Ashenafi Gedamu - Gobena

# Triticale Production in Ethiopia – Its Impact on Food Security and Poverty Alleviation in the Amhara Region

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## Preface

Increasingly unfavourable natural conditions, like desertification and climate change on the one hand, and growing populations on the other hand make food security a burning issue on the global level. The fact that a large share of the world's population has neither the purchasing power for buying nor the productive resources for producing sufficient food for themselves and their dependents interferes with global ideals of human rights and causes social and political conflicts at local, national and international levels. Under the given circumstances, the search for solutions brings the urgently needed innovations for increasing the land productivity into the focus.

One of the most well-known countries suffering from these problems is Ethiopia which for some time has almost become a synonym for lack of food security, and a prominent case for food support by the international community. Most of its population of about 80 million people live in regions dominated by land degradation and droughts, and are increasingly dependent on food aid or other forms of external support. Millions are chronically food insecure which impairs their chances of a healthy and productive life.

The present volume written by Ashenafi Gedamu-Gobena on the basis of intensvive field work in the Amhara Region, one of the poorest regions in Ethiopia, characterized by undependable rainfall, and wide-spread land degradation, presents a valuable step forward on the long way to improved food security for the most vulnarable. It explains the results of extensive research activities which approached three decisive questions associated with efforts to introduce new varieties into an unfavourable environment: a) has the new variety the potential to bring a sustainable increase in land productivity for food supply? b) will it be adopted by a significant share of the farmers? and c) will be accepted by the consumers? For that purpose, the author has conducted intensive literature reviews, as well as producer and consumer surveys, covering both social and economic, as well as technical aspcets. By this, the author contributes to the improvement of Ethiopia's food situation. At the same time, his results provide insights which are important also for other regions trying to cope with similar conditions.

Beyond that, his innovative methodological approach offers inspirations for similar research projects in the area. The combination of well-based theoretical and methodological reflections with empirical work for research questions which are highly relevant for food policy and development policy is the major strength of this volume. It will surely find its way as an extensively used resource in the sceintific as well as the policy community.

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## Dedication

This work is dedicated to my father Gedamu-Gobena who passed away while I was abroad for my studies; thus I could not express my feelings of sorrow along with my mother and other family members affected by his loss.

## Acknowledgments

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I would like to express my deep appreciation to the Heinrich-Boell Foundation for awarding me a scholarship for this PhD study and to the Sustainable Utilization of Natural Resources (SUN)-Amhara Food Security Project of the German Agency for Technical Cooperation (GTZ) for its logistical and financial assistance during the field survey and the organisation of a workshop.

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My sincere gratitude goes to my wife Wesene Mulu for bearing the hardship of separation during my study abroad. I also owe deep gratitude to my sister Haimanot and my brother Bimir Gedamu who have been assisting me tirelessly in many ways.

*Ashenafi Gedamu*
*Witzenhausen, March 2008, Germany*

## Abbreviations and Symbols

| | |
|---|---|
| ADLI | Agricultural Development Led Industrialization |
| ANRS | Amhara National Regional State (syn. Amhara Region) |
| AIDS | Acquired Immune Deficiency Syndrome |
| Al | Aluminium |
| AU | African Union |
| BoA | Bureau of Agriculture |
| CfW | Cash for Work |
| CIMMYT | International Maize and Wheat Improvement Centre |
| CIA | Central Intelligence Agency |
| CSA | Central Statistical Agency |
| DAP | Diammonium Phosphate |
| DFID | Department for International Development |
| ECA | Economic Commission for Africa |
| FAO | Food and Agriculture Organization |
| FDRE | Federal Democratic Republic of Ethiopia |
| FSS | Food Security Strategy |
| FfW | Food for Work |
| GDP | Gross Domestic Product |
| GTZ | German Agency for Economic Cooperation |
| HA | Hectare |
| HH | Household |
| HIV | Human Immunodeficiency Virus |
| IFPRI | International Food Policy Research Institute |
| IFSP | Integrated Food Security Programme |
| ILCA | International Livestock Centre for Africa |
| IPM | Integrated Pest Management |
| K | Potassium |
| MT | Metric Tonnes |
| MDG | Millennium Development Goal |
| MoFA | Ministry of Foreign Affairs |
| NGO | Non-governmental Organization |
| N | Nitrogen |
| NEDECO | Netherlands Engineering Consultants |
| PADETS | Participatory Demonstration and Training Extension System |
| PA | Peasant Association |

| | |
|---|---|
| P | Phosphorus |
| PEDD | Planning and Economic Development Department |
| PSNP | Productive Safety Net Programme |
| Qt | Quintal |
| SUN | Sustainable Utilisation of Natural Resources for food security |
| T | tonnes (tone) |
| TLU | Tropical Livestock Unit |
| TVET | Technical Vocational Education Training |
| UNECA | United Nations Economic Commission for Africa |
| UNESCO | United Nations Education |
| UNICEF | United Nations Children's Fund |
| UN SCN | United Nations System Standing Committee on Nutrition |
| UNDP | United Nations Development Programme |
| USDA | United States Department of Agriculture |
| WFP | World Food Programme |
| WHO | World Health Organization |
| WFS | World Food Summit |
| WOARD | Wereda Office of Agriculture and Rural Development |
| ZOARD | Zone Office of Agriculture and Rural Development |

## Glossary of Local Terms

| | |
|---|---|
| *Absit* | Hot thick dough fluid which resulted from a mixture of small portion fermented dough while preparing *injera* |
| *Addisu sinde* | Literally means “the new wheat”, i.e. a name given to the triticale crop in some areas of South Gondar |
| *Akababi zer* | Amharic (Eth. language) expression for *local seeds* |
| *Akimbalo* | A parabola shaped cover made either from bamboo and smeared with cow dung or the mixture of cow dung and tef straw. It is used to cover the injera baking pan (*mitad*) |
| *Amedma/ nechate/ baha* | Whitish colour soils |
| *Areke /areqe* | Traditionally distilled strong dry liquors like wodka (schnapps) |
| *Atana* | A long piece of wood usually from eucalyptus plant and used for house construction |
| *Awdma* | Threshing yard where triticale and other crops are threshed |
| *Belg* | The *short cycle rainy season* which may extend from February to May |
| *Bereha* | (Hot and hyper-arid) - General term that refers to the extreme form of *kolla*, where annual rainfall is less than 200-mm. The *bereha* has desert type vegetation where pastoralism is the main economic activity (USDA 2003) |
| *Birr* | Ethiopian currency unit |
| *Bicha wag* | Amharic name for *Septoria leaf blotch,* a fungal disease due to *Septoria tritici* that affects wheat and occasionally other grasses including barley |
| *Chincha* | Non fertile, poorly cultivable rocky soils |
| *Debo /webera* | Work festive group formed by the farming community |
| *Dingayama meret* | Rocky or stony land |
| *Dega* | *Dega (Cool, humid, highlands)*: Areas from 2500-3000 meters where annual rainfall ranges from 1200 to 2200-mm. Barley and wheat are the dominate crops (USDA 2003) |
| *Gena* | Ethiopian Christmas |
| *Injera* | Ethiopian staple food usually prepared from sour dough |
| *Indir /kire (qire)* | Funeral associations, also functional during wedding ceremonies |
| *Kebele/* | The smallest political administrative unit (equivalent to communes) |
| *Keyate* | Reddish colour soils |
| *Kita* | Unleavened bread usually from cereals including triticale flour |

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|---|---|
| *Kilil* | Wereda are typically collected together into Zones and form *Kilil* or a National Regional State |
| *Kolla (qolla)* | *Kolla (Warm, semi-arid lowlands)* Areas below 1500 meters with annual rainfall ranges from 200-800 mm. Sorghum and corn are grown, with teff grown in the better areas. The *kolla* is warm year round and temperatures range from 27 to 50 degrees Celsius. |
| *Kollo (qollo)* | Roasted food from cereals or legume crops |
| *Komtata* | Sour usually used for injera, bread, milk |
| *Logaw shibo* | A name given to the triticale crop, meaning = tall and elegant |
| *Mahber* | A religious festive association formed in the name of a selected Saint and organised monthly in rotation usually among members of the Orthodox Christians |
| *Maresha* | Ethiopian traditional plough (the ard plough) |
| *Maynet* | A place called Maynet in South Gondar zone and given for a South African triticale variety called “Usgen 19” |
| *Meher* | The long cycle cropping season in Ethiopia which runs from June to September |
| *Mekakelegna meret* | Moderately fertile soil |
| *Meret* | Amharic name for earth or land |
| *Meskel* festival | Celebrated in September among Ethiopia's Coptic Christian traditions marking the finding of the true cross on which Jesus Christ was crucified |
| *Mitad* | A clay pan used to bake injera and bread |
| *Mogn aiybelash* | “Crop not for lazy farmers”, indicating triticale’s high effort requirement, particularly during threshing |
| *Muja* [*Snowdenia polystachya* (Fresen.) Pilg.] | Grass weeds affecting wheat and other crops |
| *Noug [Guizotia Abyssinica* (L.F.)] | Oil plants mainly cultivated in highland Ethiopia |
| *Nifro* | Boiled food from cereals or legume crops |
| *Quintal* | A unit of mass in the metric system equal to 100 kilograms |
| *Sinar* [*Avena fatua* (L.)] | Wild oats grown mainly on wheat, triticale and barley fields as weeds |
| *Sinan* | Amharic name for a short maturing triticale variety |
| *Shimbira* | Chickpea [*Cicer arietinum* (L.)] is an edible legume of the family Fabaceae |

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|---|---|
| *Sis meret* | Amharic expression used to describe less fertile soils (literally means “thin land” |
| *Timket* | (Epiphany) is one of the greatest festival of the Ethiopian year, falling 2 weeks after Ethiopian Christmas |
| *Timad /eqa* | A traditional land measurement unit in Ethiopia where four *timad* is. approximately one hectare |
| *Tef* (*teff*) | [*Ergrostis tef*] Most Ethiopian's traditional staple used for the preparation of *injera* (flat bread) |
| *Tella* | A traditional beer from Ethiopia. It is brewed from various grains (typically barley, maize, sorghum, millet and triticale (in some regions tef and other crops may be used) and *gesho (Rhamnus prinoides)*, a local plant used in a similar manner to hopes (*Humulus lupulus*) |
| *Walka* | Amharic name for “black cotton” soils or vertisols |
| *Wassie ena kibre* | “My insurance and my pride” Amharic names given to triticale crop in Gondar |
| *Weina dega* | *Weina Dega (Temperate, cool sub-humid, highlands)*: Areas between 1500 to 2500 meters, where annual rainfall ranges from 800-1200-mm. This is where most of the population lives and all regional types of crops are grown, especially tef (USDA 2003) |
| *Wereda (also spelled woreda)* | An administrative ward, or local government of Ethiopia (equivalent to a district). Woredas are composed of a number of *kebele* or neighbourhood associations, which are the smallest unit of local government |
| *Wofram meret* | Amharic expression used to describe fertile soils in the study areas |
| *Wurch (Cold highlands)* | Areas above 3000 meters and annual rainfall is above 2200-mm. Barley is the dominate crop and light frost often forms at night |
| *Yeshimbra meret* | Literally translated to “chickpea land” and means that these types of agricultural lands are usually sown with legumes, such as chickpea, field peas and beans since they are regarded as poor in soil nutrients and less suitable for other crops like cereals until land regeneration takes place |
| *Zone* | An administrative division above a *wereda* and below a Federal Regional State |

## Summary

Ethiopia is frequently affected by food shortages; on average 5 million people require food aid each year. Since the 1980s, the country could increase its grain production by 70%, but at the same time rose the total population from 40 to 77.1 million and will further increase by 31 million to 108.7 million people within the next 25 years (Haub 2007). This, coupled with low fertilizer use, susceptibility to pest and disease outbreaks and extensive highland soil erosion has meant high variability in year-to-year agricultural production, which is predominantly in the hands of smallholdings. Therefore without suitable grain production and economic development the majority of the population which belongs to the world's poorest, remains at risk of starvation.

With this background, the study was initiated with the question to which extent the growing of triticale crop (X *Triticosecale* Wittmack) improves food security, and which factors can play a major role for its successful adoption, particularly in major food insecure areas of Ethiopia. The study has three main objectives: (1) to investigate the adaptability of triticale to the Ethiopian agro-ecological conditions, particularly in areas with low soil fertility, hence this is a crop considered to provide considerably a higher harvest under low agricultural inputs, such as fertilizer, insects and pests sprays; (2) to identify the determining factors affecting the decision by farmers to grow the crop with the view of increasing the availability of and access to food to ensure food self-sufficiency and reduce poverty; (3) to analyse the *injera*- and bread-baking quality of the crop in comparison with tef (a staple cereal limited to Ethiopia) and wheat cereals, and examine the acceptance by consumers of these products made from this grain.

Triticale is a crop that resulted from the addition of chromosomes of wheat (*Triticum aestivum*) and rye cereals (*Secale cereale*). The plant came on the market as bread cereal in the 1980s in different varieties. It is a high yielding crop when compared with tef, wheat and barley, particularly on locations with soil nutrient deficiency.

The study was conducted in the two major triticale producing districts (*wereda*), Farta and Estie of the South Gondar Administrative Zone in the Amhara Region, Ethiopia.

The data was collected with the kind cooperation of the German Technical Cooperation Agency (GTZ)/SUN – "Sustainable Utilization of Natural Resources for Food Security" project in the Amhara Region. The project is engaged in various development projects, one of which is the commencement of triticale research and production programme

with the objective to improve food security for peasant farmers in the various districts of the South Gondar Administrative Zone.

The sample households were selected in a three stage sampling procedure. First, seven out of the nine districts of South Gondar were visited in order to have an insight into the food security projects under implementation by the SUN-Amhara project of the GTZ, and the demographic, social, and economical features of the selected rural *kebele* (peasant associations – PAs). Second, the sample rural *kebele* were chosen based on the number of triticale growing farmers and highest rate of expansion of the crop within the selected districts. In the last stage, a random sample of 204 triticale growing and another 204 non-triticale growing farmers was drawn from the selected PAs with the assistance of the community chairpersons, so-called team leaders and Extension Service Offices.

The data was collected from the respective Wereda Offices of Agriculture and Rural Development (WOARD), from the food security project office of the GTZ/SUN-Amhara, from published and unpublished documents, and knowledgeable individuals. Primary data was collected from the sample households using a structured questionnaire on demographic, socio-economic, institutional factors and farming practices that were hypothesized to affect the growing of triticale. The data collection took place during the 2005/ 06 main crop season from November 2005 to March 2006.

After the completion of the first phase of the field survey, a workshop was organised that brought the local agricultural authorities, the farming community and the SUN-Amhara project employees together in order to discuss the first results, particularly the acceptance of injera and bread prepared from triticale flour by the population. Because there is a strong traditional preference for the production and consumption of tef, a crop with significantly lower returns, but special properties of consumption which make it unique from other cereals.

For the data analysis quantitative and qualitative research methods were applied. The significance of the relationship between the dependent and the independent variables was examined using the comparative analysis. The t-test and chi-square test were applied to compare the mean values of two variables and to identify the significance level of the influencing factors on the dependent variables. The relationship between the dependent and independent variables was identified with the Probit adoption model which is similar to the Logit regression model. The statistical analysis software SPSS –

Statistical Programme for Social Sciences - and the software packet Microsoft Office were used.

Basic household food security indicators including availability of food, frequency of daily meal consumption during the “worst dry” and “normal seasons”, frequency of daily meal consumption before and after the growing of triticale, availability of and access to clean drinking water and availability and utilisation of alternative energy sources to firewood as household energy source, are used as proxies for household food security and level of poverty in the study areas.

The Probit adoption model reveals that nine out of the fifteen independent variables selected to have an impact on the frequency of daily meal intake, were identified. Larger family size is negatively correlated with daily meal intake frequency.

Animal and crop production are the major activities in the study areas, thus the major sources of food and income. Tef, wheat and barley are the most important cereals along with legume crops such as chickpea, field peas and horse beans. Triticale is also becoming an important cereal both in the study areas and the neighbouring districts constituting about 10% of the total source of income (from on farm produce) for the sample triticale-growing households. The production of crops and the adoption of triticale as a new technology by smallholder farmers is influenced by several factors such as family size, age, gender and education of the household head, availability of agricultural extension services and farm credits, and labour.

The study has also found a significant association between farm-size per household and frequency in daily meal intake. Even though larger farm size alone may not guarantee higher production and ensure food self-sufficiency, the study revealed that the ever decreasing farm-size and landholding insecurity to be two of the most crucial factors affecting food security negatively in the study areas. This is attributed to the fact that in addition to extremely small farm sizes, the areas are over-utilised and exposed to water erosion, which makes the perceived intensive agriculture quite difficult.

The Probit estimate showed no statistically significant association between the market distance and daily meal intake frequency, which was used as a proxy for food security, despite prior predictions that larger market distance would have a negative impact on food consumption and security.

The purchasing power of agricultural inputs, such as fertilizer, pesticides und insecticides, which have a direct linkage with markets along with the total monetary income, showed a positive impact on the frequency of daily food consumption and thus food security. This relationship is statistically high significant.

Income, other than rearing of animals and crop farming showed the highest level of significance in food consumption frequency in the Probit regression model. Off-farm activities, such as beekeeping, retailing of firewood, trading of eucalyptus wood (locally known as *atana*) for house construction, selling of locally brewed beer (*tella*) and participating in cash for work or food for work (CfW/FfW) operations (specifically, in GTZ-run projects) are the major sources of additional income other than farming for both, triticale- growing and non-growing sample households in the study areas.

Despite the high yield and widespread adoption of triticale crop in the study areas and the Amhara Region at large, it faced some amount of resistance from a few farmers and some agriculturalists. This is because of the possibility of soil nutrients exploitation by the triticale plant, with a consequent drop of nutrition for the succeeding crops. This is however, a hardly valid concern, since triticale takes up soil nutrients the same as other cereals do, there is the same need to replace the removed nutrients by compost and organic and/ or chemical fertilizers.

The suitability of triticale grain for the preparation of a variety of foods such as the main staple food *injera* and bread, and local beverages were tasted and acknowledged by the sample households, which was asserted by the researcher's own experiment during a workshop in Debretabor town in January 2006.

Taking into account the empirical results and own observations altogether, the following conclusive remarks can be made with regard to the baking quality of triticale and its acceptance by consumers:

1) Based on the investigation results concerning the quality of triticale grain for *injera* and bread baking, it shall be underscored that in spite of the fact that tef and wheat flours outperformed triticale flour in the 0:100 (triticale to tef, and triticale to wheat) mixture ratios in terms of flavour, appearance, texture and taste, triticale flour has met the expectations of the panellists on these four food quality features used for judging the suitability of the triticale grain for baking. In our experiment:

   a) triticale flour provided the best or “most preferred quality” of *injera* and bread in the 25:75 triticale to tef, and triticale to wheat) mixtures ratio respectively, followed by the 50:50 mix-ratios.
   b) triticale grain has also provided very good quality of *tella* and *areke*/*areqe* (locally distilled schnapps like vodka), which is comparable with that from finger millet (*Eleusine coracana*) and sorghum (*Sorghum bicolor*).

