bekabil et al. (2011)
to estimate. In the market chain, each player adds little value beyond transportation; and practices that could reduce transaction costs and increase farmers’ market power, such as collective marketing through cooperatives, forward sales, and contract farming, are almost entirely unknown.

**Challenge 2: Tef market prices are volatile, due to lack of standardization, seasonality, etc.**

The tef market is under-developed and contains many small players. These small players drive volatility in the market and contribute to a lack of standardized, quality-grade tef. This in turn drives an inconsistency in product and sales, as the market contains varying types and colors of tef, and sale prices differ dramatically by geography and season.

This variability in type of tef and seasonal price has two important implications, one affecting farmers’ incomes, and the other the cost of tef to consumers.

On the first point, by selling their crops immediately after harvest, farmers lose the greater potential income to be gained from high market prices that exist during the lean season. Prices are generally much lower immediately after harvest and higher during lean seasons, following the fluctuations of supply while demand remains constant over the year. This immediate sale after harvest is motivated by liquidity requirements, with farmers needing to cover various expenses, such as credit, social obligations, school fees, and clothing, etc. However, so many farmers selling their tef crop at harvest reduces the farm-gate price available at that time. It is estimated that most farmers sell their produce right after harvest (representing more than 80% of annual tef production) due to these liquidity constraints.

As the chart on the next page displays, the price varied up to 40% for tef grain sold in Ada’a in 2012.

**Exhibit 30: Monthly price of tef by type**

Source: ATA Tef Program team analysis (2012)

---

45 Bekabil et a. (2011)
Price volatility significantly affects the margin obtained by farmers and reduces incentives to increase production and productivity. As depicted by the above chart, field discussions with farmers revealed that the price difference between the harvest and lean season ranges from 15-40% depending on the type of tef, location, and year.

The exhibit below displays the annual average price of staple crops. As shown, tef is the highest-priced cereal grown in Ethiopia and, following the high food price inflation in the country in 2008, the price of tef has also experienced a huge increase in recent years. White tef, for instance, has increased by 200% from 2005 to 2010, on average. The price of tef first jumped in May and June of 2008 when wheat and maize prices also spiked.

Exhibit 31: Wholesale Price Trends of Tef and Other Staple Crops

Source: Authors’ computation on EGTE data (2011)

The price gap between white tef, mixed tef, and red tef has expanded from 7% and 30% in 2005 to 24% and 55%, respectively, in 2010, which indicates a preference by consumers for white tef.\[46\]

The second major implication of this price variability is that it imposes high costs of purchase on consumers in certain seasons, affecting consumption patterns over the year. Moreover, based on field visits to market trading days and group discussions with farmers, it has been reported that much of the tef produce sold to local assemblers is manipulated through the use of unfairly calibrated weighing scales. Traders may also manipulate tef prices using various mechanisms, such as collusion and the use of privileged information, especially during the harvest months when there is a tef glut in the market.

Furthermore, time of sale and consumers’ unique preferences influence price volatility. Consumers have preferences for specific grain qualities found in tef produced in specific localities; with additional preferences based on color, taste, and preparation practices. This fact makes it difficult to achieve economies of scale within the trading system. For instance, the color between Gojam white and Adda white tef varies in brightness, which makes consistent tef marketing problematic from place to place.

---

46 Rashid and Asfaw (2011)
A final market aspect challenge is associated with implementing a grading system in such an unstructured market. As described in a 2008 ECX report on tef, the Quality and Standard Authority of Ethiopia has set tef standards by classifying the grain into four categories: very white (magna) which include 98-100% very white tef grains, white (nech) which includes 95-98% white tef grains, brown (key) which includes 94-100% of brown tef grains, and mixed (sergegna) which include a mixture of white and brown tef grains. Each tef class has been further defined by characteristics and assigned a grade level based on the occurrence of impurities.

Exhibit 32: Tef Grades by Class and Characteristic

<table>
<thead>
<tr>
<th>Classes</th>
<th>Characteristics</th>
<th>Maximum limits of impurities in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very white</td>
<td>Foreign matter</td>
<td>1.5  2.5  3.5  5.0</td>
</tr>
<tr>
<td></td>
<td>Stone</td>
<td>0.6  0.6  0.6  0.6</td>
</tr>
<tr>
<td>White</td>
<td>Foreign matter</td>
<td>1.5  2.5  3.5  5.0</td>
</tr>
<tr>
<td></td>
<td>Stone</td>
<td>0.6  0.6  0.6  0.6</td>
</tr>
<tr>
<td>Brown</td>
<td>Foreign matter</td>
<td>1.5  2.5  3.5  5.0</td>
</tr>
<tr>
<td></td>
<td>Stone</td>
<td>0.6  0.6  0.6  0.6</td>
</tr>
<tr>
<td>Mixed</td>
<td>Foreign matter</td>
<td>1.5  2.5  3.5  5.0</td>
</tr>
<tr>
<td></td>
<td>Stone</td>
<td>0.6  0.6  0.6  0.6</td>
</tr>
</tbody>
</table>

Source: ECX (2008)

However, the value of this grading system is limited as the existence of tef grades is not widely known, implemented, or leveraged by market actors. In addition, the grading system does not consider the characteristics of grain quality produced from specific localities, with different attributes tied to different geographic origins.

**Challenge 3: Large demand sinks, that could connect farmers more closely to end-buyers, are not well-developed**

The final challenge facing the tef market is the lack of large-scale players that can be leveraged to drive market development. As noted, tef is one of the major cereal crops in Ethiopia; valued throughout the country, especially for the preparation of injera. In addition, in some parts of the country, low-quality tef grain (which does not meet the standards and grading system requirements) is often used for the preparation of local alcoholic drinks, called ‘Tela’ and ‘Katikala’.

As described earlier, the tef market is characterized by a complex supply chain with many small-scale players. This provides incentive for investment in the development of the tef market. For example, investing in the infrastructure to build a large-scale tef processing plant may streamline the number of handovers that currently exist in the market. This would occur by linking the processor to consumers, rather than having consumers purchase from traders and then processing their tef grain themselves to

71
complete the final value addition step. As the exhibit below shows, there are strong regional variations in the use of tef, although ~60% of national tef production remains for household consumption. This number is likely to increase, however, as tef becomes more popular as a cash crop.

Exhibit 33: Tef production by household consumption, sale, and other uses

<table>
<thead>
<tr>
<th>Region</th>
<th>HH consumption</th>
<th>Sale</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amhara</td>
<td>12,791,077</td>
<td>58%</td>
<td>23%</td>
</tr>
<tr>
<td>Oromia</td>
<td>16,718,025</td>
<td>26%</td>
<td>19%</td>
</tr>
<tr>
<td>SNNP</td>
<td>2,967,594</td>
<td>36%</td>
<td>20%</td>
</tr>
<tr>
<td>Tigray</td>
<td>2,095,067</td>
<td>43%</td>
<td>17%</td>
</tr>
<tr>
<td>National</td>
<td>34,571,763</td>
<td>54%</td>
<td>26%</td>
</tr>
</tbody>
</table>

Source: CSA (2011)

In addition to developing the overall market, integration of activities may incentivize the creation of demand sinks. If a large-scale processing plant existed, for example, they could supply specified amounts of tef flour to institutions on a contractual, rather than ad-hoc, basis. Today, however, there are no such commercial processors, and the only seemingly large players, such as Mama Fresh Injera, hold a negligible market share. By example, Mama Fresh Injera, considered one of the dominant retail tef consumers, had a purchase volume in 2011 of 1,800 tons of tef, which comprised 0.12% of the total tef market.

Lack of large-scale domestic or international consumers is also driven by policy issues. In January 2006, Ethiopia banned the export of tef grain due to consensus regarding a shortage in supply to address domestic demand. Tef grain produced in Ethiopia cannot be exported at present, which in principle limits the potential returns to tef farmers and may even provide a dis-incentive to pursue yield-enhancing technologies. The tef grain export ban also partly contributes to the currently under-developed market, as there is no systematic, continuous demand from international consumers.

As seen in Exhibit 34, export of fresh and dry injera is increasing, but remains nominal. For example, in 2011, the export volume for fresh and dry Injera from Ethiopia was 18,000 quintals. This is 0.21% of the overall tef market production and represents only 56 million ETB of export revenue.
Exhibit 34: Export of tef from 2008-2011

3.6.3 Interventions

Intervention 1: Link smallholder tef producers (through cooperatives) to direct market outlets

The implications of transaction costs are that markets are weak, or likely to fail, if prohibitively high costs prevent exchange. Transaction costs, which are distinct from physical marketing costs, such as those for transport and storage, arise from the coordination of exchange among market actors. One of the measures that can be employed to reduce multiple transaction costs is engaging farmers in collective organizations, particularly through cooperatives, to collectively market their produce. Encouraging farmers to join together can reduce unneeded handovers in the supply chain and provide farmers with the opportunity to earn a higher percentage of the retail price.

In accordance with international and Ethiopian best practices, agricultural cooperatives should provide two key services: selling output on behalf of farmers, using robust market information; and maintaining consistent, strong relationships with reliable demand sources. In parallel, the markets should be strengthened through investments in infrastructure. Concerted efforts to strengthen cooperatives and market infrastructure will shorten the tef supply chain. This in turn will open an opportunity for cooperatives to engage in more value-addition activities and thereby increase margins for farmers.

Directly linking smallholder tef producers to markets, through cooperatives, can be realized in different ways. Cooperatives are organized to increase the value of members’ output, by reducing the number of intermediaries and taking on the tasks of assembling/aggregation, cleaning, grading, storing, packaging, distribution, and other functions. They can also play a role in tef grain branding (based on origin),
production process, and other features designed to give members a common identity and help gain premium pricing.

One way that cooperatives can improve farmers’ marketing is through improved storage facilities. Many collective marketing and sales mechanisms require large investments, such as warehouse space and working capital. Most rural teff traders have small amounts of stock holding and poor storage facilities. And many traders, especially those with insufficient working capital, transport their stock holding immediately to the central grain market, in order to maintain liquidity.

Another way that cooperatives can help link farmers more closely to markets is through sales contracts. Contract farming is one of the options gaining importance as a mechanism for governing transactions in agri-food supply chains and as a tool to improve market access for smallholders. A farming contract that was recently created between the Adama Lume Farmers Union and Mama Fresh Injera (a private injera baking company) serves as a successful example of this.

The contract requires farmers, through the union, to provide previously agreed-upon quantities of teff (that adheres to the quality standards set by Mama Fresh Injera) and supply it at the established time and place; while Mama Fresh Injera will then pay the agreed-upon price. Developing the contract required a series of consultations and discussions between the company and the union, with the ATA playing a significant role in linking both actors. The contract contains clearly stipulated responsibilities and timeframes for land preparation, farming practices, delivery and quality of inputs, and credit and extension advice, as well as the key issues related to product quality, prices, and payment. Contract farming, in addition to enhancing teff production, guarantees a secure market and can potentially increase farmers’ revenues. It also plays a role in supporting farmers with inputs, standards, and even risk management counseling as needed. Experience reveals that similar market linkages can be created with other types of entities, such as universities, hospitals, etc., through contract farming arrangements.

Linking farmers to end-markets through cooperatives can also be done by directly opening teff sales shops that are targeted at the larger teff markets (though there are few). Opening urban teff sales shops in Addis and other regional hubs could reduce trade and transaction costs while also increasing farmers’ incomes.

**Intervention 2: Create Community Warehouse Receipt Systems (CWRS) to increase potential earned income of farmers**

A concrete example of linking farmers more closely to end-markets is through the use of financial mechanisms, such as a community warehouse receipt system (CWRS). As mentioned, due to liquidity constraints, farmers often sell their produce immediately after harvest when prices are relatively low, reducing their potential earnings. The CWRS allows producers and traders to consolidate marketable volumes, and through collateralized receipts, teff farmers and traders can convert their produce inventories into readily tradable products. The receipts are negotiable instruments, in that, once institutionalized they can be traded, sold, swapped, and leveraged as collateral to support loans. Cooperatives may be engaged to facilitate the CWRS by acting as the intermediary between farmers and buyers or traders. A CWRS could provide farmers with improved storage facilities and financing options.
Moreover, CWRS will provide a platform for introducing new institutional arrangements and enhance rural entrepreneurship.

Through mechanisms like this, farmers will be assured of an adequate market and will likely be able to agree on a fixed price that is higher than the immediate post-harvest price at which tef is normally sold. Moreover, by working with institutions, such as commercial banks and micro-lending organizations, it may be possible to secure loans for financing short-term costs, while holding produce to sell later in the season to capitalize on price increases during the lean season market.

**Intervention 3: Improve tef market transparency and enforce standardization by adding tef to ECX in the future**

Enhancing tef market transparency and enforcing existing standardization can be accelerated by adding tef to the ECX trading system. A standards and grading system has already been established by the Quality & Standards Authority of Ethiopia (QSAE), however, this system is not extremely well-known or used. In order to address this, steps must be taken to include tef in the ECX suite of traded commodities and high-priority crops. This will lead to more efficient transaction opportunities and a wide-scale prevalence of market information on tef.

Today, farmers attempt to access price information either by physically visiting the major markets or by communicating with other farmers before delivering their tef to market. On the other hand, traders get price information through their personal networks. Currently, because of the rapid diffusion of mobile phone networks, market information among traders has been easily accessed. However, even though the Central Statistical Agency collects prices from 119 markets to feed Consumer Price Indices, they are released too late to be used as a decision making tool by farmers and traders. Similarly, the Ethiopia Grain Trade Enterprise collects market information from about 25 markets throughout the country, but it is rarely published in time to be used by smallholder farmers or the broader market. Inclusion in a formal Commodity Exchange will provide real-time pricing data for tef farmers, traders, and processors, in order to sell and/or buy the commodity at regional levels.

Many collective farmer agreements, such as contract farming or warehouse receipt systems through cooperatives, will benefit from enhanced market transparency. In fact, this additional level of data and information can help facilitate fairly agreed-upon contracts. In addition, the inclusion of tef in the ECX trading system can help in creating new financing schemes that will benefit farmers and stabilize the market. For example, attempting to engage in forward contracts without reference to a well-functioning national market leads to complicated enforcement challenges, as parties may display a bias in the grading or renge when the market changes. To tackle market-related obstacles such as this, adding tef to the suite of ECX crops will prove fundamental. However, such inclusion must be done in a manner that increases transparency and market efficiency without creating any unintended consequences.

**Intervention 4: Develop and strengthen systematic demand by investing in tef value-addition opportunities**

---

47 ECX (2008)
Given the lack of large-scale demand, little work has been done in value-addition of tef. To change this, there are several key related areas that require development in the tef market:

**Milling and processing development:** as discussed earlier, tef value addition, particularly through milling (cleaning grain and making flour) and processing (baking injera and other products) remains in a rudimentary state. Few Addis millers, or millers in other major cities, engage in creating tef flour from tef grain. Similarly, processing of tef flour into injera is limited to a small number of urban processors. Increasing systematic demand can be done by creating more large-scale milling and processing enterprises, and linking them to large-scale end-consumers, such as universities, hospitals, and restaurants, etc., in major tef market destinations (e.g., near Ehel Berenda in Addis).