2) According to the empirical results, appearance, texture, flavour and taste are the major attributes affecting the food quality and suitability of the triticale grain for *injera* and bread making. Particularly appearance, which includes colour and freshness, can be significantly associated with food quality and thus the acceptability of the grain for production. The latter however, depends upon the interaction of a number of factors, such as drought, hail, diseases and pests tolerance or resistance, crop yield and quality, and value of residues (e.g. amount and quality of straw for animal feed and suitability for roof-thatching).
3) As the triticale grain meets the preceding criteria for bread and *injera*-baking thus consumer acceptability, the conclusion can be drawn that its adoption can lead to enhance household food availability, and contribute significantly to alleviate rural poverty.

## Zusammenfassung

Äthiopien ist permanent von Nahrungsmittelmangel betroffen, im Durchschnitt leiden jedes Jahr etwa 5 Millionen Menschen darunter. Die Mehrheit der Bevölkerung gehört zu den Ärmsten der Welt. Zwar hat das Land seit den 1980er Jahren seine Getreideproduktion um 70% steigern können, doch gleichzeitig stieg die Bevölkerungszahl von 40 auf 77.1 Millionen an und sie wird innerhalb der nächsten 25 Jahre um weitere 31 Millionen auf 108.7 Millionen Menschen anwachsen (Haub 2007). Diese und eine Reihe von Probleme, z.B. niedriger Düngemitteleinsatz, Pflanzenkrankheiten, hohe Bodenerosion und die Übermüdung des landwirtschaftlichen Bodens verursachen eine Verringerung der landwirtschaftlichen Produktion, die überwiegend in den Händen von Kleinbauern ist. Deshalb ist ohne geeignete Getreideproduktion keine Entwicklung und letztlich für einen Großteil der Bevölkerung kein Überleben möglich.

Vor diesem Hintergrund konzentrierte sich das Forschungsprojekt auf die Frage, wie weit der Nahrungsmittelmangel in den am stärksten von Hunger betroffenen Regionen Äthiopiens durch den Anbau von Triticale (X *Triticosecale* Wittmack) verbessert werden kann, und welche Faktoren zur Einführung dieser Kultur eine Rolle Spielen.
Zentral ist dabei (1) die Anpassungsfähigkeit von Triticale an unterschiedliche äthiopische Klimaverhältnisse, insbesondere für Trocken- und Tieflandgebiete zu untersuchen, um die Ernährungssituation sowohl in Äthiopien als auch darüber hinaus für Regionen mit ähnlichen Bedingungen zu verbessern, (2) die Haupteinflussfaktoren zu ermitteln, die die Entscheidung der Landwirte beeinflussen können, das Getreide anzubauen, (3) die Lebensmittelqualität des Triticalegetreides durch Bereitung von Brot, injera (ein weiches Fladenbrot u. a. aus der heimischen Getreideart Tef[1]-, Triticale-, Weizen- und Gerstemehl) und anderen ortsüblichen Speisen mit an Umfragen beteiligten Bauern zu verkosten und zu beurteilen.

Bei Triticale handelt es sich um eine Chromosomenaddition von Weizen (*Triticum aestivum*) und Roggen (*Secale cereale*) als Mutterpflanze. Diese Züchtung kam in den 1980er Jahren in verschiedenen Sorten auf den Markt und sollte z.B. als alleiniges Brotgetreide dienen. Sein Ertrag liegt vor allem auf Standorten mit niedriger Bodenqualität weit über dem anderer Getreidekulturen.

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[1] Tef (*Eragrostis tef*) ist ein Getreide aus der Familie der Süßgräser; das Hauptanbaugebiet ist Äthiopien.

Die Feldstudie fand in den Distrikten Farta und Estie des Südgondar-Bezirks in der Amhara Region statt.

Die Datenerhebung wurde in Zusammenarbeit mit einem Projekt der Deutschen Gesellschaft für Technische Zusammenarbeit (GTZ), welche die „Nachhaltige Nutzung natürlicher Ressourcen zur Ernährungssicherung“ zum Ziel hat, durchgeführt. Es beschäftigt sich u. a. mit der Entwicklung und Verbreitung von Triticale, für den Landwirten eine Chance zu bieten, ihre Ernährungssituation zu verbessern, und durch Überschüsse und Weiterverarbeitung zusätzliches Einkommen zu erwirtschaften eventuell, und damit dem Land zu helfen, die beständigen Nahrungsmitteldefizite zu überwinden.

Für die Datenerhebung wurden zuerst die sieben vom GTZ-Projekt unterstützten Distrikte in der Region besichtigt, um einen gesamten Einblick über die Ernährungssicherungsprojekte, die demographische und sozioökonomische Situationen der Menschen und der Distrikten zu verschaffen. Zweitens wurden die zwei Distrikte, in denen Triticale am häufigsten angebaut wird, ausgewählt. Drittens wurden nach der Zufallsauswahl die bäuerlichen Dörfer und die Stichproben, die 408 Haushalte umfassen, mit der Unterstützung von Vertrettern der Bauern und Gemeinden, und landwirtschaftsexperten zufällig ausgewählt. Während die Hälfte der Hausehalte Triticale anbauende Bauern waren, hat die andere Hälfte noch nie Triticale angebaut. Für die Auswahlentscheidung wurde eine stratifizierte Zufallsauswahl vorgenommen.

Die Daten wurden von den jeweiligen Distrikten, vom GTZ/SUN-Amhara Ernährungssicherungsprojekt-Büro, von publizierten und unpublizierten Quellen und von einzelnen Informanten erhoben. Die Primärdaten, die den Anbau von Triticale beeinflussen können, wurden von der Befragung über die demographische, sozioökonomische und institutionelle Situationen der Stichproben, bzw. deren Anbaumethoden gewonnen. Die Feldforschung erstreckte sich während der Hauptanbaujahreszeit der Region über einen Zeitraum von vier Monaten (zwischen November 2005 und März 2006).

Nach der Beendigung dieser Phase wurde ein Workshop vor Ort organisiert, um die ersten Ergebnisse zu diskutieren. Dabei handelte es sich um die Frage, ob Triticale auch im Konsum eine ausreichende Akzeptanz erreicht, da die Bevölkerung traditionell stark auf das geschmacklich deutlich unterschiedliche Tef als Hauptnahrungsmittel fixiert ist.

Für die Datenanalyse wurden quantitative und qualitative Forschungsmethoden verwendet. Signifikante Beziehungen zwischen den abhängigen und unabhängigen Variablen wurden mit einer komparativen Analyse erfasst. Um einen Vergleich zwischen zwei Mittelwerten zu ermitteln und die Signifikanzniveau der Einflussfaktoren zu finden, wurden der t-Test und der Chi-Quadrat Test angewandt. Mit dem Probit Modell, das auch ähnlich dem Logit Modell ist, wurden die Beziehungen der abhängigen und unabhängigen Variablen identifiziert. Für die Datenanalyse wurden die *Statistical Analysis* Software SPSS und das Softwarepaket MS-Office verwendet.

Um die grundlegende Ernährungssicherungssituation der Haushalte zu identifizieren, wurden die Variablen, wie der Zugang zu Nahrungsmitteln und die Versorgungslage während der Dürre- und normalen Jahreszeiten, die Versorgungslage vor dem Anbau von Triticale und danach, der Zugang zu sauberem Trinkwasser und zu alternativen Möglichkeiten zu Feuerholz als Energiequelle, angewandt.

Die Ergebnisse deuten daraufhin, dass neun von fünfzehn Variablen die Konsumfrequenz und demzufolge die Nahrungsmittelsicherung positiv beeinflussen können. Eine größere Familie ist mit dem täglichen Lebensmittelverbrauch negativ korreliert.

Tier- und Getreideproduktion sind die Haupttätigkeiten der Haushalte im Untersuchungsgebieten und daher die Hauptnahrungs- und die Haupteinnahmequellen. Tef, Weizen und Gerste sind die wichtigsten Getreidearten. Hülsenfrüchte, wie Kircherbse, Felderbse und Ackerbohnen, werden auch in weiten Teilen der Distrikte angebaut. Aber Triticale wird auch als wichtiges Getreide in den Untersuchungs- und benachbarten Gebieten mit großem Nutzen angebaut. So haben zum Beispiel die Triticale anbauenden Bauern ihr Gesamteinkommen von der Triticalevermarktung im Forschungsjahr um 10% steigern oder verbessern können. Dieses positive Fallbeispiel zeigt, dass die Ernährungssicherheit in Äthiopien durch den Anbau von Triticale in kurzer Zeit verbessert werden kann. Die Getreideproduktion, Anbauintensität und die Entscheidung der Bauern, Triticale als ein neues Getreide anzunehmen, hängt von mehreren Einflussfaktoren ab; z. B. von Familiengröße, vom Alter, Geschlecht, und Bildung des Familienvorstandes, von der technischer Unterstützung der Landwirtschaftsexperten (Extension Service), vom Vorhandensein von Farmkrediten und der Arbeitskraft.

Die Studie zeigte, dass eine signifikante Beziehung zwischen der Größe der landwirtschaftlichen Anbaufläche und der Konsumfrequenz besteht. Obwohl eine größere Anbaufläche allein eine höhere Produktion und Ernährungssicherung nicht garantieren kann, wurde herausgestellt, dass die Verunsicherung des Landbesitzrechtes und die immer kleiner werdende Anbaufläche einige der wichtigsten Einflussfaktoren der Lebensmittelunsicherheit in den Untersuchungsgebieten sind. Die Anbauflächen sind nicht nur klein, sondern auch abgenutzt und die fruchtbaren Böden sind durch Wassererosion abgetragen.

Es wurde keine signifikante Beziehung zwischen der Marktdistanz und der Konsumfrequenz festgestellt. Dies widerspricht der vorherigen Hypothese, dass eine größere Marktdistanz einen Anstieg von Transaktionskosten und einen verlängerten Fahrzeit verursachen könnte.

Der Einsatz von Düngemitteln, Pestiziden und Insektiziden, der eine direkte Beziehung zu dem Marktzugang und Monetäreinkommen des Haushaltes hat, zeigt, dass der Zugang zu Düngemitteln eine positive und signifikante Wirkung auf die Konsumfrequenz bzw. die Ernährungssicherung hat. Diese Beziehung ist statistisch hochsignifikant.

Das Probit Modell bezüglich der Haushaltseinkommen hat gezeigt, dass Einkommensquellen außerhalb der Landwirtschaft eine hochsignifikante Wirkung auf die Konsumfrequenz der Haushalt haben. Außerlandwirtschaftliche Aktivitäten, die zur Verbesserung des Gesamteinkommens betrieben werden, sind traditionell Imkerei, Holzhandel, Herstellung von hausgemachten Bier (*tella*), sowie Beschäftigung in *Food* oder *Cash for Work* (FfW/ CfW) Projekten der GTZ.

Die Akzeptanz von Triticale bei den Landwirten in der Region Süd- bzw. Nordgondar ist hoch. Aber einige Landwirte und Landwirtschaftsexperten haben die Frage gestellt, ob die Bodennährstoffe durch den Anbau von Triticale eher ausgeschöpft sein würden, was ein großer Verlust für die nachkommende Kultur bedeuten könnte. Dies ist jedoch unbegründet, da Triticale genauso wie die anderen Getreidekulturen seine Ansprüche auf Bodennährstoffe hat und daher die aufgebrauchten Nährstoffe wieder mit Handelsdünger oder organischem Material, wie Kompost und Gründünger, ausgeglichen werden müssen.

Im Hinblick auf die Eignung von Triticale zur Bereitung von lokalen Getränken, Brot und injera, wurde mit an Umfragen beteiligten Bauern eine Verkostungsprobe durchgeführt. Das Ergebnis deutet daraufhin, dass das neue Getreide sowohl für injera und Brot als auch für Getränke gut geeignet ist und bei den Haushalten gut ankam.

Zusammenfassend soll noch einmal insbesondere die Backqualität des Triticalemehls und die Akzeptanz des Getreides bei den an der Feldforschung beteiligten Haushalten verdeutlicht werden:

1) Das empirische Untersuchungsergebnis hinsichtlich der Backqualität von Triticale für injera und Brot zeigt, dass Tef- und Weizenmehl bezüglich äußere Erscheinung, Oberflächenstruktur, Aroma und Geschmack, welche für die Beurteilung der Lebensmittelqualität von größer Bedeutung sind, das Triticalemehl übertroffen haben. In unserem Experiment:
   a) erzielte das Triticalemehl eine beste Note in der 25:75 Backmischung (d. h. Triticale vs. Tef für *injera*, und Triticale und Weizen für Brot)
   b) zeigte, dass das Triticale sich für die Herstellung des lokalen Biers und Schnaps (*areke/areqe*) bestens eignet und dabei vergleichbar mit der Fingerhirse (*Eleusine coracana*) und Sorghum (*Sorghum bicolor*) ist.

2) Der Verkostungsprobe zufolge sind äußere Erscheinung, Oberflächenstruktur, Aroma und Geschmack die Hauptcharakterzüge, die die Akzeptanz und den Anbau des Triticalegetreides für *injera* und Brot ausmachen. Insbesondere die äußere Erscheinung des Backproduktes, welche für erweiterte Produktion eine signifikante Rolle. Aber das letztere hängt z.B. Farbe und Frische beinhaltet, spielt für die Backqualität und Akzeptanz des Getreides von der Widerstandsfähigkeit des Getreides gegenüber Trockenheit, Pflanzenkrankheit, Kornertrag und Qualität, sowie, Strohmenge und Qualität als Viehfutter und/oder als Dachstroh ab.

3) Wie das Experiment der Geschmacksprobe bestätigte, ist die Qualität des Triticalegetreides für *injera*, Brot und andere ortsübliche Speisen gut geeignet und wurde bei der Mehrheit der an der Feldforschung beteiligten Haushalte gut akzeptiert. Daher könnte man abschließend sagen, dass die Weiterverbreitung des Getreides über die Untersuchungsgebieten hinaus für die Verbesserung der Ernährungssituation bzw. Armutsbekämpfung eine große Rolle spielen kann.

# 1 INTRODUCTION

## 1.1 Statement of the problem

According to the World Bank (2007 est.), most of Ethiopia's population lives in the highlands, where land degradation and droughts threaten their food security. Highland households in less-favoured areas are increasingly dependent on food aid or external assistance during drought seasons, apart from the millions chronically food insecure people living from food or cash handouts.

Ethiopia is frequently affected by food shortages; on average 5 million people require food aid each year. Since the 1980s, the country could increase its grain production by 70% but at the same time rose the total population from 40 to 77.1 million and will further increase by 31 million to 108.7 million people within the next 25 years (Haub 2007). Therefore without suitable grain production and economic development the majority of the population, which belongs to the world's poorest, remains at risk of starvation.

The Amhara National Regional State - ANRS (syn. Amhara Region) is one of the poorest regions in Ethiopia, and is characterized by undependable rainfall, enormous land degradation, rapid population growth, high rate of poverty and malnutrition. Food security is also threatened by frequent droughts which, as a result, make the majority of the population food aid recipient. These and other problems force Ethiopian farmers to look for alternatives to the present production pattern in order to be food self-sufficient. In that context, since the late 1990's, triticale has come into the focus in the Amhara Region.

However, there is a strong traditional preference for the production and consumption of tef, a crop with significantly lower returns but special properties of consumption which make it unique. The present project addresses the questions which factors at household and district level determine the growing of triticale in the Amhara Region and how far the growing of this crop contributes to household food security.

Indicators, such as daily meal intake frequency, daily meal consumption frequency during the "worst dry" and "normal season", availability of clean drinking water, utilisation of alternative energy sources to firewood such as kerosene and income were used as proxies for household food security.

Food security at national and international level is measured using per capita food intake per day in kilocalories. According to FAO for example, 2200 kcal/day is taken as an indication of very low level of food security. Daily meal intake per day in kilocalories as an indicator of food security was difficult to apply in this study as the energy values of the types of food (for example, *injera*, bread, boiled and/or roasted grain) with the accompanied sauces from various types of legume crops and meat, the amount of food consumed by each person per day calculated for over 400 households, would produce an enormous amount of work and might consume quite a lot of time and resources. Therefore, this indicator was avoided as a proxy for food security in our study.

Determinants, for example, demographic profile of the sample households, size of crop land, availability of and access to extension service, farm credits and fertilizer were hypothesized to determine the adoption of the new crop by farmers in the region.

The Ethiopian agricultural system is divided into smallholder mixed farming in the highlands and pastoralism in the lowlands. The highlands cover only 40% of the total land area but contain 88% of the human population and account for 94% of the regularly cultivated cropland, 70% of the livestock and 90% of the country's economic activities (Gryseels M., 1988). The highlands are favoured by good soil and suitable climatic conditions for farming. The climate is temperate, rainfall well distributed and disease incidence low, thus supporting higher productivity and population densities than the lowland areas. The highlands thus provide suitable conditions for the introduction of high yielding plant varieties and exotic animal breeds, allowing for intensification of agricultural production. Despite this potential, the performance of the agricultural sector has been disappointing until the change of government in 1991, since which a steady growth in real Gross Domestic Product (GDP) has been observed. The average growth rate in agriculture between 1980 and 1991 was, according to Berhanu and Berhanu (1999/2000), 2% which is significantly lower than the rate of population growth. According to the UNICEF (2005) report the population growth rate in the year 2002 stood at 2.7% per annum.

Among the major problems Ethiopia has been facing, are directly or indirectly linked with agriculture, include the challenge to meet the intensifying demand for food by the ever growing population, reducing the widespread poverty and malnutrition in rural areas and the spread of HIV/AIDS that is eroding the working manpower. Above all, food and nutrition security remain the country's fundamental challenges for human welfare and for economic growth. Far too many people in the country are unable to acquire at all times the food they need for a healthy life. Food security is on the one hand, an income issue and is acquired in the form of one's own food production or from non-agricultural activities and employment through the market. Nutrition security, on the other hand, depends primarily on education, hygiene and sanitation. The food insecure households are the poor, who do not have sufficient resources to produce the income to permanently acquire quantities and qualities of food, in order to ensure active and healthy life.

With a total population of about 19 million (CSA 2006), the Amhara Region is the second largest region in terms of the number of inhabitants after the Oromia Region. Farmers are subsistence, owning 0.8 to 1.5 ha of land. As a result, since the last two decades, the region has been prominently food insecure and food aid dependency is on the rise. Taking this into account, the German Agency for Technical Cooperation (GTZ) with the collaboration of the Ethiopian Government launched a project in 1996 with the view to improve food security in the South Gondar Administrative Zone of the ANRS.

Commercialization of cereal production by smallholder farmers has been identified as a potential means of improving the food security and well being of the households in low income countries (von Braun and E. Kennedy (1994). Ethiopia has experienced the compounding effects of civil strife, drought and famine during the past thirty years, and poverty and malnutrition are obvious in the rural areas of the country where most of the population is engaged in small-scale subsistence-oriented farming. This is also the case for the Ethiopian highlands, including the Amhara Region, well known for its outstanding biophysical farming potential. It has been suggested that Ethiopia could theoretically support two to four harvests a year, which would turn it into the granary of East Africa and the Near East (Steglich M., 1998). Yet, agricultural productivity remains low. In addition, population growth and soil degradation have increased pressure on the scarce land resources. According to the United Nations Children's Fund (UNICEF 1993), the number of malnourished people in Ethiopia is among the highest in the world. They often lack sufficient amounts of protein and energy in their diets, as well as micro-nutrients, such as iodine and vitamins.

## 1.2 Research questions and specific objectives of the study

The triticale crop is a result of addition of chromosomes of wheat and rye crops, and is widely cultivated in central and eastern Europe, Canada, the United States and Australia. Like the common cereals, there are spring and winter varieties. It inherits the vitality of rye in terms of disease and drought tolerance, adaptation to poor soil conditions, with the highest yield and grain quality characteristics of wheat. However, there still exists the need for exploring the factors in detail which influence the adoption of the crop in the Amhara Region. It is also important to investigate the impact of this implementation to poverty reduction and the increase of calorie intake, thereby reducing malnutrition.

The study was carried out in order to investigate the determinants which influence the adoption of triticale crop; the particular importance of adopting the new technology in the Amhara Region, and its impacts on household food security and poverty reduction. The principal objectives of the dissertation can be summarized in the following research questions:

- What makes the farming community to apply triticale rather than cultivating the common staple crops like tef, wheat and barley?
- Do the characteristics of triticale crop comply with the demands of households in terms of the preparation of food (e.g. *injera* and bread making quality)?
- What are the outcomes of triticale production with respect to poverty reduction in terms of household food security, calorie intake and household income?
- What is the role can agricultural extensionists play in increasing the farmers' awareness of agricultural productivity, thereby improving food security?

The specific objectives of the study were:

1 to investigate the adaptability of triticale crop to Ethiopian agro-ecological conditions, specially in communities of low input capabilities. Hence, this is a crop which is hypothesized to provide a considerably higher harvest under low input circumstances in comparison with other cereals (tef, wheat and barley),

2 to investigate the determining factors which influence the farmer's decision to grow triticale, a crop that we hypothesize will increase food availability, thus improves household food security and income,

3 to analyze the injera and bread-backing quality of the crop, as compared to tef and wheat, and examine the acceptance by consumers of these products prepared from triticale grain.

## 1.3 Research hypotheses

Based on the conceptual framework (Figure 2.1), the study attempts to test the following hypotheses:

- If it is proved that the crop yield of the triticale plant is significantly higher than other staple crops cultivated in the Amhara Region, the adoption of the crop will improve food security by increasing the supply of staple food significantly.
- It is hypothesized that the demographic and socio-economic characteristics, physical capital (e.g. livestock ownership, availability of draught animals), social capital, farm characteristics (e.g. farm size), access to agricultural extension services and availability of household labour, and institutional characteristics (e.g. access to market and availability of agricultural external inputs at *wereda* level) will influence the decision on triticale adoption, and thereby increase food availability.
- It is hypothesized that triticale grain is suitable for injera and bread baking and will have a positive impact on the adoption of triticale, thus contribute to achieve food and nutrition security at household level.

## 1.4 Significance of the study

This study was expected to be a significant contribution in increasing triticale adoption and thereby increasing total crop production, which, in turn, will increase food self-sufficiency at household level. As the Amhara Region is one of the major food insecure regions of Ethiopia, agricultural productivity ought to be increased considerably to feed the ever growing population. Because triticale is a new crop for the country, the study can be an additional source of reference to both, agriculturalists and extensionists who are involved in the adoption process of this new crop. As the preliminary findings of the study confirm the relative advantage of the crop in comparison with the major crops grown in the Amhara Region, it could be an alternative crop to be grown in areas of low input capabilities and with similar agro-climatic conditions of the study districts. Hence, this is a crop which performs relatively better than the common cereals under poor agro-climatic conditions which prevail largely in the region of this study.

## 1.5 Limitation of the study

This study has three major limitations.

1) In order to assess the impacts of triticale on food security accurately, the number of farmers growing triticale, and the size of triticale areas and yield obtained per hectare need to be monitored regularly. This may also restrict the generalisability of the findings.
2) The total number of triticale growers (since its introduction) both, at district and regional level, was not exactly known as the study had limitations of financial resources and time for research; as a result, we were not able to figure out the exact number of households growing the crop and at which rate it is expanding both, at district and regional level since its first introduction in 2002. Ideally, all adopters throughout the districts should have been surveyed and results measured. However, this requires a much more detailed and task force-based study which could only be done with the direct coordination of local and regional administrators. These were some of the limitations with respect to the analysis and data that may affect the accuracy of the results. In addition, since the crop is new for the country, the pool of adopters in 2007 may be quite higher than the figures indicated in the study.
3) The study was limited to two districts and the representativeness of these districts to the agro-climatic conditions of the whole Amhara Region is questionable. Hence, the results may only to a limited extent be generalisable to areas with different geographical features.

With respect to triticale seed availability, many respondents had problems in accessing triticale seed and chemical fertilizers during the sowing seasons of 2005/06. Very early in the data collection phase, it was noted that many non-grower households were unable to sow triticale due to the high price and scarcely availability of triticale seed during sowing times. Many others were complaining to us during the survey that they were excluded from the list of households who were supposed to receive seed in 2005/06 main (or *meher* 1997/98 - Ethiopian calendar) season. However, during the interviews, non-grower respondents were encouraged for being interviewed and fully cooperative with the expectation that we would address their complaints to the respective district agricultural offices and the GTZ/ SUN - Amhara project office for the provision of seed during the forthcoming growing season (2006/07).

## 1.6 Organisation of the thesis

The study is organized into nine chapters. The first chapter highlights the rationale of the study, the research questions and the hypotheses. It also provides a brief introduction of food security and the purposes of this research. Following this introduction, Chapter 2 discusses the theoretical and literature review on the Ethiopian agriculture and food insecurity situation. The chapter first provides an operational definition of food security which considers how well this definition fits with local people's understanding and experience of food insecurity and extreme poverty. The chapter also discusses the food security and agricultural development policy of the Ethiopian Government including the resettlement programme underway at the national level.

Chapter 3 sets out the methodology of the study, first outlining the general rationale and strategies for combining qualitative and quantitative approaches. The sample structure and size for the household questionnaire survey and the qualitative community research are explained, together with the field procedures adopted to ensure an unbiased random sampling. The chapter goes on to document the implementation of the fieldwork, and to describe the main data collection instruments that include a household questionnaire and structured key informant interviews.

Chapter 4 focuses on the analysis of determinants of poverty in Ethiopia and the effects of poverty indicators on food security. It examines the dimensions of poverty, particularly in the Amhara Region and the importance of cultivating triticale crop to reduce poverty and food insecurity. This section also discusses the characteristics of households identified as absolutely poor or destitute by the household questionnaire, considering factors, such as household energy, livestock, farm size, availability of draught animals, gender and education. The situation of destitute households is further investigated in terms of their ability to meet basic food and non-food needs; their access to regional markets and access to food aid and other monetary income sources; and their dependence on transfers. It addresses the socio-economic profiles of the households in the study areas. Descriptive statistics are used to present the demographic and socio-economic characteristics of triticale adopting-households and non-adopters.

Following the introduction of triticale crop, chapter 5 focuses on the determinants influencing the importance of triticale to be adopted and implemented in the Amhara Region. The agronomy, yield and production, fertilizer application, post-harvest technology and quality characteristics, such as bread baking quality and food taste based on the farmers' response, are also analysed in this chapter.

Chapter 6 shows the baking quality of triticale crop in comparison with tef and wheat cereals. The data source used for this section is resulted from a workshop which was organised by the researcher in cooperation with the SUN-Amhara project office in order to discuss the prelimenary results of the field survey, own observations and the suitability of the triticale grain for local foods and drinks on the basis of sensory evaluation experiments. The experiment was conducted to assess the baking quality and applicability of triticale flour for *injera* and bread, and local drinks called *tella* and *areke*. The sensory evaluation test was carried out in Debretabor town, Amhara Region in January 2006, to which 52 panellists including, a home economist from the Farta Wereda Office of Agriculture and Rural Development (WOARD), farming households and emploees of the SUN-Amhara project were invited to test the quality of injera, bread and the two local drinks mentioned above.

Chapter 7 presents a comprehensive discussion of the overall findings of the study. The conclusions addressing the hypotheses of the study, followed by comments on the perspectives and the need for further research are presented in this section. Based on the findings of the research, recommendations complemented with a summary of the entire work are also stated in this chapter.

Chapter 8 presents a brief appraisal in respect to the future perspectives for the production and consumption of triticale in Ethiopia and beyond, and its impact on food security on the basis of the research findings. It also presents the thoughts of the interviewed agricultural researchers and workers on triticale and its impact on food security.

Chapter 9 provides recommendations for policy options with regard to the successful adoption and wider implementation of the triticale crop in the view to increase production and ensure food security, particularly in the study areas and Ethiopia as a whole.

# 2 FOOD SECURITY AND UNDERNOURSIHMENT

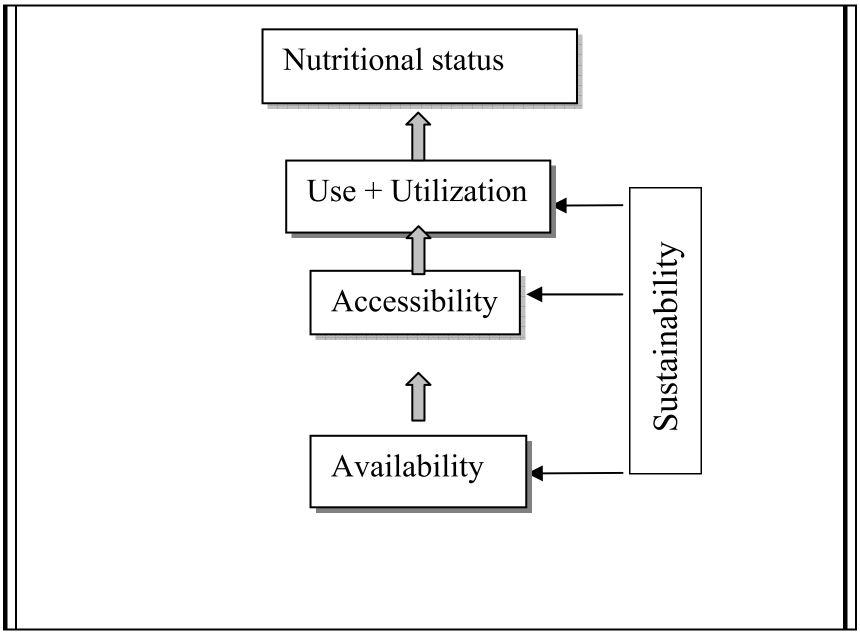
## 2.1 Definitions and causes of food insecurity

Early definitions of food security focused on aggregate food supplies at national and global levels, and analysts advocated production self-sufficiency as a strategy for nations to achieve food security. Food security is a concept that has evolved over time. The International Food Policy Research Institute (IFPRI 1999) listed about 200 definitions and 450 indicators of food security. According to the refined definition of the FAO (2002), food security is defined as a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets dietary needs and food preferences for an active and healthy life. Food security addresses people's risks of not having access to needed food. These risks can be, for example, with respect to employment, prices and food production (von Braun et al., 1992). Food in this study is defined as any substance that people eat and drink to maintain life and growth. This implies that safe and clean water is an essential part of basic nutrition and food commodities. This definition is larger than the previous definitions e.g. that of the World Bank (1986), which was summed up by Maxwell and Frankenberg as "secure access at all times to sufficient food for a healthy life (Maxwell, S. and Frankenberger T. (1992). Food insecurity on the other side means that it can be either temporary or chronic.

Nutritional status is a measure of the health condition of an individual as affected primarily by the intake of food and utilization of nutrients. The nutritional status of each member of the household depends on several conditions that should be met, for example: the food available to the household must be shared according to individual needs, the food must be of sufficient variety, quality and safety, and each family member must have good health status in order to benefit from the food consumed (FAO 2004). The nutritional status of households could be influenced not only by availability of and access to food but also by non food factors, such as safe drinking water, health care and sanitary infrastructure.

Nutrition security can be defined as adequate nutritional status in terms of protein, energy, vitamins and minerals for all household members at all times, and thus means in principle more than food security. Food and nutrition security is achieved if adequate food (quantity, quality, safety, socio-cultural acceptability) including water is available and satisfactorily utilized by all individuals at all times to live a healthy life (Quisumbing 1995:12). As illustrated in Figure 2.1, there are two major factors affecting the framework of food security. (1) The physical determinant is the food flow consisting of the availability, accessibility, use and utilization, and (2) temporal determinant of food and nutrition security refers to stability, which affects all three physical elements.

Figure 2.1. Conceptual framework of food security



Source: Quisumbing et al. (1995)

The broader reasons for food insecurity may include civil strife, poverty, population growth, environmental degradation, limited agricultural technology, ineffective economic policies and diseases which lead to trans-national refugees and internally displaced people, as well as to economic disruptions. According to Machel (2004), social and political conflict, refugee status and internal displacement, and food security are closely interlinked. Machel states that climate change, which provokes droughts or floods, deforestation, and more recently, the impact of HIV/AIDS on households and communities, particularly its impact on young men and women who are producers of food are other problems that can contribute to the increment of food insecurity. The risk of inadequate rainfall appears to have increased in recent years in different parts of the world. This global climate change may be responsible for the increased incidence of drought in areas not affected by earlier droughts. Wars and misdirected agricultural policies have also contributed to a vicious spiral of poverty, land degradation and food insecurity. Specially urgent is the need for alternative development strategies that address land degradation and food insecurity in less-favoured areas where drought risk is high or market access is poor (IFPRI 2005).

**Gender:** equality and the empowerment of women are also keys to progress and alleviation of food insecurity. Without secure land tenure, women often cannot obtain the credit they would need to make improvements – such as irrigation and drainage systems - in order to increase production and maintain the fertility of the soil. As the FAO report reveals, in sub-Saharan Africa, where the numbers of women and men farmers are roughly equal, women farmers receive only 10% of loans granted to male smallholders and less than 1% of the total credit advanced to the agriculture sector (FAO 2005).

The Millennium Development Goals (MDGs) of the United Nations had set the target of eliminating the "gender gap" in primary and secondary education by 2005 and at all levels by 2015. Nevertheless, although significant progress has been made worldwide, it has not been sufficient to reach the 2005 target and has lagged most notably in countries and regions plagued by widespread and persistent hunger.

Hence gender is an important issue to be stressed in the context of food security policies, it is necessary to take into account the involvement of both, men and women. Universally, women are the people who prepare food for their families and are responsible for the distribution of food at the household level. Yet, women (e.g. in many African countries) do not have control over land, and they can not easily diversify their food crops in order to meet the nutritional requirements of their families. Also, they lack the nutritional knowledge required to enable them to balance the quality of the food that they serve for their families (Kurwijila 2004). Generally, according to Kurwijila, access to technologies that enable both men and women to process and preserve food to be eaten during times of food shortage is essential in order to insure household food security in a sustainable manner.

At the Third Ordinary Session of the African Union (2004) Assembly of Heads of State and Government in Addis Ababa, Ethiopia in July 2004, the Heads of State and Government adopted what is called the Solemn Declaration on Gender Equality in Africa *(*SDGEA*)*, which is said to be an important African instrument for promoting gender equality and women's empowerment as it keeps the issues alive at the highest political level in Africa.

In the case of Ethiopia, although women in the country constitute 49.8% of the population and contribute their share in agricultural production and other household activities, their participation in qualified jobs and related fields is at its lowest level. For instance, the National Labour Force Survey (CSA 1999) indicates that women account for only 23.9% in technical and professional fields. The 1994 census on employment also shows that women represent only 27.3% of the total government employees and 93.2% of them are engaged in low-grade jobs. However, since recent years, the number of women's representation in the Federal Parliament has increased from 42 in 2000 to 117 in 2005 out of 502 total parliament seats (FDRE 2006). Therefore, the empowerment of women through protected rights, for example, to ownership of land which is an integral part of sustainable food production and the first pillar of food security is essential. Providing women with basic health and education would help to raise agricultural productivity and incomes, which would not only improve the quantity and quality of food produced but also the health of the families themselves and consumers at large.

## 2.2 Relation between poverty and food security

### 2.2.1 Poverty and food security

Food and nutrition insecurity and poverty are closely interlinked in a vicious cycle. Hunger perpetuates poverty, since it prevents people from realising their potential of making contributions to the progress of their societies.

Food security is an issue of income: either income in the form of one's own production of food, or income earned from activities that might be related to agriculture or not and allow access to food through the market. Nutrition security on the other hand, is very much dependent on education, health, hygiene, and on sanitation conditions (Dioné 2004). When these put together, according to Dione, food and nutrition insecurity remains a fundamentally poverty problem.

It is increasingly being recognised that food security and nutrition are foundations for development. The nutritional status of children is used as one of the key indicators for poverty reduction in the framework of the MDGs. This reflects the insight that policies, programmes, and processes to improve nutrition outcomes have a role to play in poverty reduction and global development (UN/SCN 2004). The United Nations and its Millennium Project issued several reports and guidelines related to the MDGs in 2005. Among them is a report by the "Task Force on Hunger", which presented an agenda of the highest priorities for action to be considered for cutting hunger in half.

Achieving the MDG agenda for reducing hunger and malnutrition will require:

- strengthening governance of the food and agriculture system at the global, national and local levels to translate the new initiatives of 2005 into action on the ground,
- scaling up public investment for agricultural and rural growth,
- taking targeted steps to improve nutrition and health, and
- creating an effective global system for preventing and mitigating disasters.

Thus far, as von Braun (2005) put it, the greatest progress in reducing the proportion of hunger, malnutrition, and poverty has taken place in the large developing countries of Asia and Latin America. According to him, at present, it is time to direct efforts towards Africa and towards smaller and poorer countries that have few resources and little capacity to plan and implement effective policy action.