**Tef-based product development:** despite the high potential for developing tef-based products, efforts in the space have thusfar been insignificant. However, being highly nutritional and gluten-free, the development of tef-based products is expected to attract increasing attention from food-related research institutions and food processing companies. One noted effort is the blending of cereals in an attempt to prepare different foods, which is currently being led by Haramaya University and the Ethiopian Health and Nutrition Research Institute (EHNRI). This effort has to be further strengthened and research by EHNRI has to intensify to specifically target tef, in order to further improve its nutritional qualities.

In other countries, especially the USA, there is growing demand for tef as part of a healthy, gluten-free diet, which may lead to greater processing in the future. Food processors, such as Faffa and Mama Fresh Injera, should be encouraged to increase their use of tef in cereal-based foods and to increase production of ready-to-eat injera destined for local and global markets. In parallel, Ethiopia must create campaigns to promote the nutritional benefits of tef at the local and global levels. Increasing public awareness of tef will serve to further incentivize food development efforts.

**Consistent demand sources:** a final way to create systematic demand for tef is through the creation of consistent, large-scale demand sources in the Ethiopian market. For example, school feeding and food aid programs should start purchasing tef as an additional cereal crop.

By blending tef with lysine and other nutritional options, school-age children and the general population will be provided with a strong source of nutrients that will prevent challenges such as malnutrition. Tef is well-suited for these programs, given its nutritional value, particularly since the traditional meal of injera with shiro wot provides a well-balanced diet that does not require additional protein. Tef is nutritionally rich while high in complex carbohydrates. And tef is gluten-free, so it can easily be tolerated by patients suffering from celiac disease. Tef is also high in fiber, making it an ideal dietary substitute for other cereals, such as wheat and barley, and it has a high calcium and iron content (the latter being important in preventing pregnancy anemia).
Section 4  Summary of interventions

This Strategy document has identified six stages of the tef value chain, including: tef research and technology development, inputs production and supply, inputs distribution, on-farm production, post-harvest processing, and market access and processing. At each stage of the value chain, several challenges were identified and strategies for overcoming them were synthesized into clearly defined, actionable interventions.

The exhibit below describes the full list of priority interventions that will be undertaken, categorized by value chain step, in order to achieve the overall vision for the tef sector described earlier. It is important to note that these interventions reflect only the highest-priority efforts, rather than a comprehensive list of actions to be completed to achieve productivity, profitability, and sustainability improvements in tef production. These interventions can be summarized into major focus areas as follows:

Exhibit 35: Overview of interventions by tef value chain step

<table>
<thead>
<tr>
<th>Value Chain Step</th>
<th>Systemic challenges</th>
<th>Interventions</th>
</tr>
</thead>
</table>
| Research development  
(listed as a discrete step although research is an activity related to and included in all value chain steps) | ▪ Insufficient priority is given to tef research, resulting in limited institutional and resource capacity  
▪ Limited basic research on tef exists to serve as a basis for further exploration  
▪ Genetic resource collection and management is insufficient  
▪ Tef varieties released so far do not adequately address lodging, biotic/abiotic stress, shattering, food products, etc.  
▪ Limited applied research in many areas, such as socioeconomics, soil, physiology, food chemistry, crop protection, and mechanization | ▪ Enhance institutional system and capacity in financial, human, and material capital  
▪ Strengthen basic research (physiology, genetics, cytogenetics, and genomics) on tef  
▪ Develop comprehensive genetic resources collection and characterization  
▪ Strengthen and accelerate varietal development through breeding  
▪ Enhance applied research in areas such as socioeconomics, soil, physiology, food chemistry, crop protection, and mechanization  
▪ Strengthen research related to other value chain steps |
| Inputs production | ▪ Production of seed is inconsistent, containing high variability in quality and quantity produced  
▪ Lime, which is used to treat highly acidic soil, is both in limited supply and costly to farmers  
▪ Existing farm implements (e.g., row planters, broad-bed makers, and ploughs) are inadequate and not readily available to farmers  
▪ Pesticides are currently costly and are not widely accessible for farmers | ▪ Strengthen capacity of public and private enterprises to improve seed production efficiency  
▪ Develop a system to accurately predict demand for seed  
▪ Increase the availability and affordability of lime to treat acidic soils  
▪ Facilitate the development of improved farm implements by public and private enterprises  
▪ Disseminate knowledge on integrated pest management and encourage pesticide production |
<p>| Inputs supply and distribution | ▪ Current complexities in the seed distribution process cause delays and | ▪ Enhance the efficiency of the seed distribution process by improving existing |</p>
<table>
<thead>
<tr>
<th><strong>distribution</strong></th>
<th><strong>On-farm production</strong></th>
<th><strong>Post-harvest processing and utilization</strong></th>
<th><strong>Market access and growth</strong></th>
</tr>
</thead>
</table>
| • supply shortages  
  ▪ Fertilizer prices remain high for farmers, partly due to importation and domestic distribution processes  
  ▪ Institutional constraints limit the effectiveness of inputs suppliers and distributors | • Farmers have insufficient knowledge of inputs, such as fertilizer and seed, and a financial inability to purchase and use them  
  ▪ Yield-enhancing farming practices are not well utilized or applied  
  ▪ Cropping systems (rotation, double, relay cropping, and agroforestry) are not efficiently practiced | • Traditional post-harvest activities lead to large quality and quantity losses  
  ▪ Labor-intensive practices increase operating costs, especially gathering, piling, threshing, and cleaning  
  ▪ Improper straw handling and utilization  
  ▪ Limited information available on tef food product development | • Market transaction costs are artificially elevated due to a complex supply chain  
  ▪ Tef market prices are volatile due to lack of standardization, seasonality, etc.  
  ▪ Large demand sinks, that could connect farmers more closely to end buyers, are not well-developed |
| | | | • Link smallholder tef producers (through cooperatives) to direct market outlets  
  ▪ Create Community Warehouse Receipt Systems (CWRS) to increase potential earned income of farmers  
  ▪ Improve tef market transparency and enforce standardization by adding tef to ECX in the future  
  ▪ Develop and strengthen systematic demand by investing in tef value-addition opportunities |

**Source:** ATA Tef Program team analysis
Section 5 Implementation Framework

5.1 Prioritization and sequencing of interventions

While most of the interventions listed above present an opportunity to improve the value chain, the Agricultural Transformation Agency’s focus is on enabling partner organizations to achieve the interventions that will have the greatest impact and that are most feasible.

The interventions described above are still being assessed for their potential impact and feasibility, but preliminary analysis indicates that initial focus should be on the central part of value chain (Inputs Production and Supply, Inputs Distribution, On-farm Production, and Post-Harvest Processing), while medium- to long-term focus should be placed on strengthening the bookends of the value chain (e.g. Research and Technology Development, and Market Access and Processing).

This prioritization is due to the fact that the most critical interventions are those that are feasible in the short-term and that will serve to boost tef production through increased productivity and reduced pre- and post-harvest losses within one to two planting cycles.