### 2.2.2 Household food security

At the household level, food security refers to the ability of the household to secure, either from its own production or through purchases, adequate food for meeting the dietary needs of all members of the household. Food insecurity at household level can be transitory or short-term, resulting from a temporary limited access to food, whereas, chronic food insecurity is a long-term food shortage causing a more noticeable effect and may be more difficult to control. There are various food security indicators that are applied for assessing and evaluation of nutrition security status at different levels. Mentioned here is the food security situation, restricted at micro or household level.

Household food security, according to Callens and Seiffert (2003), refers to the ability of a household to secure a year round access to an adequate supply of nutritious and safe food to meet the nutritional needs of all family members. Hence, household food security is a key determinant for the nutritional status of the individual household members. As the undernourished and disease- stricken household members are unable to contribute to their own food security, the intra-household status of health which can be determined by adequate quality of nutritional intake, is also highly relevant to household food security. The World Health Organization (WHO) defined that health is not only the absence of disease but a state of complete mental and physical wellbeing in relation to the productivity and performance of an individual. Moreover, undernourished people are much more susceptible to diseases than people with a regular balanced diet.

In this study the terms nutrition status and malnutrition refer to undernutrition, which are defined as insufficient or inadequate nutritious food (lack of protein, adequate energy and micronutrients) intake to meet basic energy requirements of the development and maintenance of the human body on a continuing basis. Also, Latham (1997) stresses that malnutrition or disease conditions related to nutrition can be caused by eating an unbalanced diet that does not contain all nutrients necessary for a good nutritional status. Therefore, the necessity of adequate nutrition in order to enable the body to resist organisms and toxins that tend to damage the tissues and organs of the human body is primordial.

Protein- and/or calorie-deficient diets are specially widespread in the rural areas of the Amhara Region including the study areas, where they can cause thousands of deaths. Important micronutrients, such as iron, zinc, and vitamin A are also often deficient in the diets, some of which maybe addressed through plant breeding. Tef, a major food source for millions of people in Ethiopia is the single largest source of calories in the study areas, and contains micronutrients, such as iron (Fe). Nevertheless, other protein and micronutrient concentrations in other staple cereals, such as triticale should be enhanced to improve the households' nutrition. As triticale contains a protein level of nearly between its parents - wheat and rye –, and higher levels of the amino acid lysine than tef, it would help to reduce nutrition-related diseases and deaths, and significantly improves the nutritional quality for individuals who primarily depend only on tef or wheat. Lysine, the first limiting essential amino acid in human consumption is higher in triticale, wheat, barley and rye than in tef, rice, sorghum and maize. Other amino acids, such as *tyrosine, histide, arginine* and phenylalanine are also significantly higher in triticale grain than in tef, whereas the latter contains a higher *metheonine* amino acid than triticale. Maize with improved protein quality, which would also help to reduce nutritional deficiencies in the diets of the poor households, is another cereal that contains more or less similar amounts of essential amino acids except for lysine and tryptophan. However, as large parts of the study areas are not well-suited for maize or rice cultivation, triticale remains a crucial option to supplement tef, wheat and barley.

## 2.3 State of research on food security and undernourishment

### 2.3.1 Progress in world food security

In 2007, less than eight years are left to achieve the first of the MDG of halving the proportion of people suffering from hunger and those living in extreme poverty (less than US $1 per day). The world is on track to achieve the poverty reduction goal by 2015, but according to estimates from the World Bank, the hunger reduction of MDG will not be achieved by 2015 at the pace of progress of 2006.

At the global level, poverty has declined both, in absolute numbers (from 1.2 billion to 1.1 billion) and in relative terms (from 30% to 21%) of the world’s population. The East Asia region met its poverty reduction target in 2001, 14 years ahead of the timetable. South Asia made considerable progress during the 1990s reducing the proportion of extreme poor from 41% to 31%, and is on track to achieve the poverty MDG (FAO 2005). The poverty reduction goals seem much more challenging in the other regions. In sub-Saharan Africa poverty increased between 1990 and 2001 in both absolute and relative terms. According to FAO, the World Bank projections suggest that the MDG poverty goal may be beyond reach for sub-Saharan Africa, where indeed the absolute number of poor may in fact rise considerably. If this scenario should materialize, close to half the world's poor will live in sub-Saharan Africa in 2015.

Also, the World Bank Group (2006) reported that if the economic growth rates in developing countries (i.e. countries with low per capita income or low GDP, low Human Development Index - HDI, which is a measure of life expectancy, rate of literacy and education) are sustained, global poverty will fall to 10% by 2015. But more than 600 million people will still be trapped in poverty in 2015, most of them in Sub-Saharan Africa and South Asia.

Nevertheless, the economy of the Sub-Saharan countries shows a considerable progress due to the globalization process, and may indeed help to reduce poverty and food insecurity. The International Monetary Fund - IMF (2007) in its 2007 Global Economic Trend Report indicates that Sub-Sahara Africa (SSA) is enjoying a strong year, with an overall growth in the region projected to rise from 5.7% in 2006 to 6.1% in 2007 and further to 6.8% in 2008. According to the Report, taking a longer-term perspective, SSA is clearly enjoying its best period of sustained growth since independence. While the oil-exporting countries are achieving the most rapid growth, most other countries are also growing strongly and outperforming historic trends. Moreover, faster-growing countries in the region are making substantial progress in reducing poverty rates. This growth success reflects a potent combination of a favourable external environment (particularly, improving terms of trade), sound policy implementation, and the rising openness of the sub region's economies,

### 2.3.2 The global food security situation in the lead up towards 2015

The 1996 World Food Summit (WFS) brought back to centre-stage in the development debate the issue of hunger and food insecurity as both, cause and effect of poverty and slow growth. In the wake of this new push, reducing hunger and food insecurity also became one of the Millennium Development Goals, bringing with it the necessity by individual countries to measure progress in achieving the proposed targets. The target was established of halving the number of undernourished people by no latter than 2015 (FAO 2006[a]). FAO uses the average of the period 1990–92 as the baseline for monitoring progress towards this target. The FAO further indicated that even if the MDG target is achieved in 2015 (by the developing countries as a group), the 2006 population projections suggest that there will still be left around 585 million undernourished people, 173 million, more than the WFS target of 412 million.

### 2.3.3 Regional trends in food security and undernourishment

At the World Food Summit in November 1996, 186 countries had committed themselves to reducing the number of undernourished people by half in 2015. Donors pledged to provide support, in particular, in the area of technological transfers. According to USDA, almost all regions in developing countries have shared to different degrees in this long-term progress in per caput food production (USDA 2005).

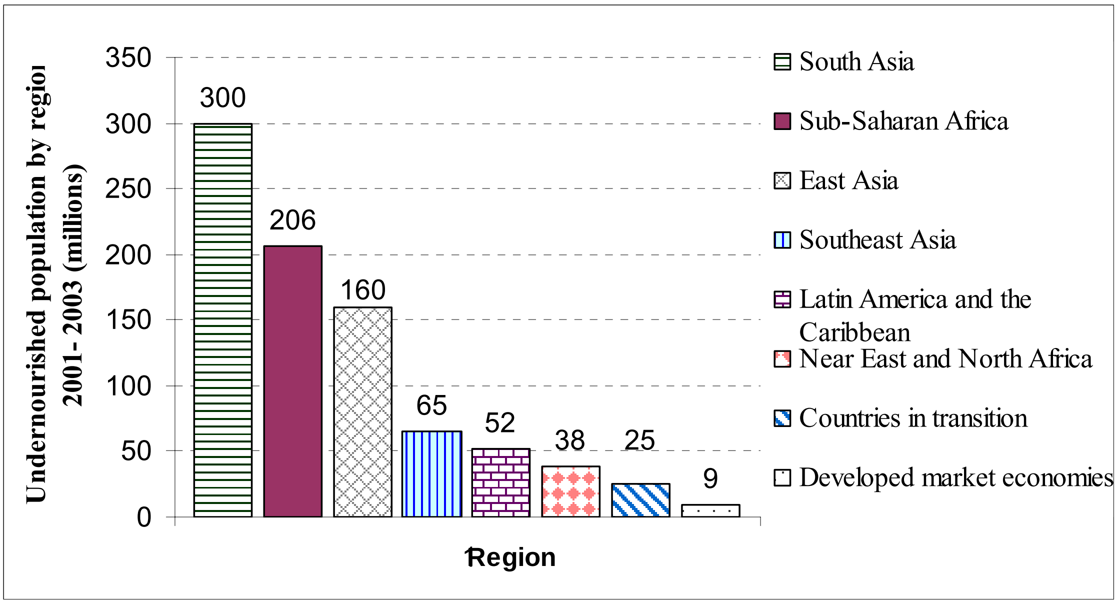
Global stagnation in hunger reduction masks significant disparities among regions: Asia and the Pacific, and Latin America and the Caribbean have seen an overall reduction in both, the number and prevalence of undernourished people since the WFS baseline period. Nevertheless, as the FAO (2005) Report indicates, the average rate of reduction has fallen short of what would be required to halve the undernourished population by 2015 in regions. In 2006, according to the FAO (2006), still about 850 million people worldwide live with undernourishment, a number that has hardly changed from the 1990–1992 figures on which the World Food Summit and Millennium Development Goal commitments to halving hunger by 2015 were based.

### 2.3.3.1 The trend of food security in Sub-Saharan Africa

At the continent level, food and nutrition security remain Africa's most fundamental challenges. According to IFPRI (2004), the number of Africans who are undernourished has been on the rise for decades and stood at about 200 million people in 2004. However, as IFPRI reported, new commitment to a change was emerging both among African leaders and in the international community in the last years.

As the FAO (2005) Report indicates, Sub-Sahara Africa accounts for 13% of the population and 25% of the undernourished people in the developing countries. In addition to Ghana, which has already reached the target, only Gabon reduced the number of undernourished by 25% (and is thus halfway towards the target). Ethiopia, Ghana and Mozambique are among the countries that have achieved a significant reduction in the number of undernourished. Although less significant when compared to the whole of Sub-Sahara countries, Angola, Benin, Chad, Congo, Guinea, Lesotho, Malawi, Mauritania and Namibia have also reduced the number of undernourished. Ten years after the 1996 Rome WFS, the number of undernourished people in the world remains stubbornly high. In 2001–03, FAO estimates there were still 854 million undernourished people worldwide:  820 million in the developing countries, 25 million in the transition countries and 9 million in the industrialized countries. Virtually no progress has been made towards the WFS target of halving the number of undernourished people by 2015. The persistence of undernourishment in the world is underlined by Figure 2.2, which shows the share of the individual sub-regions.

Figure 2.2: Undernourished population by region (2001-2003)



Source: Based on data from FAO (2006)

Taking the FAO Report into account, the projected progress in hunger reduction reflects significant increases in average per capita food consumption. However, overall gains in food consumption in several countries will not be sufficient to allow for a significant reduction of the number of undernourished people. Low initial levels of calorie intake coupled with high population growth are among the major attributes that are said to contribute to the slow reduction in the number of the undernourished population. Sub-Saharan Africa, particularly will still have an average per capita daily calorie intake of 2420 kilocalories (kcal) in 2015 – close to that of South Asia at the turn of the century. However, high income inequality, which reflects uneven access and distribution to productive assets such as land, may remain a key factor underlying food insecurity and under development in the region.

#### 2.3.3.2 The food security situation in Ethiopia

Ethiopia has a high level of chronic food insecurity and is vulnerable to acute food insecurity, primarily caused by drought, heavy rain, environmental degradation and low access to and availability of food.

The agricultural sector is nearly totally dependent on rainfall with only 2% of the total arable land being irrigated. The proportion of areas under improved seeds is less than 3% and the proportion of area treated with pesticides is less than 10% (FAO/WFP (2006). This, coupled with low fertilizer use, susceptibility to pest and disease outbreaks and extensive highland soil erosion results high variability in year-to-year agricultural production which is predominantly in the hands of peasants with smallholdings of the proportion of land under crops according to CSA (2004), was treated with chemical fertilizers in 2003/04 represented about 40%. This high variability in agricultural production increases food insecurity in the country. Crop production is highly subsistence oriented, but the trend during the last 20 years has shifted from households being net sellers of food grains to being net buyers (Holden and Shiferaw 2000).

Ethiopia's food security has been constantly eroded by progressive soil exhaustion (particularly in the highlands) and overcrowding of land, which has caused declining food production per capita since the 1960s. As a consequence, the country’s production of the main cereals (tef, wheat, barley, maize and sorghum) fell short since the mid 1990s, depending on imports averaging to one million mt in these years (ACC/SCN 1994), and nearly 340,000 mt in 2006 (FAO/WFP 2006). However, as the Central Statistical Agency survey indicates, the food supply per capita has increased to 176 kg grain intake per person per annum compared to the usually used 156 kg per person per annum, which reflects the increased per capita food consumption.

During the 1980ies, the real GDP grew at a rate of 1.9% while the population growth was 3.1%, which results in a negative per capita growth rate of -1.2% (Devereux 2000). During the 1990s (between 1991 and 1998), as was reported by Befekadu and Berhanu (2000:18), the real GDP growth rate averaged 4.4% or 1.3% per capita. Nevertheless, food production in the country is highly variable and unpredictable mainly due to the adverse combination of agro-climatic, demographic and unpredictable rainfall constraints. Von Braun (1991) for example reported that a 10% decline in rainfall below its long average results in a 4.4%, reduction in national food production. As shown in Table 2.1 out of the estimated population of 76.5 million, those requiring assistance since 2000 has risen in a roughly constant trend. The number of people requiring food aid has reached its historically highest level of about 13 million in 2003, and for the first time in decades, in 2007, according to FAO/WFP (2007), the government has requested the least amount of emergency food aid for an estimated 1.3 million people. The European Union (EU) and the United States of America (USA) are the major food aid donors.

Table 2.1. The trend of estimated crop production, food aid requirements and needy population in Ethiopia from 1995 to 2007

| **Year** | **Est. total population (mio)** | **Est. crop prod. (cereal + pulse (mt)[a]** | **Est. of needy population (mio)[b]** | **Est. food aid requirements (mt)[c]** | **Est. Food aid req. Per capita (kg)** |
|---|---|---|---|---|---|
| 1995 | 53.5 | 9.41 | 3,99 | 1,025,000 | 256.9 |
| 1996 | 56.7 | 9.48 | 3,00 | 421,000 | 140.3 |
| 1997 | 57.8 | 12.50 | 5,31 | 420,000 | 70.1 |
| 1998 | 58.4 | 11.69 | 5,0 | 530,000 | 106 |
| 1999 | 61.7 | 12.54 | 2,00 | 180,000 | 90 |
| 2000 | 63.5 | 10,72 | 7,76 | 764,000 | 98.5 |
| 2001 | 65.9 | 12,60 | 7,85 | 970,000 | 123.6 |
| 2002 | 67.3 | 12,33 | 5,20 | 560,000 | 107.7 |
| 2003 | 68.6 | 9,27 | 12,65 | 2,300,000 | 181.8 |
| 2004 | 71.0 | 13.05 | 7,39 + 5,0 | 980,000 + na | 132+ |
| 2005 | 73.0 | 14,59 | 2,20 + 7,3 | 1,302,000 + na | 500.8+ |
| 2006 | 75.1 | 17,12 | 2,60 + 7,2 | 340,000 + na | 130.8+ |
| 2007 | 76.5 | 20,10 | 1,30 + 7,2 | 150,000 + na | 115.4+ |

Notes: a) Crop production does not include the short rainy season (*belg*) harvests, which lies approx. between 200, 000 and 275, 000 tonnes with the latter being estimated for 2007 harvest.

b) The needy population number for the years 2005-2007 includes the 7.2 and 7.3 million chronically food insecure households which require continued support through the so-called Productive Safety Net Programme (PSNP) that was launched in 2005 (discussed in section 2.5.3). The amount of food required for the chronically food insecure people was not verified in the reports of the Mission (na = not available).

c) Food aid required does not always equal food aid pledged or delivered.

Source: FAO/FAO Global Information and Early Warning System (2000, 2001…2007)

In the last months of 2006, Ethiopia has experienced heavy floods throughout the country from the extended main season rain that runs from June to September. The worst hit region was the Ethiopian Somali Region where hundreds of people have been reported dead and many more hundreds were made homeless.

The World Food Programme of the United Nations (WFP 2007) reported that between June and December of 2006, almost every region in Ethiopia experienced some of the heaviest and most intense rains and floods on record, which resulted in widespread displacement and upheaval, and the subsequent loss of life and livelihoods, damage to property, agricultural land, crops and infrastructure. Prior to the heavy floods, which occurred in the country, the WFP pointed out that some 1.5 million pastoralists and agro-pastoralists in the country had required urgent humanitarian assistance as large numbers of livestock died due to drought and increased malnutrition rates. According to WFP, the Ethiopian Government, the UN and other humanitarian partners appealed for 340,000 tonnes of emergency food aid, valued at approximately US $ 145 million to assist some 2.6 million people for 2006.

According to the WFP/FAO (2007) joint report, the food aggregate cereal and pulse production in Ethiopia from the 2006/07 *meher* (long cycle) season is forecast at 20.1 million tonnes, about 10% above the previous year's post-harvest revised estimates and 53% above the average of the previous five years. This represents a third consecutive bumper harvest. With a *belg* (short cycle) season harvest in July/August 2007 anticipated as the report indicated, it raises the historical average to 275,000 tonnes, raising the total domestic availability of cereal and pulses to an estimated 20.4 million tonnes for 2007.

From the above, it follows that the overall food situation is highly favourable with an increase in food availability and possible access for a large number of vulnerable groups. As the WFP/ FAO joint report indicates, Ethiopia is able to cover all its cereal requirements at the country level. Food stocks are expected to increase and a relatively large quantity of grains could also be exported. However, a significant number of vulnerable households are still expected to remain largely food insecure and dependent on humanitarian assistance also in 2007. The sustained high food prices, although beneficial to surplus crop producing households, will also negatively affect the poorer households that are net buyers of grains.

According to the Economic Intelligence Unit Report (2007), the price inflation in 2006 was estimated at an average of 12.2%, and forecast to ease to 8% in 2007 as a result of good 2006/07 harvest and slightly downward trend of world oil prices. However, the inflation rate in 2007, which stood at 12.3% in June 2006, surged to 15.6%. The CSA (2006/07) monthly Consumer Price Index (CPI) also indicates, for example, in July 2007 the country level general CPI has increased by 16.7% (for Amhara 18.2%) compared to July 2006. This was attributed to the rise of the CPI for food 19.2% (for Amhara 21.9%), house rent, construction materials, water, fuel and power by 13%, transport and communication by 12%, etc. In view of expected good domestic grain production, WFP and FAO recommend that local purchases by governmental institutions and relief agencies in surplus producing areas should be considered despite continued high prices of grains.

According to the Ministry of Finance and Economic Development (MoFED 2007) the price hike on food items, the major contributing factor to the spiral inflation rate, increased from 14 to 16.2% during the stated period. Consequently, the government has decided distributing wheat from its national food reserves for lower prices to major city dwellers with the particular focus on Addis Ababa.

## 2.4 Food security and agriculture in the Amhara Region

### 2.4.1 The Amhara Region

The Amhara Region is located in the north-western part of the country between 8°45'N and 13°45'N latitude and 35°46' and 40°25' E longitude. It is bounded by the Afar, Benishangul, Oromia and Tigray Regions in the East, South-west, South and North, respectively, and by Sudan in the West. The total area of the region is estimated at 170,152 km$^2$, which is about one-sixth of the country's total area (BoA 1997). The state is structured into 11 administrative zones and 113 districts including the capital city, Bahr Dar. West and East Gojam, North and South Gondar, Awi, Wag Himra, North and South Wello, Semen Shoa, and Oromia are the other ten administrative zones. There are 101 districts and 5,300 rural and urban associations (UNECA 1996).

The total population size of the region is estimated at about 19.62 million (CSA 2007) of which nearly 9.81 and 9.82 million are estimated to be male and female, respectively.

The region is characterized by erratic rainfall, high land degradation, and high population density, high rate of poverty and malnutrition.
According to a Report by the GTZ/IFSP (2002) project, the region losses annually an estimated 119 million tonnes of agricultural soil (70% of the total soil loss in the

country) due to water erosion. This results in a reduction in agricultural productivity of 2-3 % per annum as a direct effect of the decrease in arable farmland and increased pressure on the remaining land.

Other studies indicate that in many highland areas, for example, in North Wello and Gondar erosion exceeds soil formation. The latter is estimated at about 15 t ha$^{-1}$ year$^{-1}$. In the highland regions of the *abay* (Nile) Basin, soil loss in areas cultivated through traditional practices amount to 122–128 tonnes ha$^{-1}$ year$^{-1}$, which doubles in the absence of vegetation (NEDECO 1997, cited by the World Bank (2006).

About 85% of the population in the region are engaged primarily in crop-livestock mixed farming systems. The main cereal staples include tef, complemented by other cereals, such as maize (*Zea mays*) and sorghum (*Sorghum bicolor*). Other crops, such as grass pea (*Lathyrus sativus*), wheat (*Triticum aestivum*), barley (*Hordium vulgare*), peas (*Cicer arietinum*), lentils (*Lens culinaris* Medik), faba beans (*Vicia faba*), *noug* or niger seed (*Guizotia abyssinica (*L.f.)) Cass. and linseed (*Linum usitatissymum*), sesame (*Sesamum indicum*) and finger millet (*Eleusine coracana*) are also grown in varying proportions according to soils, altitude, and the prevailing climatic conditions. Field beans, peas and potatoes are also grown in the region. Reported yield levels of cereals revolve around 1 t ha $^{-1}$ for cereals except for maize that reaches 1.5 t ha$^{-1.}$ The production of crops is well integrated with the production of livestock in the area. Oxen are the dominant source of traction power. Cattle, sheep and poultry being the dominant animal types, goats and equines are also common (Table 2.2).

Table 2.2 Number of livestock by type of animal for Ethiopia, Amhara and South Gondar zone for selected years

| | **National** | | **Amhara** | | **South Gondar** | |
|---|---|---|---|---|---|---|
| **Animal** | 2005/06 | 2006/07 | 2005/06 | 2006/07 | 2005/06 | 2006/07 |
| Cattle | 40,281,110 | 43,007,315 | 10,077,301 | 10,483,057 | 1,209,617 | 1,233,628 |
| Sheep | 20,721,562 | 23,617,496 | 7,530,518 | 8,235,904 | 759,047 | 775,281 |
| Goats | 16,248,899 | 18,423,395 | 4,856,472 | 5,140,542 | 523,517 | 542,136 |
| Horses | 1,569,318 | 1,655,284 | 289,895 | 283,813 | 21,705 | 18,282 |
| Donkeys | 4,280,542 | 4,486,171 | 1,513,891 | 1,539,949 | 172,485 | 158,960 |
| Mules | 340,572 | 325,659 | 102,580 | 92,787 | 16,139 | 11,711 |
| Camels | 436,622 | 615,197 | 14,678 | 31,911 | na | na |
| Poultry | 32,032,199 | 33,957,837 | 9,400,917 | 10,368,274 | 990,287 | 1,186,839 |
| Beehives | 1,012,515 | 4,870,679 | 791,661 | 852,495 | 98,399 | 105,936 |

Note: na = not available

Source: CSA (2005/06) and CSA (2006/07)

Hand cultivation is used only on very steep slopes inaccessible by oxen. Animal manure is used for fuel or as fertilizer on crops. Use of chemical inputs to protect seed quality or fight pests and diseases is limited.

The Amhara Region benefits from two rainy seasons, *belg* and *meher*. The first refers to the short rainy crop season which runs from February to April and the latter refers to the main crop rainy season which runs from June to September.

The western part of the region benefits only from the short season rains while the eastern zones benefit from both sources (Engida Mersha (2002).

Food security in the region is threatened mainly by frequent droughts, which as a result, makes the majority of the population food aid recipient. The major food aid is distributed through cash or food for work programmes in many districts by international organisations, such as the GTZ.

The Ethiopian Government has a policy of committing 80% of food aid resources to link with FfW programmes (Sanford and Habtu (2002). The FfW programmes have been according to Holden et al. (2004) widespread, specially in northern Ethiopia which may be due to frequent droughts and high soil degradation, and on government attempts to improve food security and promote sustainable rural development in the food insecure areas of this region.

### 2.4.2 Food security in the research districts

The main stay of the economy of South Gondar is agriculture, like that of the Regional State and the country as a whole. Crop production in the Zone is marked with low use of improved varieties and external inputs, such as fertilizers and herbicides. Cereals, pulses and vegetables are predominant crops grown by smallholder farmers. Cereals cover slightly more than two-thirds of the cultivated land and the major crops produced in their descending order of importance are tef, barley, wheat, sorghum, maize and finger millet with average yields ranging between 1 and 1.5 t $ha^{-1}$ (ZOARD 2004). Triticale and some of the major crops grown in South Gondar, (e.g. Farta *wereda*) according to their level of importance and the pre-harvest assessment made by the WOARD for the survey year, is shown in Table 2.3.

Table 2.3. Area and production of major crops in Farta district, a pre-harvest assessment for 2005/06 *meher* crop season

| Farta | | | |
|---|---|---|---|
| **Crop (Cereals)** | **Area (ha)** | **Production (qt)** | **Yield (qt/ha)** |
| Tef | 6,503 | 8,7084 | 13 |
| Barley | 6,134 | 70,942 | 11 |
| Wheat | 7,239 | 120,197 | 16 |
| Triticale | 103 | 2,575 | 25 |

Note: The pre-harvest assessment error of probability is estimated at 3-4%; 1 qt (1 quintal = 100 kg)

Source: Farta (WOARD, personal communication)

South Gondar has one of the lowest crop productivities per unit area as compared to the national average. According to the World Bank (2004), 14% of the population in the zone is engaged in non-farm related jobs, compared to the national average of 25% and a regional average of 21%. The World Bank also indicates that 49% of all eligible children are enrolled in primary school and 9% in secondary schools.

The average yield comparison of selected crops for Ethiopia, Amhara and South Gondar Zone for 2004/05 and 2005/06 *meher* seasons is shown in Table 2.4.

Table 2.4. Average yield comparison (qt/ha) of selected crops (private holdings)

| | **National** | | | **Amhara** | | | **South Gondar** | | |
|---|---|---|---|---|---|---|---|---|---|
| **Crop** | 04/05 | 05/06 | 06/07 | 04/05 | 05/06 | 06/07 | 04/05 | 05/06 | 06/07 |
| Tef | 9.48 | 9.69 | 10.14 | 9.55 | 9.55 | 10.35 | 6.81 | 8.80 | 8.12 |
| Wheat | 15.57 | 15.20 | 16.71 | 14.50 | 11.08 | 15.94 | 7.54 | 9.83 | 10.41 |
| Barley | 12.12 | 12.73 | 13.27 | 10.61 | 12.45 | 13.39 | 6.84 | 9.82 | 10.11 |
| Triticale | na | na | na | na | 24.6[a] | na | 18.0[b] | 22.6[c] | na |
| Maize | 17.19 | 21.87 | 22.29 | 17.43 | 21.28 | 23.05 | 10.66 | 15.13 | 15.99 |
| Sorghum | 13.69 | 14.81 | 15.82 | 13.75 | 15.84 | 16.40 | 9.48 | 11.76 | 13.12 |
| F. millet | 10.64 | 11.92 | 12.95 | 10.10 | 11.22 | 12.32 | 7.85 | 10.85 | 11.64 |
| Chickpeas | 9.64 | 10.48 | 12.69 | 9.71 | 10.36 | 12.86 | 7.61 | 11.03 | 10.43 |
| Field peas | 8.98 | 7.82 | 9.48 | 8.46 | 8.04 | 9.99 | 4.96 | 6.82 | 7.75 |
| F. beans | 11.92 | 11.22 | 12.55 | 8.46 | 11.36 | 13.23 | 7.24 | 11.28 | 11.99 |

Note: (a) consist only 8 *wereda* of South and North Gondar zones (Estie, Simada, Tach Gayint, Lay Gayint, Farta, Lay Armacheho, Dabat and Debark); (b) mean yield for Farta *wereda* (Mesfin 2005); (c) shows mean yield of major triticale growing w*ereda* (Estie, Simada, Tach Gayint, Lay Gayint and Farta) for the survey year (2005/06); na = not available

Source: CSA (2004/05), CSA 2005/06, CSA (2006/07) and triticale yields were calculated based on sources from our personal communications with agricultural extensionists and NGO representatives

## 2.5 The agricultural and food security policy of Ethiopia

Ethiopia's small-holder traditional agriculture is characterized by land insecurity, small and highly fragmented holdings of farms (about 1.0 ha per household), low agricultural inputs, such as fertilizer and improved seeds application and impoverished peasantry whose productivity and welfare is among the lowest in the world. According to Berhanu (2003), the problem of smallholder agriculture in Ethiopia is a technical and resource related problem, which, however, has to do with the technical knowledge, education and farm extension policies. This view identifies the low level of agricultural productivity as the key problem and the solution that follows is to find ways to enhance productivity. Since the technology required for enhancing productivity is internationally available, what remains to be done is to widely diffuse this technology, particularly fertilizers and improved seeds to areas with low productivity. The government of Ethiopia has tried to implement this technology-led extension programme since the mid-1990s in a high-profile national programme called the Agricultural Development-Led Industrialisation (ADLI).

The national strategy coincides with a widely held view that poverty reduction in Ethiopia is impossible without significant growth in crop yields for major staples, and this requires improving farmers' access to fertiliser, improved seeds, agricultural credit and other inputs, which critics say is not a new view. For example, Samuel (2006) reported that previous Ethiopian governments had also attempted to implement this strategy selectively in the 1960s and 1970s as part of their development programmes. According to him, there was no government in Ethiopia's history who has invested so much political capital on this strategy as the current one (2007), which he writes, not only has the government accorded priority focused on the agricultural sector, but also has made agricultural development the centrepiece of its overall development strategy.

### 2.5.1 The Agricultural Development Led Industrialisation

Ethiopia's Food Security Strategy (FSS) issued in November 1996 highlighted the government's plan to address causality and effect of food insecurity in Ethiopia. The regional food security programmes and projects were subsequently designed on the basis of that strategy. The ADLI policy primarily focuses on the intensification of production systems. Agriculture is found to be the starting point for initiating the structural transformation of the economy; as a result, according to the Ministry of Foreign Affairs (MoFA 2007), ADLI is pursued as a major policy framework for development since 1991 with the following objectives:

- To expand borrowers' coverage of micro-financing institutions;
- To establish an institute for diploma-level training of extension agents and expand agricultural Technical Vocational Education Training (TVET);
- To introduce measures for the improved functioning of markets for agricultural inputs (fertilizer, seed) and outputs;
- To organize, strengthen and diversify autonomous cooperatives to provide better marketing services and serve as bridges between peasants and the non-peasant private sector;
- To establish an agricultural commodities exchange market;
- To enhance agricultural research, water harvesting, and development of small-scale irrigation schemes.

The strategy generally envisages developing an agriculture-based economy by raising farm productivity and income. It however, relies heavily on the distribution of farm inputs, such as chemical fertilizer and improved seeds (which are expensive and less accessible to smallholder farmers) to smallholder producers through its extension packet called Participatory Demonstration and Training Extension System (PADETES) - a system based on demonstrating and training of farmers in proven technologies in a participatory manner. The intervention strategy in this system involves a package approach geared towards three different agro-ecologies namely: reliable moisture, moisture stress, and nomadic pastoralist areas (FDRE 2006). ADLI forms the basis of Ethiopia's FSS and is viewed by the government as the engine for poverty reduction in the country. However, due to the reliance nature of the strategy on smallholder agriculture, critics, for example Berhanu (2003), say that the ADLI strategy will not overcome Ethiopia's food insecurity problems due to (1) the rising population, which is estimated to reach 83 and 130 million in 2010 and 2030 respectively; (2) lack of alternative means (off farm employment) to absorb surplus rural population; (3) declining farm holding-size whose national average is about 1.0 ha; (4) poor growth of demand owing to declining income of the population making the smallholders vulnerable even during periods of bumper harvest; (5) negligence of development in other non-farm sectors on the side of economic policy and strategy.

Generally, the long term development or ADLI strategy of the government aims to use agriculture as the base for the country's overall development and food self-sufficiency at the country level where the food security strategy aims to enhance the productivity of smallholder farms and to improve food security at household level. But the success of this agriculture led development programme may be in doubt unless it incorporates the growth of the secondary and tertiary sectors in conjunction with the primary sector (agriculture) to make accelerated growth and sustainable development possible in the country.

### 2.5.2 The resettlement programme and food security

To bolster the national food security, the Ethiopian government has been following two strategies. First, the national resettlement programme which aims to resettle 2.2 million people from the over crowded and drought-affected areas into areas where sufficient land is available. The second strategy is “The Productive Safety Net Programme” created for about 7.2 million people who are deemed to be chronically food insecure nationwide.

Resettlement policy in Ethiopia dates back to 1958 when the government established the first known planned resettlement in Sidamo (South Ethiopia). According to sources from the Library of Congress of the United States Government (1991), the military government in 1975/76 had established eighty eight resettlement centres accommodating nearly 39,000 households. By 1986 the government had resettled more than 600,000 people to three resettlement areas from the drought affected northern regions to the South and Southwest parts of the country.

Beginning 2003, the current (2007) Ethiopian government has begun relocating peasant farmers from mostly the arid northern highlands to relatively moisture rich and densely populated areas. The current administration claims that its programme is based on 4 pillars and 13 key principles. Partnership, community participation, transparency of program design, and development are some of the 13 principles. According to Gebre (2005), voluntarism, availability of under utilized land, consultation with host communities and provision of minimum infrastructure make up the 4 main pillars. The authorities also argue that the current resettlement scheme is implemented in accordance to the ethnic, language and cultural similarities within the Regional States (*Kilil*). So far, according to a study by *Forum for Social Studies* (2005), more than half a million people have been resettled since 2003 in four major regions. However, little is known about key issues, such as site selection and preparation, selection of the settling families, the food security situation, the adaptation of the resettlers with the local people, sustainability of the resettlement programme and impact on the environment.

Partnership, self-help and cost sharing, transparency of programme design and execution, interactiveness, capacity building, proper preparation, environmental concerns, self reliance, income and employment creation, community management, development process are the 13 key principles that the authorities claim to have been following - a different and so to say a “client friendly” approach – as compared to what resettlement opponents of the previous government called a highly coercive resettlement programme. However, a number of studies, for example by Kassahun (2005) point out that, contrary to official pledges to provide the resettlers with standard houses on arrival, the host communities were asked to erect temporary collective shelters for up to 50 newcomers. After their arrival, the resettlers were thus required to build their own houses. According to the study, neither did promises to provide the new-comers with 2 hectares of farmland materialize until the resettlers had to clear their plots on their own, nor contrary to what has been set out in the Resettlement Implementation Manual (RIM), forest and wildlife resources were protected. Assefa (2005) has also reported that there were heavy losses of natural resources, particularly in the forest areas which have been already under fragile conditions due to continuous clearing for firewood, charcoal production, house construction etc.

On the basis of past resettlement related research findings, the success of the programme in terms of food security is viewed in a contentious or sceptical way. Authorities usually focus on food self reliance whereas for example, Pankhurst (2005) points out that the settlers mention not only the amounts but also the quality and type of food, and stress the need for cash for other basic necessities. Nevertheless, according to Pankhurst, despite disputes in the success of the resettlement scheme, there have been successful households producing a wider range of crops, such as maize and sesame, the latter being used for cash generation which enables farmers to purchase animal power, sheep, goats and poultry to improve their livelihoods.

### 2.5.3 The Productive Safety Net Programme

Making sure that all the people get the food they need to sustain a healthy life at all times remains a challenge for the government of Ethiopia. The revised version of the former Safety Net Programme (SNP) started in 2005, and provides support for over 7 million chronically food insecure people located in 8 Regional States. This programme aims to ensure a consistent support to the permanently food insecure people through cash and food for work schemes. It further aims to build community assets addressing root causes of food insecurity. According to Thomson and Winter (2004), the initial safety net programme targeted 5.1 million people in permanent need of support by the international aid organisations. However, the programme is in most respects no more than a formalisation process of the previously existing approaches. For example, these authors reveal that FfW or CfW and direct relief assistance – the major component of the safety net scheme – have been an integral part of life in the overpopulated and degraded highlands in the past decades.

In 2006, according to the British Department for International Development (DFID 2007), the programme was jointly appraised by the government of Ethiopia, the World Bank and DFID. Unlike the resettlement scheme, the Productive Safety Net Programme (PSNP), was praised by the international donors and is reported to have been bearing fruits. For example Slater et al. (2006) reported that beneficiaries were commonly eating more food of different types, of better quality, more often. In terms of asset protection, significant numbers of beneficiaries were said to have been able to avoid selling food, livestock and land to pay for short-term household needs, such as medicine or school fees. PSNP is also said to be playing a key role enabling the beneficiaries to avoid loans for food and migrating, thereby allowing more investment in their own household livelihood activities, and stay off harvesting their crops prematurely to meet immediate food shortages.

Also, the World Food Programme (WFP, 2007) reported that the humanitarian needs in 2005 – introduction year of the PSNP programme - were reduced significantly due to the PSNP which shifts the emphasis from emergency humanitarian aid to longer-term food security initiatives, targeting the food aid in the form of cash or food transfers in exchange for undertaking labour intensive public works, such as soil and water conservation activities, soil banding or terracing to improve the water content of agricultural lands, providing hand dug wells or ponds, building school classrooms and health posts.