In the chart below, the specific interventions proposed in the above sections have been prioritized according to impact and feasibility. This will enable organizations to allocate resources to the most pressing interventions.
**Legend:**
1. Research development
2. Inputs production
3. Inputs supply and distribution
4. On-farm production
5. Post-harvest processing and utilization
6. Market access and growth

### Exhibit 36: Prioritization of interventions by feasibility and impact

<table>
<thead>
<tr>
<th>IMPACT</th>
<th>FEASIBILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Provide policy, financial, and organizational support to promote use of inputs</td>
<td>1. Enhance applied research in areas such as socioeconomics, soil, physiology, food chemistry, crop protection and mechanization</td>
</tr>
<tr>
<td>6. Improve tef market transparency and enforce standardization by adding tef to ECX in the future</td>
<td>2. Develop a system to accurately predict demand for seed</td>
</tr>
<tr>
<td>2. Facilitate the development of improved farm implements by public and private enterprises</td>
<td>6. Link smallholder tef producers (through cooperatives) to direct market outlets</td>
</tr>
<tr>
<td>4. Create financial mechanisms to support farmers in purchasing inputs such as fertilizer</td>
<td>3. Enhance the efficiency of the seed distribution process by improving existing channels and creating new alternative channels</td>
</tr>
<tr>
<td>6. Create Community Warehouse Receipt Systems (CWRS) to increase potential earned income of farmers</td>
<td>4. Support scale up of yield-enhancing technologies</td>
</tr>
<tr>
<td>1. Enhance institutional system and capacity in financial, human and material capital</td>
<td>4. Promote efficient cropping systems (crop rotations, double, relay, agroforestry)</td>
</tr>
<tr>
<td>2. Facilitate the development of improved farm implements by public and private enterprises</td>
<td>5. Create awareness of and provide access to proven, efficient post-harvest technologies</td>
</tr>
<tr>
<td>6. Create Community Warehouse Receipt Systems (CWRS) to increase potential earned income of farmers</td>
<td>1. Strengthen and accelerate varietal development through breeding</td>
</tr>
<tr>
<td>1. Enhance institutional system and capacity in financial, human and material capital</td>
<td>2. Increase the availability and affordability of lime to treat acidic soils</td>
</tr>
<tr>
<td>2. Facilitate the development of improved farm implements by public and private enterprises</td>
<td>3. Enable flexibility in the fertilizer shipping, inland transport, and distribution process to lower costs</td>
</tr>
<tr>
<td>6. Create Community Warehouse Receipt Systems (CWRS) to increase potential earned income of farmers</td>
<td>1. Strengthen research related to other value chain steps</td>
</tr>
<tr>
<td>1. Strengthen and accelerate varietal development through breeding</td>
<td>2. Increase the availability and affordability of lime to treat acidic soils</td>
</tr>
<tr>
<td>2. Develop a system to accurately predict demand for seed</td>
<td>3. Enable flexibility in the fertilizer shipping, inland transport, and distribution process to lower costs</td>
</tr>
<tr>
<td>6. Link smallholder tef producers (through cooperatives) to direct market outlets</td>
<td>1. Strengthen research related to other value chain steps</td>
</tr>
<tr>
<td>3. Enhance the efficiency of the seed distribution process by improving existing channels and creating new alternative channels</td>
<td>2. Increase the availability and affordability of lime to treat acidic soils</td>
</tr>
<tr>
<td>4. Support scale up of yield-enhancing technologies</td>
<td>3. Enable flexibility in the fertilizer shipping, inland transport, and distribution process to lower costs</td>
</tr>
<tr>
<td>4. Promote efficient cropping systems (crop rotations, double, relay, agroforestry)</td>
<td>5. Support scale-up of proven straw handling methods</td>
</tr>
<tr>
<td>5. Create awareness of and provide access to proven, efficient post-harvest technologies</td>
<td>1. Test and promote tef food products developed in other countries</td>
</tr>
<tr>
<td>6. Create Community Warehouse Receipt Systems (CWRS) to increase potential earned income of farmers</td>
<td>2. Support scale-up of proven straw handling methods</td>
</tr>
<tr>
<td>1. Strengthen basic research (physiology, genetics, cytogenetics, and genomics) on tef</td>
<td>1. Develop comprehensive genetic resources collection and characterization</td>
</tr>
<tr>
<td>2. Strengthen capacity of public and private enterprises to improve seed production efficiency</td>
<td>2. Disseminate knowledge on integrated pest management and encourage pesticide production</td>
</tr>
</tbody>
</table>

**Source:** ATA Tef Program team analysis
Of the possible interventions that are deemed feasible in the short-term, preliminary analysis indicates that the highest impact interventions would be promoting agronomic practices, such as row planting, reduced seed rates, and use of improved seeds, while also increasing access to mechanized threshers and cleaners. These activities could drastically increase yields while also decreasing post-harvest losses, and they have the potential to be implemented and adopted immediately.

In the medium-term, preliminary analysis indicates that focusing on increasing support for tef research across multiple areas (e.g., breeding, agronomic practices, and mechanization), and focusing on expanding market access and processing opportunities (e.g., through value addition like fortification or improved grading systems) should be the next stage. This bifurcated approach will ensure that research institutions are strengthened so that productivity can continue to be increased, while also ensuring that a strong market exists to absorb the increased supply.

In the long-term, preliminary analysis indicates that investments must be made in more complicated, systemic interventions that exist at all steps in the value chain. For example, expanding the use of new, proven technologies first requires that new technologies are identified, selected, tested, and approved, which can take several planting cycles to accomplish. In addition, several interventions may require enabling policies related to financing or research capabilities, which will require specific shifts in policy. Overall, these long-term interventions are more focused on systemic changes and are no less important in the long run, but are less immediately implementable and first require significant changes in order to be fully possible.

These perspectives on the appropriate set of interventions, with an order of priority and sequence for implementation, has been developed based on detailed analysis and has been validated with input from tef experts from various institutions and the MoA. Below is a table depicting the proposed interventions according to specific timeframes. This will enable institutional owners to focus on the correct interventions over the next five to seven years.
Exhibit 37: Sequencing of interventions over time

<table>
<thead>
<tr>
<th>Value chain step</th>
<th>Interventions</th>
<th>Timeline</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>ST(^{48})</td>
</tr>
<tr>
<td><strong>Research development</strong></td>
<td>Enhance institutional system, and capacity in financial, human and material capital</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Strengthen basic research (physiology, genetics, cytogenetics, and genomics) on tef</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Develop comprehensive genetic resources collection and characterization</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Strengthen and accelerate varietal development through breeding</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Enhance applied research in areas such as socioeconomics, soil, physiology, food chemistry, crop protection, and mechanization</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Strengthen research related to other value chain steps</td>
<td></td>
</tr>
<tr>
<td><strong>Inputs production</strong></td>
<td>Strengthen capacity of public and private enterprises to improve seed production efficiency</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Develop a system to accurately predict demand for seed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Increase the availability and affordability of lime to treat acidic soils</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Facilitate the development of improved farm implements by public and private enterprises</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Disseminate knowledge on integrated pest management and encourage pesticide production</td>
<td></td>
</tr>
<tr>
<td><strong>Inputs supply and distribution</strong></td>
<td>Enhance the efficiency of the seed distribution process by improving existing channels and creating new alternative channels</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Enable flexibility in the fertilizer shipping, inland transport, and distribution process, in order to lower costs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Provide policy, financial, and organizational support to promote use of inputs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Promote use of organic fertilizer as a cost-effective alternative to inorganic, internationally-sourced fertilizer</td>
<td></td>
</tr>
<tr>
<td><strong>On-farm production</strong></td>
<td>Support scale-up of yield-enhancing technologies</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Create financial mechanisms to support farmers in purchasing inputs, such as fertilizer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Promote efficient cropping systems (crop rotation, double, relay, agroforestry)</td>
<td></td>
</tr>
<tr>
<td><strong>Post-harvest processing and utilization</strong></td>
<td>Create awareness of and provide access to proven, efficient, post-harvest technologies</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Develop, test, and introduce new post-harvest technology prototypes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Support scale-up of proven straw handling methods</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Test and promote tef food products developed in other countries</td>
<td></td>
</tr>
<tr>
<td><strong>Market access and growth</strong></td>
<td>Link smallholder tef producers (through cooperatives) to direct market outlets</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Create Community Warehouse Receipt Systems (CWRS) to increase potential earned income of farmers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Improve tef market transparency and enforce standardization by adding tef to ECX</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Develop and strengthen systematic demand by investing in tef value-addition opportunities</td>
<td></td>
</tr>
</tbody>
</table>

Source: ATA Tef Program team analysis

Note: Human and infrastructure capacities may be classified as long-term but have to start right away. Otherwise, everything else cannot be accomplished. For instance, research funds for greenhouses and additional human resources are needed immediately to accomplish longer-term research interventions.