# 3 RESEARCH METHODOLOGY, SURVEY DESIGN AND STUDY AREA

The chapter sets out the methodology of the study, first outlining the general rationale and strategies for combining qualitative and quantitative approaches. The sample structure and size for the household questionnaire survey and the qualitative household research are explained, together with the field procedures adopted to ensure an unbiased random sampling. The chapter further documents the implementation of the fieldwork, and describes the main data collection instruments that include a household questionnaire and structured key informant interviews.

## 3.1 Data collection

The research is based on mainly first hand information material which was gathered during the field work period (November 2005 – March 2006). During this time, both, primary and secondary data with regard to the agricultural production system, the food security situation of the study areas and the introduction of triticale crop were collected from the agricultural departments of the respective districts, from the food security project office of the SUN Amhara project and other knowledgeable individuals. As the main focus of the field study was on primary data, it was collected from the sample households using a structured questionnaire that was designed to generate data on demographic, socio economic, institutional and other relevant material, which we hypothesize would influence the growing/ adoption of triticale, particularly in the research districts and the Amhara Region as a whole. The secondary data sources related to the adoption of new technologies, the background of the triticale plant and other literature materials were consulted to supplement the primary data obtained from the field survey.

### 3.1.1 Selection and training of enumerators

The official language of the Amhara Region and the study areas is Amharic and data enumerators were native Amharic speakers. Enumerators were selected based on their formal education status, field experience and familiarity with the study sites. Six enumerators for each *wereda* were employed to administer the field survey. Three of the enumerators had a two years college Diploma in agricultural extension, and the rest had completed 12th grade with field experiences in agriculture. Two of the Diploma holders had been working for the food security project and had at least one year field experience as local development agent employees. Two of the enumerators were women and the others male youngsters. The recruited enumerators from the study areas including employees of the SUN Amhara project were hired and trained on the basis of the content of the questionnaire, on methods of interviewing, data collection techniques and the way of approaching farmers.

Prior to the actual data collection, both, the English and Amharic versions of the questionnaire were presented and discussed with the enumerators, which were then pre-tested on eleven non sample farmers in Debretabor and Gasay village in two rounds, that enabled us to some modifications on questions out of context or irrelevant to the current study. This pilot test on the preliminary questionnaire also enabled us to assess its comprehension and the average completion time. Two rounds of pre-testing were conducted. The first round was conducted in Debretabor in six households. Based on the feedback from the first round, some questions were rephrased for clarity. The second round of pre-testing was conducted in Gasay village (around 17 km from Debretabor) about two weeks latter.

After completing the training, several round-trips to the selected *wereda* were essential for the realisation of data collection. Then a group of enumerators with the researcher approached the households randomly in each of the selected rural *kebele* in the first round. Many of the households were visited while they were either harvesting or threshing their crops. The performance of the enumerators and their effectiveness in the field was kept steady on a bonus payment and covering of lunch and travel costs during their field trips, in addition to their regular wage.

Based on the structured questionnaire, a total of 408 farm households were interviewed during the survey period both, in groups and individually. The group questionnaire took place during church ceremonies, communal meetings and other social festivities, and was quite essential due to the limited financial and logistical resources as well as the time constraint to reach the required number of households within the four months field research frame.

### 3.1.2 Constraints faced during the data collection

Firstly, as the field survey was carried out during a peak harvesting season and due to the lengthy questionnaire, sometimes there was a need to rush and postpone field visits to other times as respondents had little time and patience to complete all the questions in one set of interviews. Secondly, in some cases, the farmers report not simply what they think is right, but what they think the researcher wants to hear (mainly just only positive ones) from them. Some of the respondents were thinking that we were project employees and therefore, they were listing personal problems and were biased in their answers. Nevertheless, we mitigated such problems by making clear that this was an independent survey, and that they should feel honest and critical in their answers, also towards the food security projects in their surroundings. Another problem was that the respondents were not always honest in their income issues, number of animals and the size of farm plots they possess. This was cross-checked through indirect questions. Therefore, despite precautions and refined measures, a possibility of error in the quantitative findings is not to rule out completely.

### 3.2 Sampling procedure

A multistage sampling procedure with a stratified random sampling was used to identify the sample households. First eleven out of the nine *wereda* of the South Gondar Administrative Zone were visited in order to observe the food security projects being undertaken and the overall features of the selected rural *kebele*. The choice of this administrative zone was: 1) because of the initial introduction of triticale (x *Triticosecale* Wittmack) by the IFSP to these *wereda*, and its fastest expansion rate above any other places in Ethiopia since its official reintroduction to the country in 2002; 2) because of the researchers familiarity with the local language and the IFSP food security programme, since he had become to know this programme when he first conducted field surveys for his BSc. and MSc. studies. Within the South Gondar administrative zone, the Farta and Estie *wereda* were selected, particularly because of:

- the availability of a large number of triticale growing households who are among the first beneficiaries of the triticale introduction and implementation project.
- the seat of the IFSP now SUN Amhara project which is located in Debretabor, the zonal capital, hence the study was carried out with the assistance and close collaboration of the project office.
- the high interest and motivation of the households in these *wereda* to grow triticale which was observed during the preliminary field visits, and
- the varying agro-climatic conditions which could be observed even at short distances and assumed to represent large areas of the Amhara Region.

After the selection of these *wereda*, all the respective agricultural offices were approached and relevant data concerning the major crops grown, the overall situation about the triticale crop and its acceptance by farmers, etc. were gathered. In the second stage, the sample rural *kebele* were chosen based on the number of triticale growing farmers and highest rate of expansion of the crop within these *wereda*. Following the selection of the rural *kebele*, 408 triticale growing and non-triticale growing farmers were randomly selected. Because of scarcely availability of non-triticale growers in the selected *kebele*, special arrangements were made with the *kebele* chairpersons, team leaders and extension officers to approach non-triticale growers in their respective locality and call for special gatherings during Sundays and other non working days.

## 3.3 Data Analysis

Following the completion of data collection, the data was coded and computed into the SPSS computer programme for analysis. The analytical techniques applied throughout the study included descriptive statistics and a regression model.

### 3.3.1 Model Specification

As the dependent variables are dichotomous (zero, one), a Linear Probability Model, or a Logit or Probit Regression Models can be applied. Logit and Probit regression models are widely applied statistical techniques in which the probability of a dichotomous outcome (for e.g. grower or non-grower) is related to a set of explanatory variables that are hypothesized to influence the outcome (Neupane et al. (2002). Also Hausman and Wise (1978) reported that these two analytical methods (Logit and Probit) are the most widely used techniques for estimating the relationship between choices on the one hand and attributes of alternatives and individual decision makers on the other in binary choice, or two alternatives.

In this study, the Probit model was applied to test the determinants or factors affecting the farmers whether or not to grow triticale crop ($Z_{GrowT}$). The Improvement of the total household income ($Z_{Income}$) of triticale growers versus non-growers was compared by using the Probit model. The probability model is also used in order to identify the causality of the determinants on the improvement of daily meal intake ($Z_{dMealint}$) of the households. Hausman and Wise further argue that an important characteristic of the Probit model is the provision for correlation among the random components of utility and, as a by product, the explicit allowance for variation in tastes across individuals for attributes of alternatives.

### 3.3.2 The Probability regression equations and econometric model

The decision to grow triticale crop is hypothesized to be a function consisting of the following components. These and other components are applied throughout the study.

**(1) $Z_{GrowT}$ = f (D, E, F, M, X, L, P, I, G, H, S, O, C, R)**

Where

D = the demographic characteristics of the households consisting of family size, age, gender and marital status of the household (hh) head
E = the education level of the household head
F = the farm size including rented in or crop shared land the hh cultivates
M = access to local markets measured by distance in km
X = availability of and access to agricultural extension services
L = physical capital (livestock without oxen) the household owns
P = availability of and access to farm input (application of fertilizer)
I = income sources other than crop- and animal production
H = the total number of labour available to the household
G = food and seed grain aid/ or loan
S = social networks (e.g. being a member of community based associations)
O = ox (en) ownership including borrowing and sharing (or pairing it with others')
C = availability of and access to cash credits for the hh
R = the distance of all weather roads from households' farm to the WOARD, measured in total time it takes on foot

The model is a linear relationship of interest model and specified as follows:

**(2) $Z_i = X_i \beta + u_i$**

Where

$Z_i$ = the outcome or dependent variable
$X_i$ = vector of the covariates or independent variables for the $i^{th}$ household
β = the value of the unknown regression or vector of coefficients
$u_i$ = the value of the random disturbance or error term for the $i^{th}$ household

We assert that each variable of $Z_{GrowT}$, denoted as $Z_{GrowTi}$ for the household i is generated by a relationship of the form:

**(3)** $Z_{GrowTi}$ = f (FAMSIZE, AGEHEAD, GENDERi, MARSTATi, EDULEVELi, FARMSIZEi, PURINPUTi, DMARKTi, EXTNSONi, LVSTOCKi, NOXENi, OFRINCOMi, CREDITi, RODTNCEi, HLABOR, GRAINAID) + $U_i$

$Z_{GrowTi} = \beta_0 + \beta_1 FAMSIZE_i + \beta_2 AGEHEAD_i + \beta_3 GENDER_i + \beta_4 MARSTAT_i + \beta_5 EDULEVEL_i + \beta_6 FARMSIZE_i + \beta_7 PURINPUT_i + \beta_8 DMARKT_i + \beta_9 EXTNSON_i + \beta_{10} LVSTOCK_i + \beta_{11} NOXEN_i + \beta_{12} OFRINCOM_i + \beta_{13} CREDIT_i + \beta_{14} RODTNCEi + ß_{15} HLABOR + ß_{16} GRAINAID + U_i$

Where

$Z_{GrowTi}$ = the value of the dependent variable $Z_{growT}$ for the i-th household

$U_i$ = value of the random error term for the i-th household
with the regression coefficients $\beta_0, \beta_1, \ldots \beta_{16}$ as the unknown parameters

$\beta_0$ = intercept (constant) coefficient
$\beta_1 \ldots \beta_{16}$ = the slope/ regression coefficients on $FAMSIZE_i \ldots GRAINAID_i$

Household total income

The total annual household income in consideration of growing triticale crop, denoted as $Z_{Income}$, is generated by the relationship of the form:

$\mathbf{Z_{Incomei} = f (D, E, F, X, M, O, P, C, G, L, R) + U_i}$

The following determinants are hypothesized to have an impact on the total annual income of the households. The equation can be expressed as follows:

$Z_{Incomei} = f (FAMSIZE_i, AGEHEAD_i, GENDER_i, MARSTAT_i, EDULEVEL_i, FARMSIZE_i, PURINPUT_i, DMARKT_i, EXTNSON_i, LVSTOCK_i, NOXEN_i, CREDIT_i, RODTNCEi, GRAINAID_i) + U_i$

The equation for the regression model is expressed as:

$Z_{Incomei} = \beta_0 + \beta_1 FAMSIZE_i + \beta_2 AGEHEAD_i + \beta_3 GENDER_i + \beta_4 MARSTAT_i + \beta_5 EDULEVEL_i + \beta_6 FARMSIZE_i + \beta_7 PURINPUT_i + \beta_8 DMARKT_i + \beta_9 EXTNSON_i + \beta_{10} LVSTOCK_i + \beta_{11} NOXEN_i + \beta_{12} CREDIT_i + ß_{13} RODTNCEi + ß_{14} GRAINAID_i + U_i$

Where

$U_i$ = value of the random error term for the i-th household (household index)
with the regression coefficients $\beta_0, \beta_1, \ldots \beta_{14}$ as unknown parameters

$\beta_0$ = the intercept or constant coefficient
$\beta_1 \ldots \beta_{14}$ = regression coefficients on $FAMSIZE_i \ldots GRAINAID_i$

Daily meal intake and nutrition improvement

The daily meal intake and nutrition situation of the households in consideration of growing triticale crop is assumed to be influenced by the following determinants

Daily meal intake and nutrition improvement denoted as $Z_{dMealinti}$ is generated by the relationship of the form:

$\mathbf{Z_{dMealinti} = f (D, E, F, M, L, I, G, P, H)}$

$Z_{dMealinti}$ = f (FAMSIZE$_i$, EDULEVEL$_i$, FARMSIZE$_i$, PURINPUT$_i$, FAMRENT$_i$, DMARKT, LVSTOCK$_i$, NOXEN, GRAINAID$_i$, OFRINCOM, HLABOR$_i$) + U$_i$

The equation is expressed as:

$Z_{dMealinti} = \beta_0 + \beta_1 FAMSIZE_i + \beta_2 EDULEVEL_i + \beta_3 FARMSIZE_i + \beta_4 PURINPUT_i + \beta_5 FARMRENT_i + \beta_6 DMARKT_i + \beta_7 LVSTOCK_i + ß_8 NOEXNi + \beta_9 GRAINAID_i + \beta_{10} OFRINCOM_i + \beta_{11} HLABOR_i + U_i$

Where

$U_i$ = value of the random error term for the $i^{-th}$ household with the regression coefficients $\beta_0, \beta_{1,} \beta_2 \ldots \beta_{11}$ as unknown parameters

$\beta_0$ = the intercept or constant term

$\beta_{1,} \beta_2 \ldots \beta_{10}$ = the regression coefficients on FAMSIZE$_i$, . . . HLABOR$_i$

Yield of triticale grain compared to other cereals

Triticale crop is assumed to provide more grain yield than other cereals; and the function consists the following determinants:

$\mathbf{Z_{tYieldi} = f (D, E, M, X, I, H, P, O, F) + U_i}$

$Zt_{Yieldi}$ = f (FAMSIZE$_i$, EDULEVEL$_i$, FARMSIZE$_i$, PURINPUT$_i$, DMARKT$_i$, EXTNSON$_i$, NOEXN$_i$, OFRINCOM$_i$) + U$_i$

$Zt_{Yieldi} = \beta_{0\,+}\, \beta_1 FAMSIZE_i + \beta_2 EDULEVEL_i + \beta_3 FARMSIZE_i + \beta_4 PURINPUT_i + \beta_5 DMARKT_i + \beta_6 EXTNSON_i + \beta_7 NOXEN_i + \beta_8 OFRINCOM_i + + Ui$

Where

$U_i$ = value of the random error term for the $i^{-th}$ household (household index) with the regression coefficients $\beta_0, \beta_{1,} \beta_2 \ldots \beta_8$ as unknown parameters

$\beta_0$ = the intercept or constant term

$\beta_{1,} \beta_2 \ldots \beta_8$ = the regression coefficients on $FAMSIZE_i, \ldots OFRINCOM_i$

### 3.3.3 The Probability regression analysis

Conceptually, the regression analysis was used to examine the relationship between growing triticale crop and the impact of the explanatory variables on the dependent or outcome variables. The outcome variable is dichotomous taking two values, 1 if the event occurs and 2 otherwise. According to Adesina and Zinah, and Misra et al. (1992) factors influencing the adoption of new technologies can be divided into three major categories: i) farm and farmers' associated attributes (e.g. farmer's education level, age, family and farm size); ii) attributes associated with the technology (e.g. the characteristics a farmer prefers in a new technology, such as high yield, disease, drought, hailstorm resistance and quality of the grain for bread and *injera* making); and iii) the farming objectives (CIMMYT 1988). As Bekele Hunde et al. (2000) indicated this category includes the influence of different farm categories, like commercial versus subsistence farming on the adoption of new technologies.

### 3.3.4 Definition of variables

A decision by farmers either to adopt or reject a new technology is influenced by the combined effect of a number of factors related to farmer's objectives and constraints (CIMMYT 1993). In this study, Demographic characteristics (e.g. family size, education level, age and sex of hh heads); Socio-economic characteristics (e.g. ownership of livestock and draught animals farm size of hh heads); Institutional characteristics (e.g. availability and contact to agricultural extension agents, availability of farm credits and chemical fertilizer, seed loan or gifts), and grain characteristics (grain yield and quality for bread and *injera* preparation) were identified as determining factors related to farm households' objectives and constraints. The following variables were applied for the hypotheses testing and the regression equations, and were assumed to influence farmer's decision to the adoption or growing of triticale crop in the research districts.

The independent or explanatory variables

**Demographic profiles (D),** consisting of FAMSIZE, AGE, GENDER and MARSTAT of hh head

**FAMSIZE** - refers to number of all family members living in the household. As subsistence farmers almost entirely rely on family labour for field activities, they are hypothesized to grow triticale crop. Because larger farm families will be able to provide more labour that might be required to adopt a new technology, family size is hypothesized to influence the adoption of triticale crop.

**AGEHEAD** - the age of the household head in years. Older farmers are supposed to have more farming experience than younger ones and are expected to have better understanding for new implements. In other words, with longer farm experience, a farmer may become less risk averse when judging this new implement. However, younger farmers can also grow triticale crop earlier than older farmers as they could be eager to the new technology. Therefore, this variable could affect farmers` decision to grow triticale positively.

**GENDER** - sex of the household head, a dummy variable if the head is female or male (1 = male, 2 = female). Traditionally, male household heads are believed to have more access to information on improved technologies through extension agents, public gatherings, *wenfel* (work festivities), and more access to credits, etc. Therefore, gender is hypothesized to influence farmers positively to grow triticale.

**MARSTAT** - if the household head is married (cont)

(1= married 2= divorced 3= separated 4= widow 5= never married)

Marital status of the household head can positively influence the decision to grow triticale as married households might have better social relations to the rest of the community. Marital status is therefore, hypothesized to influence adoption positively.

**EDULVEL** (L) – the education level of the household head. Education is assumed to increase the farmer’s knowledge to better process and make use of information that are relevant to triticale. Education is therefore, hypothesized to increase the probability of growing Triticale.

(0 = illiterate 1= read and write 2 = elementary and junior high school 3 = senior secondary school

**FARMSIZE (F)** – total size of cultivated land in 2005 cropping season including the renting of land from other households. Farmland is quite limited in the Amhara Region at large and the study districts in particular due to rapid population growth, over utilisation of natural resources and degraded land combined with rugged environments. Increasing production and allocation of land for triticale adoption might therefore depend on availability of larger cultivable land for a given household. Therefore, family size is hypothesized to positively influence farmers’ to grow triticale.

**FARMRENT** – having opportunity to share land, access to rent in or to rent out land will increase land availability, which can be allotted to grow triticale. However, agreement might need to be reached with the actual land owner whether the new implement can be applied or not. In this case, the variable was hypothesized to influence farmers either positively or negatively to grow triticale.

**PURINPUT (P)** - dummy variable if household purchased fertilizer for last cropping season. Use of chemical fertilizer combined with availability of triticale seeds during sowing season is hypothesized to increase farmers' desire to grow triticale. Because triticale is highly responsive to fertilizer specially in use of Nitrogen (Urea) efficiently. If adequate fertilizer and triticale seed is not available during sowing time, farm households may prefer to continue growing the crops they use to.

**DMARKT (M)** – refers to farmers' residence from the nearest market in (km). Distance of market centres to farmers' residence is assumed to negatively influence the will of the farmers to grow triticale. Because farmers who live closer to market centres will have easier to purchase fertilizer and/or exchange seeds. In addition to that these households can easily dispose their production outputs without transportation hindrances.

**EXTNSON (X)** – dummy variable if households have contacted agricultural extension (locally known as development agents, DA) in the last growing season (1= yes 0= no). Access to agricultural extension service is regarded as a major source of information concerning agricultural activities to households involved in the study areas. Therefore, it is believed that contact with agricultural development agents will increase farmers' knowledge about a new technology and thus the desire to grow triticale.

**LVSTOCK (L)** - ownership of animals by households excluding plough oxen. Ownership of livestock in large numbers owned by a household is hypothesized to be closely related to triticale adoption. Because, farmers with a higher number of livestock possession will have a better source of income, consumption source, and pack and draught power. An increased income will add up the probability of growing triticale as these households could also afford to purchase (for e.g. seeds, fertilizer) from sell of animals. In this case a higher livestock ownership is hypothesized to influence the decision of farmers to grow triticale. The total number of livestock ownership is measured by Tropical Livestock Unit (TLU). It was calculated using the following weighing index factors from ILRI (1990): cow = 0.8, sheep & goats = 0.09, donkey = 0.36, horse & mule = 0.8

**NOXEN (O)** - number of oxen farmers own during the last cropping season. Small scale farmers in Ethiopia rely on plough oxen to cultivate their farmland. Plough oxen are also usually seen as indicator of relative wealth in the Region, including the study areas. The number of oxen owned by farmers is thus expected to influence farmers positively for triticale adoption. Weighting index = 1.10

**SHAROX -** if households shared someone else's ox (en) or other draught animals in the last cropping season; dummy variable if borrowed or shared (1= yes 0= no). Small scale farmers who do not own draught animals usually share, rent, borrow or exchange with labour for their land to get it cultivated. Farmers with only a single ox may have less difficulty than the ones without, as these farmers can pair their ox with other farmers in the neighbourhood. In the study areas, many farmers do not own a pair of oxen. Borrowing, renting or exchanging with neighbours are the most common options available for these households. As was observed during the field survey, other animals, such as heifers, horses, mules and dried cows are also increasingly used for ploughing in the study areas. In this study, having access to sharing draught is assumed to increase farmers' interest to grow triticale.

**CREDIT (C)** - availability of credits to the household, dummy if available (1= yes 0= no). Research results reported by Lelisa (1998), and Tesfaye and Alemu (2001) (cited by Mesfin 2005), confirmed that access to credits positively influence adoption of technology. Thus, it is expected that farmers with credit accessibility will grow triticale earlier than those who do not have these opportunities.

**GRAINAID (G)** - availability of seed loan in 2005/06, dummy if available (1 yes 0 = no)

**OFRINCOM (I)** – if income sources other than crop- and animal production are available to the household, dummy if available (1 = yes, 0 = no)

**HLABOR (H)** - total number of workers or labour available to the household during the survey season. The total physical labour capacity in a given household was hypothesized to positively influence households for the adoption of triticale.

**SONTWRK (S)** – households who are member of farmer's associations, work with non-governmental organisations (NGOs) and other community operated associations are considered to have better access to information on improved technologies. Being a member of an organisation or having other social networks is hypothesized to be positively associated with the adoption of triticale. This is a dummy variable (1 = a hh is a member 0 = not a member of an organisation)

The dependent variables

$Z_{GrowT}$ – dummy if household grows triticale (1 = yes 0 = no)
$Z_{tIncome}$ – total income the household earns during the survey year
$Z_{dMealint}$ - improvement of the daily meal intake after triticale cultivation, dummy if improved (1 = yes, 0 = no)
$Z_{tYield}$ – dummy if triticale has a higher grain yield than other cereals (1 = yes 0 = no

### 3.3.5 Descriptive statistics

One method used to test the impacts of the independent variables in the decision by farmers to grow triticale is through statistical comparisons of households who grow triticale and who do not. Descriptive statistics based on frequencies, means and standard deviation, was used for analysing both, dependent and independent variables applied in the study. T-test, chi-square test and correlation analysis were run to identify statistically significant differences in the continuous variables, such as age, representing the characteristics of households who grew triticale crop versus those who did not. Frequencies for categorical variables (e.g. gender, educational level), which are expected to affect farmers adoption status were calculated for both, triticale-growers and non-growers. The independent t-test was specifically used to compare the significance of the mean values of continuous variables of the two population means (growers and non-growers). The comparison between the two groups in terms of their demographic and socio-economic characteristics of the households was made to provide the basis for the more comprehensive assessment (via econometric analysis) of the variables' impact on the decision of growing triticale crop and its effect on household food security. Pearson chi-square test is applied for the nominal or ordinal scaled data.

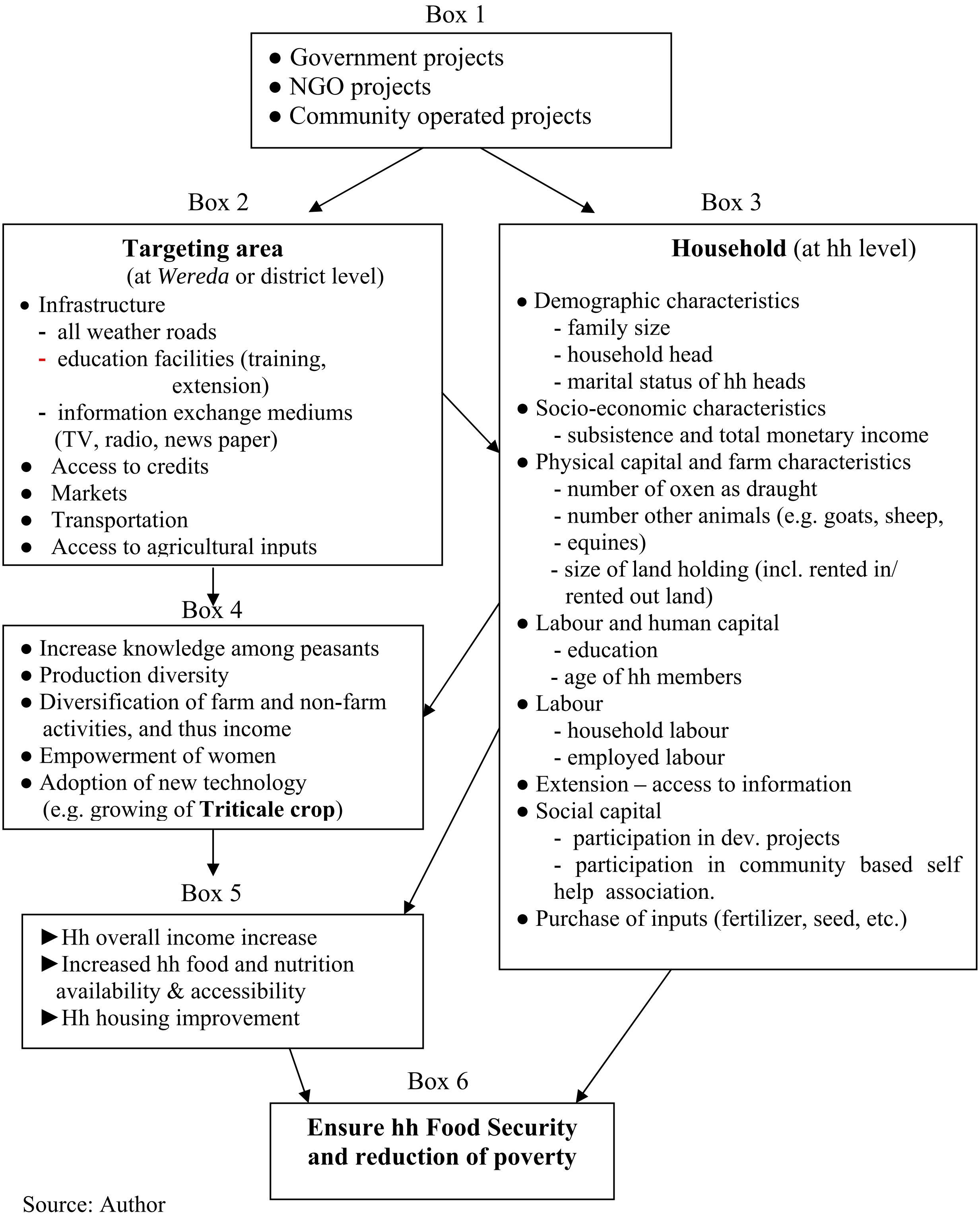
## 3.4 Conceptualisation of the hypotheses

Food security is closely associated with poverty and several other factors, e.g. lack of basic infrastructure, such as roads, basic education facilities, availability of credits, transportation and accessibility of markets at *wereda* level (Figure 3.1, Box 2), demographic socio-economic characteristics, physical capital, human resources and land holding characteristics at household level (Box 3). These, and other basic facilities can be made available or facilitated or improved by both, governmental and non-governmental (NGO) operated projects (Box 1), which can directly or indirectly influence farmers to whether or not to apply new technologies like growing triticale crop through project support. One example of such a project is the GTZ food security project in South Gondar. In our study, these factors are also hypothesized to influence households positively for deciding to grow triticale.

Availability of infrastructure and other socio economically important facilities may also increase farmers' knowledge (Box 4) which would help them to diversify income through diversification of production and engagement in non farm activities (e.g. petty trading). This would lead to higher household income, improvement of household welfare and improvement of housing (Box 5). In Debark district (North Gondar), for example, some households, which have been growing triticale through the Austrian government funded project, were interviewed and have explained to us that as a result of increased income after growing triticale crop, they were able to change their straw covered huts to corrugated iron sheet-roofed houses. During the survey season, it was reported that farmers in Debark and surrounding w*ereda* had harvested up to 34 quintal (Person. comm.) of triticale grain from one hectare of land compared to about only 8.43 quintal (CSA 2004) of tef cereal from the same amount of land. These remarkable outcomes are substantial gains of triticale crop that will result in improved food security and reduced poverty at household level (Box 6).

The nutritional well-being of the poor households is thus not merely a result of economic growth but also a precondition for it as well. The concept of the overall study is summarised in Figure 3.1.

**Figure 3.1. Conceptual framework of the study**



Source: Author

## 3.5 Description of South Gondar Administrative Zone and the study districts

### 3.5.1 South Gondar Administrative Zone

The field study was conducted during the 1997/98 E.C. *meher* (2005/06) or main cropping season in FARTA and ESTIE districts of the South Gondar Administrative Zone of the Amhara National Regional State. The zone was selected mainly: (1) because of its large triticale growing areas and its better accessibility by motor vehicles as it is also the base of the food security project of the GTZ, the cooperative partner of the study, (2) due to the fact that the two districts are the major triticale growing areas in Ethiopia as the crop was first introduced to this zone by the GTZ /SUN, formerly called Integrated Food Security Programme (IFSP). The administrative zone is classified in the middle-potential cereal–livestock zone and is severely degraded.

### 3.5.2 Geographic location and natural features

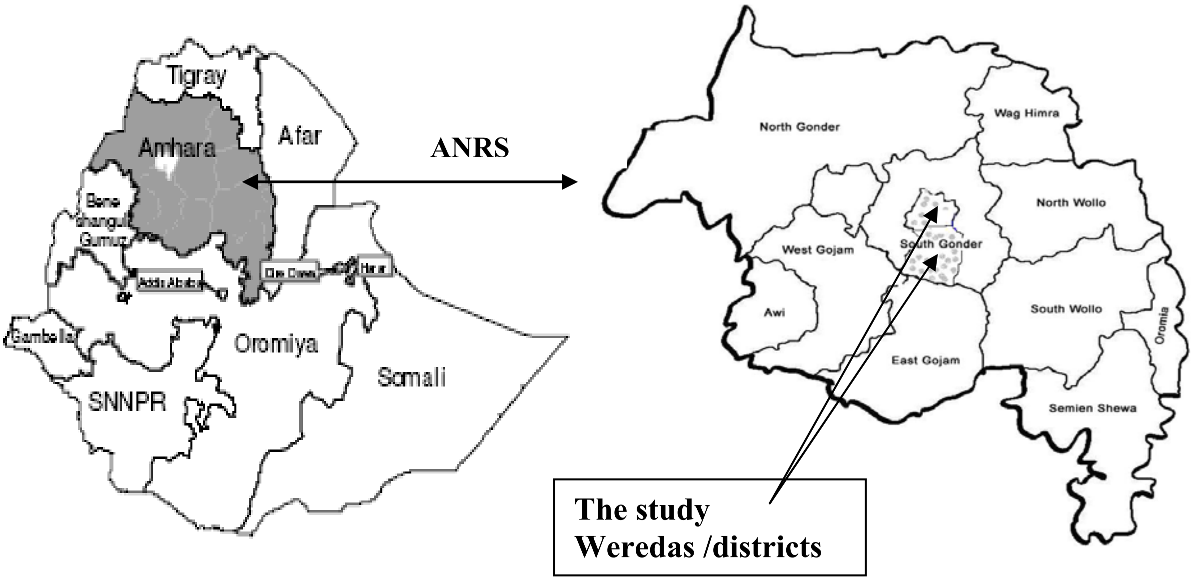
South Gondar administrative zone, with its capital Debretabor, is situated between 11°02'– 42°33'latitude and 37° 25'- 38° 43' longitude with the latitude range from 1,500 to 4,035 meters above see level. It is located about 100 kilometres southeast of Bahr Dar town, along the main road to Woldia town in the north-eastern Ethiopian Highlands.

The zone, with its 9 districts covers a total area of 14,320 km² of which the six SUN-Amhara intervention districts comprise about 9,150 km² (GTZ/IFSP 2002). Out of the total area of the zone, 41.5% is arable land. The topography of the zone varies from place to place and significant differences in altitude are observed even over a short distance. The zone is divided into four traditional agro-climatic zones of which 9% is *Kolla* (*Warm, semi-arid low lands*), 72.7% *weina dega (Temperate, cool sub-humid, highlands)*, 15.7% *dega* (*Cool, humid, highlands*) and 2.3% is classified as *wurch* (*Cold highlands*).

The rainfall distribution follows a uni-modal pattern and the total annual rainfall shows a wide variation as it varies between 500 and 1566 mm per annum, the mean rainfall being about 1314 mm is among the highest in the sub region. The mean daily temperature and the annual mean maximum temperature is about 17°c and 23.66°c respectively. The mean minimum temperature is about 9.36°c, and the mean annual temperature is about 16.51°c (PEDD 2001). There are variable soil types among which luvisols, vertisols, regosols, cambisols, nitosol and andosols predominate.

South Gondar is inhabited by a population of about 2.4 million, the majority of whom are (CSA 2006). The zone is divided into 10 *wereda*, of which only one is classified as urban. The 10 *wereda* are divided into 279 rural and 32 urban Peasant Associations. The topography of the zone is mainly undulating and mountainous. Sharp altitudinal differences can also be observed within short distances, and altitudes vary from 1,500 to 4,035 meters above sea level. The four major classical agro-ecological divisions can be found in the Zone. Based on the figures obtained from the Zonal Office of Agriculture and Rural Development (ZOARD), about 42%, 13%, 1%, 6% and 34% of the total area are respectively, used for cultivation, grazing and browsing, forest (including shrubs and bush), settlement and others respectively (ZOARD 2004). The study areas are shown in Figure 3.2.

Figure 3.2. Map of Ethiopia, the Amhara Region and the study districts



Source: Location of the study districts added based on map from Tesfaye Zegeye et al. (2001)

According to the CSA (2000) estimates, major crops grown in South Gondar are tef, barley, millet, wheat, maize, sorghum millet and oats according to their level of importance in terms of area coverage. Pulse crops, such as Horse beans, field peas, chick peas and lentils are also important crops grown in the zone next to cereals. Other crops include oil seeds and spices.

### Farta *Wereda*

Farta is one of the 105 *wereda* of the South Gondar Administrative Zone, bordered to the South by Estie, to the West by Fogera, to the North by Ebenat, and to the East by Lay Gayint. The *wereda* lies between the coordinates of 11$^0$32’ to 12$^0$03’ latitude and 37$^0$31’ to 38$^0$43’ longitude, and covers an estimated area of 1,118 km$^2$. Altitudes vary

between of 1,900 and 4,035 meters above sea level, and in terms of topography 45% of the total area is considered as gentle slopes, while flat lands and steep slopes respectively, account for 29 and 26%. An estimated 65% of the total land area is cultivated and planted with annual and perennial crops, while area under grazing and browsing, under forests and shrubs, under settlement, and wastelands account for about 10%, 0.6%, 8% and 17% respectively.
Tef, barley, wheat and millet are among the major crops grown in the *wereda*.

Agro-ecologically, about 44% of the *wereda* is classified as *dega* (cold) while the remaining 56% is considered as *weina dega* (mid altitude) (WOARD 2004).

The average rainfall is 1,570 mm per year distributed over two growing seasons, the *meher* (long cycle) season and *belg* (short cycle) season. Soil erosion rate in the area is very high, and a large share of the land has shallow soils causing reduction of soil depth which affect crop rooting depth and thus crop yields, which in turn, affects household food security.

### Estie *Wereda*

Estie *wereda* is located between 11°10' -11°56’ north latitude, and 37°46`-38°14` east longitude, and covers an area of 2,228.22 km². It is bordered to the South by the Abay (Nile) river which separates it from the East Gojjam Zone, to the West by Dera, to the northwest by Fogera, to the North by Farta, to the northeast by Lay Gayint, and to the East by Simada *wereda*.

The *wereda* is inhabited by over 394,111 people in 2005 (Table 3.1). Most of the areas of the *wereda* are more than 1900 meters above sea level, and altitude decreases as one moves from the northern part towards the South. The topography of the *wereda* comprises mountainous areas, rugged terrain, plains, valleys and gorges. The *wereda* is divided into three agro-climatic zones namely: *kolla, weina-dega and dega*. Rainfall is highly variable and so are the soil types which include Lithosols, Regosols, Vertisols, Andosols and Luvisols. The major crops grown in the *wereda* include: tef, wheat, sorghum, peas and beans.