\(^{48}\)ST- Short term (1-2 years)

\(^{49}\)MT- Medium term (3-4 years)

\(^{50}\)LT- Long term (5-7 years)
5.2 High-level Implementation plan

Implementation of the National Tef Strategy will require the close coordination and efforts of all relevant stakeholders. In particular, it will require a significant human resource commitment, a governance plan to ensure significant progress towards stated goals, and strong partnership building to ensure that the interventions that are executed lead to sustainable, long-term solutions.

Financial and Human Resource Commitment by the Government

The Government, both at the federal and regional level, has been committing resources for tef development. This must continue, along with the other agricultural development interventions of the Ministry, and will also need to be bolstered to ensure achievement of the objectives in the National Tef Strategy.

Commitment to Build Partnerships by all Involved Stakeholders

Stakeholders range from farmers, transporters, traders, processors, extension staff, and research staff, to community development organizations, development partners, international and national research institutions, politicians, and policy makers. Linkages between these stakeholders must be created alongside clear roles and responsibilities, in order to implement the National Strategy.

The government, both at the federal (MoA, Ministry of Trade, Federal Cooperative Agency, EIAR, etc.) and the regional level (Bureaus of Agriculture, Cooperative offices, Regional Agricultural Research Institutes, etc.), are critical stakeholders and partners in implementation. Civil society organizations and donors are equally vital to ensuring successful implementation. In addition to explicit national and regional linkages, the execution of the Strategy will require effective project-based collaboration in order to promote effective partnerships among stakeholders.

Governance of National Tef Strategy

Overall, the National Tef Strategy must be implemented by the federal Ministry of Agriculture (MoA) in collaboration with various Ministry directorates, in addition to the Ethiopian Institute of Agricultural Research (EIAR), Regional Agricultural Research Institutes (RARIs), and the Regional Bureaus of Agriculture (RBoAs).

According to a proposed preliminary implementation framework, the National Tef Strategy can be coordinated at a federal level through quarterly meetings chaired by the Ministry of Agriculture, and regional implementation will be overseen by a Regional Planning and Implementation Platform and Regional Secretariat in each of the four regions. With the exception of the Regional Secretariats, the other proposed organizational structures currently exist, requiring only the reallocation of existing field staff and the provision of capacity building resources.

Overview of the Regional Planning and Implementation Platform

Regional Platforms will be responsible for two primary functions:

1. Provide guidance on regional and geographic implementation interventions, including the tef strategy
2. Act as a coordinating forum among all regional stakeholders
The proposal calls for the Regional Platforms to be comprised of each region’s most senior leadership. These Regional Platforms will provide executive direction for prioritizing geographic and broader regional activities, including all work related to the National Tef Strategy. Key regional stakeholders include various heads of: RBoA offices and departments; RARIs; RSEs; NGO representatives; Higher Learning Institutions; and regional ATA representatives.

Overview of the Regional Secretariat

In further support of the Regional Planning and Implementation Platforms, it is also suggested that a permanent office known as the “Regional Secretariat Office” should be established in each of the four regions. This Regional Secretariat will report to the RBoA with significant oversight and support provided by ATA. Specific functions of the Secretariat will include:

1. Support Deputy Bureau Heads in managing the execution of regional and geographic interventions, as identified by the Platform
2. Provide full-time administrative support to coordinate implementation efforts
3. Coordinate and streamline collaboration between federal organizations and Regional Platforms

The proposed composition of the Regional Secretariat Offices will be include both full-time ATA staff and part-time regional employees that cover various functions, including financial, analytical, secretarial, and regional expertise.

Activities to be carried out by these bodies include:

1. Development of detailed implementation plans for proposed interventions by value chain step
2. Creation of implementation budget for each financial year, based on implementation plans
3. Monitoring and evaluation of physical and financial performance of the strategic action areas, according metrics and targets to be created and endorsed

In order to accomplish the above activities, institutional owners must be assigned to each priority intervention within each value chain step. The below exhibit proposes some preliminary ideas on institutional owners and partners for each intervention. The institutional owner signifies the primary institution that is responsible for achieving the specific intervention. Each intervention also details the relevant partners that are required to provide support to the institutional owner, as needed.
# Exhibit 38: Institutional Owners and Implementing Partners

<table>
<thead>
<tr>
<th>Value Chain Step</th>
<th>Interventions</th>
<th>Lead Institutions</th>
<th>Collaborating Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Research</strong></td>
<td><strong>development</strong>&lt;br&gt;(listed as a discrete step, but includes research related to all value chain steps)</td>
<td><strong>Interventions</strong></td>
<td><strong>Institutions</strong></td>
</tr>
<tr>
<td></td>
<td>▪ Enhance institutional system and capacity in financial, human, and material capital</td>
<td>• EiAR&lt;br&gt;• Universities&lt;br&gt;• RARIs&lt;br&gt;• IBC&lt;br&gt;• GoE&lt;br&gt;• ATA</td>
<td><strong>Collaborating Institution</strong>&lt;br&gt;• MoA&lt;br&gt;• ATA&lt;br&gt;• RBoAs&lt;br&gt;• Donors&lt;br&gt;• Private companies&lt;br&gt;• Universities</td>
</tr>
<tr>
<td></td>
<td>▪ Strengthen basic research (physiology, genetics, cytogenetics, and genomics) on tef</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ Develop comprehensive genetic resources collection and characterization</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ Strengthen and accelerate varietal development through breeding</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ Enhance applied research in areas such as socioeconomics, soil, physiology, food chemistry, crop protection, and mechanization</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ Strengthen research related to other value chain steps</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Inputs</strong></td>
<td><strong>production</strong></td>
<td>• MoA&lt;br&gt;• RBoAs&lt;br&gt;• ESE&lt;br&gt;• RSEs&lt;br&gt;• RARI-RAMC (Regional Agricultural Mechanization Centers)&lt;br&gt;• Universities-IOT</td>
<td><strong>Collaborating Institution</strong>&lt;br&gt;• MoA and MST&lt;br&gt;• RBoAs&lt;br&gt;• ATA&lt;br&gt;• Private Companies&lt;br&gt;• FCA (Federal Cooperative Agency)&lt;br&gt;• SMEs, Cooperatives, Unions&lt;br&gt;• NGOs&lt;br&gt;• Donors</td>
</tr>
<tr>
<td></td>
<td>▪ Strengthen capacity of public and private enterprises to improve seed production efficiency</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ Develop a system to accurately predict demand for seed</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ Increase the availability and affordability of lime to treat acidic soils</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ Facilitate the development of improved farm implements by public and private enterprises</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ Disseminate knowledge on integrated pest management and encourage pesticide production</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Inputs</strong></td>
<td><strong>supply and distribution</strong></td>
<td>• ESE&lt;br&gt;• RSEs&lt;br&gt;• MoA&lt;br&gt;• RBoAs</td>
<td><strong>Collaborating Institution</strong>&lt;br&gt;• EIAR and RARIs&lt;br&gt;• ATA&lt;br&gt;• RSEs&lt;br&gt;• FCA&lt;br&gt;• Private companies&lt;br&gt;• Cooperatives and Unions&lt;br&gt;• NGOs&lt;br&gt;• Donors</td>
</tr>
<tr>
<td></td>
<td>▪ Enhance the efficiency of the seed distribution process by improving existing channels and creating new alternative channels</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ Enable flexibility in the fertilizer shipping, inland transport, and distribution processes to lower costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ Provide policy, financial, and organizational support to promote use of inputs</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ Promote use of organic fertilizer as a cost-effective alternative to inorganic, internationally-sourced fertilizer</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| On-farm production | ▪ Support scale-up of yield-enhancing technologies  
▪ Create financial mechanisms to support farmers in purchasing inputs, such as fertilizer  
▪ Promote efficient cropping systems (crop rotations, double, relay, agroforestry) | ▪ MoA (Extension)  
▪ RBoAs  
▪ EIAR and RARIs | ▪ EIAR and RARIs  
▪ ATA  
▪ NGOs  
▪ Financial institutions  
▪ BGCA Donors  
▪ Donors |
|-------------------|--------------------------------------------------|--------------------------|--------------------------|
| Post-harvest processing and utilization | ▪ Create awareness of and provide access to proven, efficient post-harvest technologies  
▪ Develop, test, and introduce new post-harvest technology prototypes  
▪ Support scale-up of proven straw handling methods  
▪ Test and promote tef food products developed in other countries | ▪ MoA  
▪ RBoAs  
▪ EIAR and RARIs  
▪ Unions and cooperatives | ▪ Private sector  
▪ ATA  
▪ NGOs  
▪ ENHI  
▪ Universities (Food Science Units)  
▪ Donors |
| Market access and growth | ▪ Link smallholder tef producers (through cooperatives) to direct market outlets  
▪ Create Community Warehouse Receipt Systems (CWRS) to increase potential earned income of farmers  
▪ Improve tef market transparency and enforce standardization by adding tef to ECX  
▪ Develop and strengthen systematic demand by investing in tef value-addition opportunities | ▪ Ministry of Trade  
▪ Ministry of Industry  
▪ Ethiopian Standards Agency (ESA)  
▪ MoA  
▪ FCA/RCA  
▪ ECX | ▪ ECX  
▪ EGTE  
▪ CSA  
▪ ENHI  
▪ MoFA  
▪ Donors  
▪ NGOs  
▪ ECPA (Ethiopian Consumer Protection Agency) |
5.3 Monitoring, Learning and Evaluation framework (MLE)

Implementing the strategic interventions will be an extensive undertaking, requiring coordination of activities across stakeholders, detailed budget allocations, and clear work plans designed to accomplish each intervention within each value chain step. This effort will also require substantial prioritization and pacing to ensure that all tasks are achieved with sufficient focus and resources, and that they are followed by earlier activities upon which they are dependent.

In order to monitor and evaluate the National Tef Strategy work, a monitoring, learning, and evaluation (MLE) framework must be created, in collaboration with each institutional owner. The below exhibit is a proposed MLE framework that has been developed through extensive discussions with key stakeholders.

This MLE framework includes the full list of interventions, detailing outputs, indicators, targets, activities, milestones, budget, and owners for each. This framework may also be used by the institutional owners to create more detailed work plans.
Exhibit 39: Monitoring, Learning, and Evaluation framework

<table>
<thead>
<tr>
<th>Tef Value Chain Step</th>
<th>Intervention</th>
<th>Output</th>
<th>Indicator/Target</th>
<th>Activity</th>
<th>Milestone</th>
<th>Lead Institution</th>
<th>Collaborating Institutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research development</td>
<td>Enhance institutional system and capacity in financial, human, and material capital</td>
<td>Inclusion of tef as a national priority commodity of Ethiopia</td>
<td>Formal listing of tef as a national priority commodity</td>
<td>• Conduct briefings with key policymakers</td>
<td>2013</td>
<td>EIAR</td>
<td>ATA, HLIs</td>
</tr>
<tr>
<td></td>
<td>Proper institutionalization and management of EARS/NARS</td>
<td>Restructured EARS/NARS with efficient management system</td>
<td>Review NARS/EARS system and propose redesigns to increase efficiency</td>
<td>2023</td>
<td>EIAR</td>
<td>MoA, MoST, ATA, RARIs, HLIs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Increase in trained human resources</td>
<td>50 additional resources hired and on-boarded</td>
<td>Source and provide local/international trainings</td>
<td>2023</td>
<td>EIAR</td>
<td>MoA, MoST, ATA, RARIs, HLIs</td>
<td></td>
</tr>
<tr>
<td>High-quality equipment and facilities</td>
<td>Prevalence of world-class equipment and facilities</td>
<td>Purchase equipment</td>
<td>2013-20</td>
<td>GoE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adequate budget allocation</td>
<td>Increased budget</td>
<td>Appeal for budget increase for specific projects/initiatives</td>
<td>2013-17</td>
<td>GoE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Information generated</td>
<td>Increase in 20 research papers</td>
<td>Identify gaps in research areas</td>
<td>2013-14</td>
<td>Universities/ EIAR RARIs, Bern and Cornell universities</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Published articles</td>
<td>Increase in 40 articles</td>
<td>Conduct on-station and on-farm research studies</td>
<td>2014-17</td>
<td>EIAR</td>
<td>RARIs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Developed PCR markers</td>
<td>Increase in 300 markers</td>
<td>Conduct phenotypic and molecular analysis of tef genotypes and wild relatives in laboratory and on-field</td>
<td>2014-18</td>
<td>EIAR</td>
<td>RARIs, Bern and Cornell Universities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saturated tef linkage map</td>
<td>Fully-completed map</td>
<td>Develop map</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number and types of QTLs detected</td>
<td>Increase in 25 QTLs</td>
<td>Develop QTLs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tef Value Chain Step</td>
<td>Intervention</td>
<td>Output</td>
<td>Indicator/Target</td>
<td>Activity</td>
<td>Milestone</td>
<td>Lead Institution</td>
<td>Collaborating Institutions</td>
</tr>
<tr>
<td>---------------------</td>
<td>--------------</td>
<td>--------</td>
<td>-----------------</td>
<td>----------</td>
<td>-----------</td>
<td>-----------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td><strong>Research development (continued)</strong></td>
<td>Develop comprehensive genetic resources collection and characterization</td>
<td>Number of collected accessions</td>
<td>2,500 accessions</td>
<td>• Identify gaps</td>
<td>2013</td>
<td>IBC, EIAR</td>
<td>BoA and RARIs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Execute a collection mission</td>
<td>2014-15</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Conduct field evaluation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Characterized accessions (phenotypic, biochemical, molecular)</td>
<td>5,000 accessions</td>
<td>• Develop biochemical accessions</td>
<td>2016-20</td>
<td>EIAR, IBC</td>
<td>RARIs, Cornell Univ, Bern University, Universities</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Develop molecular accessions</td>
<td></td>
<td>IBC, EIAR</td>
<td>BoA and RARIs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Covered areas (area, name of the places)</td>
<td></td>
<td>• Identify collection gap areas</td>
<td>2013</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of varieties selected from the collections</td>
<td>10 varieties</td>
<td>• Manage nurseries</td>
<td>2016-20</td>
<td>EIAR</td>
<td>RARIs, Universities</td>
</tr>
<tr>
<td><strong>Strengthen and accelerate varietal development through breeding</strong></td>
<td></td>
<td>Number of varieties released</td>
<td>3 to 5 varieties</td>
<td>• Conduct yield trials to determine success of new varieties</td>
<td>2013</td>
<td>EIAR</td>
<td>RARIs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of lines developed for yield and other purpose trials</td>
<td>1,000 lines developed</td>
<td>• Identifying farmers interest</td>
<td>2013-15</td>
<td>EIAR</td>
<td>RARIs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Developed/improved crossing protocol and generation advancement methodology</td>
<td>2 crossings</td>
<td>• Evaluate and improve crossing and breeding protocol and procedure evaluation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Conduct targeted crossings</td>
<td>2013-17</td>
<td>EIAR</td>
<td>RARIs, Universities</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Promote generation advancement</td>
<td>2015-18</td>
<td>EIAR</td>
<td>RARIs, Universities</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Conduct yield trials</td>
<td>2015-19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tef Value Chain Step</td>
<td>Intervention</td>
<td>Output</td>
<td>Indicator/Target</td>
<td>Activity</td>
<td>Milestone</td>
<td>Lead Institution</td>
<td>Collaborating Institutions</td>
</tr>
<tr>
<td>----------------------</td>
<td>--------------</td>
<td>--------</td>
<td>------------------</td>
<td>----------</td>
<td>-----------</td>
<td>-----------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td><strong>Inputs production</strong></td>
<td>Strengthen capacity of public and private enterprises to improve seed production efficiency</td>
<td>Amount of quality improved seed produced</td>
<td>500 tons</td>
<td>• Identify gaps based on suitable agro-ecology</td>
<td>2013</td>
<td>ESE, PSEs</td>
<td>Private seed enterprises, private companies</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of community-based and cooperatives organized to produce improved seed</td>
<td>300 organizations</td>
<td>• Verify quantity of improved seed production</td>
<td>2013-17</td>
<td>MoA, RBoA, Private seed enterprises</td>
<td>Unions, Cooperatives</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Create awareness</td>
<td>2013</td>
<td>MoA, RBoA, Private seed enterprises</td>
<td>Unions, Cooperatives</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Organize producers and entrepreneurs</td>
<td>2014-17</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Develop a system to accurately predict demand for seed</strong></td>
<td>Improved input demand assessment system</td>
<td>System with limited delays, quality issues, etc.</td>
<td>• Analysis of the existing input demand assessment system</td>
<td>2013-14</td>
<td>MoA, RBoA</td>
<td>ESE, RSEs, AISE, FCA, RCA</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Local market tailored input delivered (flexible pricing, package size, etc.)</td>
<td>• Identify gaps and limitations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Design and implement improved demand assessment system</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Increase the availability and affordability of lime to treat acidic soils</strong></td>
<td>Quantity of lime produced</td>
<td>1,000 tons</td>
<td>• Identify gap areas</td>
<td>2013</td>
<td>MoA, RBoA</td>
<td>Private entrepreneurs</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of lime-producing mills</td>
<td>110 mills</td>
<td>• Create awareness</td>
<td>2013-16</td>
<td>MoA, RBoA</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Evaluate proper implementation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Facilitate the development of improved farm implements by public and private enterprises</strong></td>
<td>Number of improved implements produced by different enterprises</td>
<td>600 implements</td>
<td>• Create awareness</td>
<td>2013</td>
<td>MoA, RBoA, Tech. centers</td>
<td>Agri. Mech. Centers, EIAR, private entrepreneurs</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Type and units of technologies multiplied</td>
<td>100,000 units of 3 types of technologies</td>
<td>• Organize producers and entrepreneurs</td>
<td>2014-17</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Train local manufacturers/SMEs and provide prototype designs and manufacturing guidelines</td>
<td>2013-15</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Assist and strengthen local implement manufacturers/SMEs</td>
<td>2013-15</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Disseminate knowledge on integrated pest management and encourage pesticide production</strong></td>
<td>Level of IPM implementation by smallholder farmers</td>
<td>• Create awareness</td>
<td>2013</td>
<td>MoA</td>
<td>BoA</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of public and private pesticide producers</td>
<td>180 producers</td>
<td>• Organize producers and entrepreneurs</td>
<td>2014-17</td>
<td>MoA, RBoA</td>
<td>Unions, private entrepreneurs</td>
</tr>
<tr>
<td>Tef Value Chain Step</td>
<td>Interventions</td>
<td>Output</td>
<td>Indicator/Target</td>
<td>Activity</td>
<td>Milestone</td>
<td>Lead Institution</td>
<td>Collaborating Institutions</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>-------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------</td>
<td>----------------</td>
<td>------------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td>Inputs supply and distribution</td>
<td>Enhance the efficiency of the seed distribution process by improving existing channels and creating new alternative channels</td>
<td>Number of alternative input distribution channels system in place</td>
<td>Development of new alternative channel</td>
<td>• Directly link seed producers to primary cooperatives or directly to smallholder farmers</td>
<td>2015-16</td>
<td>MoA, RBoA</td>
<td>PSEs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Development of new informal channel</td>
<td>• Strengthen informal seed distribution channels (experience sharing, training, etc.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Promote use of organic fertilizer as a cost-effective alternative to inorganic, internationally-sourced fertilizer</td>
<td>Quantity of organic fertilizer prepared</td>
<td>1,000 tons</td>
<td>• Identify gaps</td>
<td>2013</td>
<td>MoA, RBoAs</td>
<td>Coops, Unions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quantity of inorganic fertilizer utilized</td>
<td>800 tons</td>
<td>• Create awareness</td>
<td>2013</td>
<td>MoA, RBoAs</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number and types of cropping systems utilized</td>
<td>4 systems</td>
<td>• Conduct field evaluation and identify implementation gap areas</td>
<td>2013-16</td>
<td>MoA, RBoAs</td>
<td>Coop, Unions</td>
</tr>
<tr>
<td></td>
<td>Enable flexibility in the fertilizer shipping, inland transport, and distribution process to lower costs</td>
<td>Reduced time and transportation costs in input delivery</td>
<td>• Conduct analysis of AISE fertilizer distribution system</td>
<td></td>
<td>2014-16</td>
<td>MoA</td>
<td>AISE</td>
</tr>
<tr>
<td></td>
<td>Provide policy, financial, and organizational support to promote use of inputs</td>
<td>Number of cooperatives strengthened through financial and management support</td>
<td>• Design an effective transportation system</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Garner policy support for new distribution modalities</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Strengthen financial and management capacity of cooperatives</td>
<td></td>
<td>2015-16</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Train on market assessments, marketing and branding, input storage, transportation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tef Value Chain Step</td>
<td>Intervention</td>
<td>Output</td>
<td>Indicator/Target</td>
<td>Activity</td>
<td>Milestone</td>
<td>Lead Institution</td>
<td>Collaborating Institutions</td>
</tr>
<tr>
<td>---------------------</td>
<td>------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
<td>----------------</td>
<td>------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>On-farm production</td>
<td>Support scale-up of yield-enhancing technologies</td>
<td>Level of yield enhanced technologies disseminated</td>
<td>X technologies</td>
<td>• Scale-up acceptable and proven technologies</td>
<td>2014-2017</td>
<td>MoA &amp; BoA</td>
<td>Private entrepreneurs</td>
</tr>
<tr>
<td></td>
<td>Trained development actors (progressing farmers, DAs, experts, tradesmen)</td>
<td>X actors trained</td>
<td>• Train development actors and technology users on use and operation of selected farm implements (MB plough, New version BBM, row planter)</td>
<td>2013-2017</td>
<td>MoA &amp; BoA</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of improved farm implement users</td>
<td>3,000 implement users</td>
<td>• Distribute selected farm implements</td>
<td>2013-2017</td>
<td>MoA &amp; BoA</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of awareness creation events and covered areas</td>
<td>200 events</td>
<td>• Organize field day and farm implement display events</td>
<td>2013-2017</td>
<td>MoA &amp; BoA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Create financial mechanisms to support farmers in purchasing inputs such as fertilizer</td>
<td>Amount of budget allocated for purchase of inputs</td>
<td>Increase budget</td>
<td>• Identify gaps</td>
<td>2013-2017</td>
<td>NGOs</td>
<td>Local Donors</td>
</tr>
<tr>
<td></td>
<td>Promote efficient cropping systems (crop rotations, double, relay, agroforestry)</td>
<td>Level and number of farmers implementing cropping systems</td>
<td>Increased number of smallholder farmers</td>
<td>• Identify type of cropping system to be implemented</td>
<td>2013</td>
<td>MoA, RBoA, EIAR</td>
<td>EIAR, RARIs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Provide training on cropping system</td>
<td></td>
<td>2013-2015</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tef Value Chain Step</td>
<td>Intervention</td>
<td>Output</td>
<td>Indicator/Target</td>
<td>Activity</td>
<td>Milestone</td>
<td>Lead Institution</td>
<td>Collaborating Institutions</td>
</tr>
<tr>
<td>--------------------------------------------------</td>
<td>------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
<td>-----------</td>
<td>---------------------------------------------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td>Post-harvest processing and utilization</td>
<td>Create awareness of and provide access to proven, efficient post-harvest</td>
<td>Trained development actors</td>
<td>• Strengthen or support existing service providers and form new farmer groups</td>
<td>2013-15</td>
<td>MoA &amp; BoA</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>technologies</td>
<td>Number of operative service providers and technologies in use</td>
<td>• Organize field day or equipment display events</td>
<td>2013-15</td>
<td>MoA &amp; BoA</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of awareness creation events and covered areas</td>
<td>• Train operators and local tradesmen on basic maintenance and equipment repair</td>
<td>2013-15</td>
<td>MoA &amp; BoA</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of PH equipment and facilities disseminated</td>
<td>• Scale-up acceptable and proven technologies</td>
<td>2013-2016</td>
<td>Mechanization MoA, RBoA</td>
<td>Private Entrepreneurs, unions, coops</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of services provided to smallholder farmers</td>
<td>• Organize and strengthen service providers</td>
<td>2013-15</td>
<td>Unions, Coop</td>
<td>Private Entrepreneurs, coops, unions</td>
<td></td>
</tr>
<tr>
<td>Develop, test, and introduce new post-harvest</td>
<td>Test reports and selected tef thresher/s fabrication manual</td>
<td>1 manual</td>
<td>• Conduct detailed evaluation of available tef threshers</td>
<td>2013-15</td>
<td>EIAR, RARIs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>technology prototypes</td>
<td>Modified tef thresher prototype (cleaning type)</td>
<td>1 prototype</td>
<td>• Improve and modify available tef threshers</td>
<td>2013-15</td>
<td>EIAR, RARIs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Support scale-up of proven straw handling</td>
<td>Amount of straw utilized by end users</td>
<td></td>
<td>• Assess available technologies</td>
<td>2013</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>methods</td>
<td></td>
<td></td>
<td>• Introduce and promote proven technologies</td>
<td>2014-16</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test and promote tef food products developed in</td>
<td>Number of tef food recipes developed</td>
<td></td>
<td>• Test and introduce new, diverse recipes</td>
<td>2013-16</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tef Value Chain Step</td>
<td>Intervention</td>
<td>Output</td>
<td>Indicator/Target</td>
<td>Activity</td>
<td>Milestone</td>
<td>Lead Institution</td>
<td>Collaborating Institutions</td>
</tr>
<tr>
<td>---------------------</td>
<td>--------------</td>
<td>--------</td>
<td>------------------</td>
<td>----------</td>
<td>-----------</td>
<td>-----------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>Market access</td>
<td>Link smallholder tef producers (through cooperatives) to direct market outlets</td>
<td>Reduced handover and tef transaction cost</td>
<td>X% decrease in farm-gate to end-buyer price hike</td>
<td>• Identify marketable surplus tef producer areas</td>
<td>2015-16</td>
<td>FCA, RCA</td>
<td>MoA, BoA, Unions/Federations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Increased tef market share of cooperatives</td>
<td></td>
<td>• Identify cooperatives</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Profit margin received by farmers</td>
<td>X% profit margin increase</td>
<td>• Enhance capacity of target cooperatives</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of cooperatives engaged in contract farming</td>
<td></td>
<td>• Link cooperatives to potential market destinations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of cooperatives engaged in value addition activities</td>
<td></td>
<td>• Identify potential primary cooperatives/unions</td>
<td>2013-14</td>
<td>FCA, RCA</td>
<td>MoA, BoA, Unions/Federations</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Enhance capacity of the cooperatives/private sector (training, etc)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Based on capacity, engage in assembling/aggregation, cleaning, grading, storing, packaging</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Create Community Warehouse Receipt Systems (CWRS) to increase potential earned income of farmers</td>
<td>Number of CWRS's created across the four priority regions</td>
<td>Count of farmers engaged</td>
<td>• Provide legal support CWRS</td>
<td>2014</td>
<td>MoT, Mol</td>
<td>ECX, private sector</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Additional income earned</td>
<td>Percentage increase in farmer income</td>
<td>• Promote and engage farmers in joining new CWRS's</td>
<td>2014-15</td>
<td>MoA &amp; BoA</td>
<td>ECX, private sector</td>
</tr>
<tr>
<td></td>
<td>Improve tef market transparency and enforce standardization by adding tef to ECX in the future</td>
<td>Number of real-time tef price information available daily/weekly</td>
<td>Regional market information more available in X areas</td>
<td>• Provide legal support for tef inclusion in the ECX</td>
<td>2015-16</td>
<td>ECX</td>
<td>MoT</td>
</tr>
<tr>
<td></td>
<td>Develop and strengthen systematic demand by investing in tef value-addition opportunities</td>
<td>Number of tef millers and processors engaged in value addition activities</td>
<td></td>
<td>• Promote and engage private sector in tef milling and processing</td>
<td>2015-16</td>
<td>MoT, Mol</td>
<td>MoA, ECX, Ethiopian Consumer Protection Agency</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of tef-based products developed</td>
<td></td>
<td>• In-country research on tef based products</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of tested and promoted tef-based products developed abroad</td>
<td></td>
<td>• Identify, import, test, and promote tef-based products from abroad</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
References


Heiniger, Ron. (undated). Thesis paper. NC State University and Molly Hamilton, NC State University


Quinones, Marco. 2012. Personal communications and interview. Addis Ababa, Ethiopia. ATA.


University of Nebraska-Lincoln. (undated). International Sorghum, Millet and other crops collaborative research project.


Appendix

The National Tef Strategy development time line and stakeholders engagement

- **Diagnostic Study**
  - November 2011
  - Panorama Hotel
  - Released Tef Value Chain Diagnostic Study prepared by Bekambil Fufa, Befekadu Behute, Rupert Simons & Tareke Berhe

- **Stakeholder Workshop**
  - January 2012
  - ATA
  - Obtained feedback from stakeholders on draft outline for National Tef Strategy
  - 15 participants represented ATA, Debre Zeit Research Centre, EIAR, IFPRI, Melkasa Research Centre, MoA & OBoA

- **Stakeholder Workshop**
  - September 2012
  - ATA
  - Obtained feedback from stakeholders on the National Tef Strategy draft
  - 35 attendees represented ATA, ARARI, ASE, Debre Zeit Research Centre, EIAR, ESE, Haremany University, Holela Research Centre, IFPRI, Mama Fresh Injera, MoA, OARI, SG2000, SNNP-BoA, SSE & World Bank

- **Stakeholder Workshop**
  - December 2012
  - EIAR
  - Sourced and incorporated feedback for National Tef Strategy revised draft
  - 10 participants represented ATA, Debre Zeit Research Centre, EIAR, Haremany University, Melkasa Research Centre & MoA

- **Stakeholder Workshop**
  - January 2013
  - Debre Zeit RC
  - Submitted stakeholder revised National Tef Strategy to Ethiopian Academy of Science and Synergos for final input

- **Review**
  - April 2013
  - Release finalized National Tef Strategy to stakeholders and media in order to guide the national transformation agenda

- **National Release**
  - June 2013
  - Launch 5 Year National Tef Strategy in alignment with the release of the next five year GTP

- **National Launch**
  - TBD - Late 2015
  - Continued iteration and refinement based on lessons learned through implementation of the national transformation agenda and design of the next five year national development plan
  - Refinements incorporated through updated releases at 12 month intervals