Table 3.1. Rural and urban population of South Gondar, Farta and Estie districts by sex, area and density

| | South Gondar | | Farta | | Estie | |
|---|---|---|---|---|---|---|
| | **N** | **%** | **N** | **%** | **N** | **%** |
| **Rural** | | | | | | |
| Male | 1,105,616 | 50.9 | 151,938 | 51.3 | 190,927 | 50.7 |
| Female | 1,066,339 | 49.1 | 144,128 | 48.7 | 185,448 | 49.3 |
| Sub total | 2,171,955 | 100 | 296,066 | 100 | 376,375 | 100 |
| **Urban** | | | | | | |
| Male | 94,806 | 49.1 | 2,780 | 47.4 | 8,743 | 49.3 |
| Female | 98,308 | 50.9 | 3,081 | 52.6 | 8,993 | 50.7 |
| Sub total | 193,114 | 100 | 5,861 | 100 | 17,736 | 100 |
| **Grand total** | 2,365,069 | | 301,927 | | 394,111 | |
| Population density/km$^2$ | 165.0 | | 236.9 | | 166.4 | |

Source: Calculated on the basis of CSA data (2005)

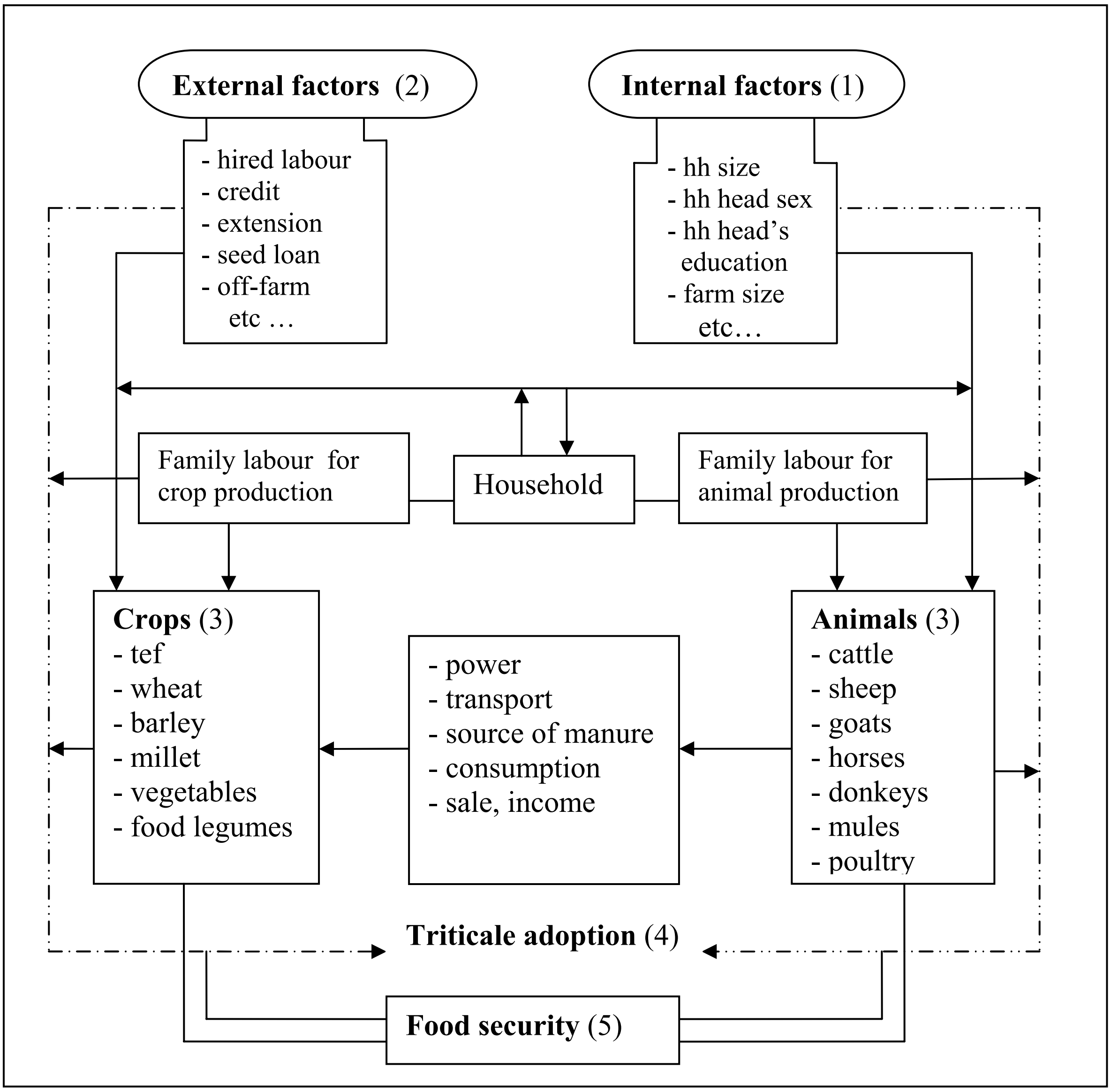
# 4 DEMOGRAPHIC, INSTITUTIONAL, SOCIOECONOMIC AND OTHER FACTORS AFFECTING TRITICALE ADOPTION AND FOOD SECURITY

## 4.1 Demographic profiles of triticale-growing and non-growing households

Animal and crop production are the major activities in the study areas and the major source of food and income. The intensity and production of these activities by a smallholder is influenced by several agricultural production factors. The purpose of this chapter is to present the main determining factors that can influence the farmers' decision for the growing of triticale crop. Based on the research results related to the growing or adoption of triticale in the study areas, two major production factors (Internal and External factors) are identified to have significant impacts on the adoption of the crop. The internal production factors include: demographic characteristics (e.g. family size, age, gender, education level) and the external production factors, such as agricultural extension services, availability of farm credits, availability of external labour and affordability of farmers to hire them. are thought to have significant impacts on farmers decision to integrate the "new" crop into their present farming systems in order to improve their household food security situation, which means reducing the time span of food deficit periods and the volume of the food deficit.

The current study deals with the decision making by farmers to grow triticale and integrate it into their crop farming systems. However, on the one hand, the behaviour of farmers to grow the crop can be mainly determined by the objectives, strategies and the resources available to them. On the other hand, based on considerations that farmers may not be easily convinced of the need of adopting a new technology and its impacts on their immediate needs, we differentiate between internal and external production factors that could determine farmers' decision of growing triticale. The demographic and institutional (internal and external production) factors are schematised in Figure 4.1 and discussed thereafter.

Figure 4.1. Schematic illustration of the relationship between internal and external factors affecting triticale adoption, and food security



Note: hh = *household*

Source: Author, conceptualized based on Beets (1990)

Agricultural systems depend heavily on the character of production, i.e. whether crops are produced in subsistence or market economy. According to Beets (1990), one of the main features of subsistence farming is that the farmer has to produce in order to live. Subsequently, he often resists changing production methods since, when the changes turn out to be unproductive, his livelihood and survival are threatened.

**Internal production factors** (1), such as availability of working household labour, gender of the household head, educational level of the household head, availability and accessibility of farmland may lead to a higher production system of both, crop and animal husbandry (3) that can in turn lead to a process of commercialisation through the use of purchased farm inputs and diversification of or specialisation of farm products. As a result, it is assumed that farmers will have the desire to try out new and productive implements, in this case to grow triticale (4), which can provide surplus production, which means more food for consumption and even for sale will be available (5).

In mixed farming systems, like that of the study areas, animals can be raised for a multitude of purposes. Oxen are universally used as draught power; pack animals are used for transporting goods and sometimes also to cultivate crop fields. Rearing chicken is also a common practice in the study areas and can supply the household with consumption and supplement income for the purchase of other household items.

**External production factors** (2): Surplus production and the integration of the triticale crop into the existing farming system can be impacted by several exogenous production factors, such as the availability of hireable workforce and of being in a position to hire any, accessibility of farm credits, availability and accessibility of farm production related information (extension services), availability of other incentives, for example, seed loan and off-farm employment that could bring additional income for the purchase of farm inputs like improved seeds, chemical fertilizer and pesticides.

Based on own observations made during the field survey, literature review with regard to the determinants that influence farmers' decision for technology adoption and the survey results, the variables shown in Table 4.1 related to the demographic, institutional and socio-economic situations of triticale growing and non growing households are hypothesized to influence the decision of farming households to adopt the triticale crop.

Table 4.1. Expected effects of the independent variables selected for the regression on the decision to grow triticale

| Variable | Expected sign of relationship |
|---|---|
| FAMSIZE - number of persons in the household (con) | + |
| AGEHEAD – refers to the age of the household head in years (con) | + |
| GENDER – gender of the household head (dum) | + |
| MARSTAT – marital status of the household head (dum) | + |
| FARMSIZE – the total size of cultivated land (con) | + |
| EDULEVL – the level of education of the household head (con) | + |
| LVSTOCK – livestock ownership of the household (con) | + |
| NOXEN – number of oxen households own (con) | + |
| CREDIT – availability of credits to farmers (dum) | + |
| OFRINCOM – income sources other than crop- and animal production the hh earned in 2005 (con) | + |
| GRAINAID – if food or seed grain aid/ loan was obtained (dum) | + |
| PURINPUT- purchase of fertilizer made in (2005) (dum) | + |
| RODTNCE – distance of all weather road from households' farm to the (WOARD), measured in total time it takes on foot (con) | - |
| DMARKT – distance of farmer's residence from the nearest market (con) | - |
| EXTNSON – if farmers have access to agricultural extension services and information (dum) | + |
| Note: con. = continuous variable; dum. = dummy variable | |

The independent or explanatory variables included in the regression are described above together with their expected effects on the decision by the farmer to grow triticale.

### 4.1.1 Gender, age, marital status and family size of the household head

As explained in section 3.3.4, GENDER of the household head was assumed to influence the farmers' positively to grow triticale. About 73% of growers and 75.5% of non-growers were male headed households. The chi-square analysis of the mean difference ($X^2$=1.06) did not reveal systematic relationship between GENDER and the decision for growing triticale (Table 4.2). The age (AGEHEAD) of the farmer in years, is one of the characteristics that is frequently mentioned in the literature as a factor in the adoption of new technologies. In this survey age too, was assumed to influence the farmers' decision to grow triticale positively.

It is expected that younger farmers will be more receptive to new technologies and thus more innovative than older farmers, who may be more experienced or wealthier and may make them more willing to try new technologies. In our study, the growers (42.7 years) were slightly younger than non-triticale growers (43.4 years). However, the mean difference in age of growers and non-growers (t=0.61) did not indicate any statistically significant association between age of household head and growing of triticale.

Another factor that was expected to play a role in determining the growing of triticale is the marital status. Marital status (MARSTAT) of the household heads was considered to positively affect farmers in their decision to grow triticale or not. The majority of growers (74.5%) and 76% of non-growers respectively, were married and there were more widowed heads (12.8%) by growers than by non-growers (8.8%). The results of the descriptive analysis (the t-test) did not suggest the existence of significant differences in the marital status between triticale growing and non-growing households. Nevertheless, there exist some differences in the proportion of categories between the two households.

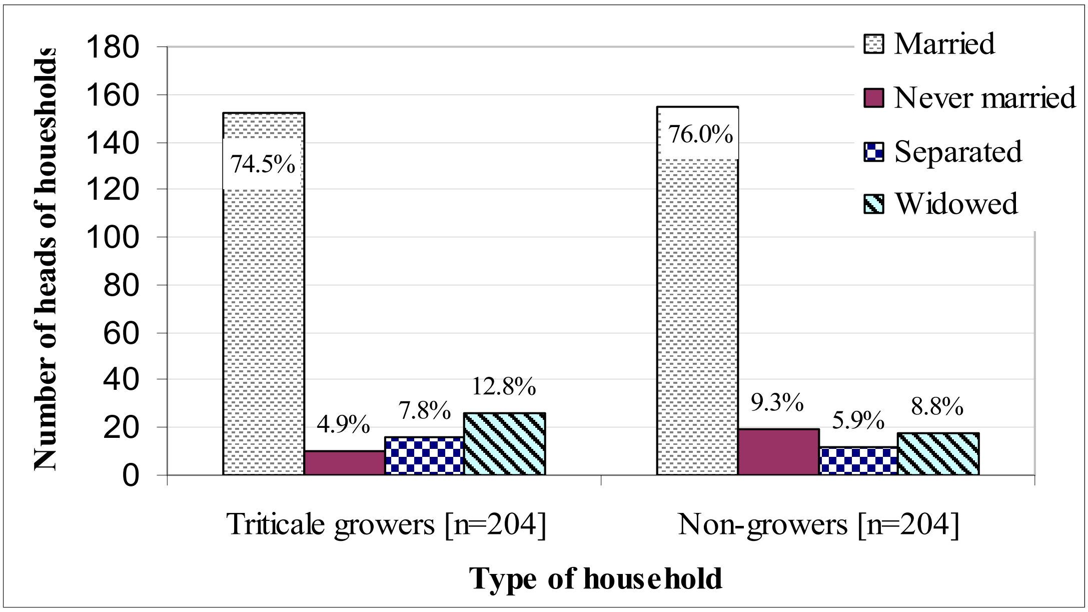
Table 4.2. Frequencies and percentages of the marital status (ms) of the sample households with and without triticale adoption

| | **Triticale growers** | | **Non-growers** | |
|---|---|---|---|---|
| **Category of ms.** | **N** | **%** | **N** | **%** |
| Married | 152 | 74.5 | 155 | 76 |
| Separated | 16 | 7.8 | 12 | 5.9 |
| Never married | 10 | 4.9 | 19 | 9.3 |
| Widowed | 26 | 12.8 | 18 | 8.8 |
| Total | 204 | 100 | 204 | 100 |

Source: own survey

Out of the total triticale growers 7.8% were separated and 4.9% live unmarried, 9.3% of non-triticale growers had never married and 5.9% were separated (Table 4.2). Percentages and frequencies of the categories in marital status is illustrated in Figure 4.2.

Figure 4.2. Percentage of the categories in marital status



Source: Based on data from the survey

Family size (FAMSIZE) was expected to have a positive influence on farmers' decision to grow triticale. Triticale growers had slightly larger families (7.9 persons), consisting of 28% of children between 5 and 10 years, 29% adult males and 34% adult females above the age of 10 years including the housewife, 6% inactive old dependents and 3% under 5 years; compared to non-growers with about (7.5 persons) consisting of 33% of children between 5 and 10 years, 30 and 30% male and female adults, respectively, 5% children under 5, and just 2% inactive dependents. The demographic profile of the studied households, distributed by age, family size and labour availability is summarized in Table 4.3.

Table 4.3. Demographic profile of the sample households distributed by age, family size and labour availability

| | **Triticale growers** | | **Non-growers** | | |
|---|---|---|---|---|---|
| **Variable** | **Mean** | **Std** | **Mean** | **Std** | **T-value** |
| Farmer's age | 42.65 | 11.91 | 43.38 | 12.19 | 0.61 |
| Family size | 7.89 | 2.24 | 7.45 | 2.45 | 2.43** |
| Hh labour + hired | 3.91 | 1.66 | 3.84 | 1.68 | 0.42 |

Note: ** = high significant at p<0.05

Source: own survey

According to this descriptive statistic, triticale growing farmers have comparatively less children between five and ten years of age and a slightly lower number of female adult members in the family than the non-growers. However, in the context of growing decisions, the result was statistically insignificant except the difference in family size, which was high significant at 5% (t=2.43) level. Contrary to our expectations, physically inactive dependents - expected to cause labour constraint, thus less likelihood of adoption - seems to be higher in triticale growing families than in the non growing ones. As expected, higher family size has an important influence on the adoption of triticale crop. The results of the Probit regression are shown in Table 4.4.

Table 4.4. Results of the Probit regression model on the decision to grow triticale

| Variable | Estimated coefficient | T-value |
|---|---|---|
| FAMSIZE | 0.64781 | 2.325** |
| AGEHEAD | -0.06314 | -0.606 |
| MARSTAT | 0.04667 | 0.653 |
| GENDER | 2.68231 | 0.653 |
| EDULEVEL | 0.65834 | 2.130* |
| FARMSIZE | -0.31236 | -0.174 |
| PURINPUT | 0.05090 | 0.975 |
| EXTNSON | 0.83038 | 2.037** |
| LVSTOCK | 0.31653 | 2.531** |
| NOXEN | -1.06730 | -2.353** |
| CREDIT | -0.26400 | -2.705** |
| DMARKT | 0.08010 | 3.605*** |
| RODSTNCE | -0.61263 | -3.402** |
| OFRINCOM | -0.14540 | -0.435 |
| GRAINAID | 0.22523 | 3.010* |

Constant = - 2.97832
N = 389; missing values = 19
Pearson Chi-sq. ( $X^2$) = 162.305
Percent correctly predicted = 59.00

Note: * Significant at 10% level of error probability
** Significant at 5% level of error probability
*** Significant at 1% level of error probability

Source: own survey

As the Probit regression results in Table 4.4 indicate, there is a differentiated pattern of factors affecting the adoption of triticale crop. In this context, there are two (EDULVEL, GRAINAID) and six variables (FAMSIZE, EXTNSON, LVSTOCK, NOXEN, RODSTNCE, CREDIT), which are just significant at the 10% and high significant at the 5% level of error probability, respectively. A short market distance (DMARKT) from farmers' residence was hypothesized to influence farmers positively to grow triticale. The Probit regression of this variable on the dependent variable shows a statistically very high significant (1% level) difference between triticale growing and non-growing households. The independent variable FARMSIZE was predicted to influence farmers positively on the decision to grow triticale. This study, however, shows a weak significant relationship between farm size and the decision by farmers to grow triticale, which is contrary to our hypothesis that the larger the lands available to households are, the higher would be the probability to grow triticale.

Another important variable predicted to positively increase the desire of adoption of triticale, was the availability of grain aid or loan other than triticale seed (GRAINAID) during sowing season, which indicated a highly significant ($t=3.010$, $p<0.01$) influence on the growing of triticale.

### 4.1.2 Education level of the heads of households

The level of education (EDULEVEL) was hypothesized to increase the probability of growing triticale, since households with basic education might better obtain and process information about improved technologies. The chi-square test ($X^2 = 2.03$) suggests a highly significant difference in the education level between the two groups of households, confirming the association between education level and the growing or adoption of triticale. This indicates that households with some basic formal education knowledge have a higher probability of growing the crop than those without or less formal education. An important outcome related to the difference in education level between triticale growing and non-growing household heads is in the category of households with basic education ("read and write") and in the category "elementary school". The comparative analysis shows that nearly 39% of growers and only 26% of non-growers had basic formal education (able to read and write). About 27.5% of non-growers had elementary school education (up to 6th grade), contrary to nearly 21% of growers (Table 4.5). Only 4 persons (2%) and 6 persons (2.9%) of growers and non-growers, respectively, reached primary school grades (7-8). Remarkably, all of these households were also engaged in a semi-intensive beekeeping business which relaxes financial constraints of the household and thus enhances the purchase of agricultural inputs, such as triticale seed or chemical fertilizer. The education level of heads of the sample households are shown in Figure 4.3.

Table 4.5. Sample households distributed by gender, education and labour availability

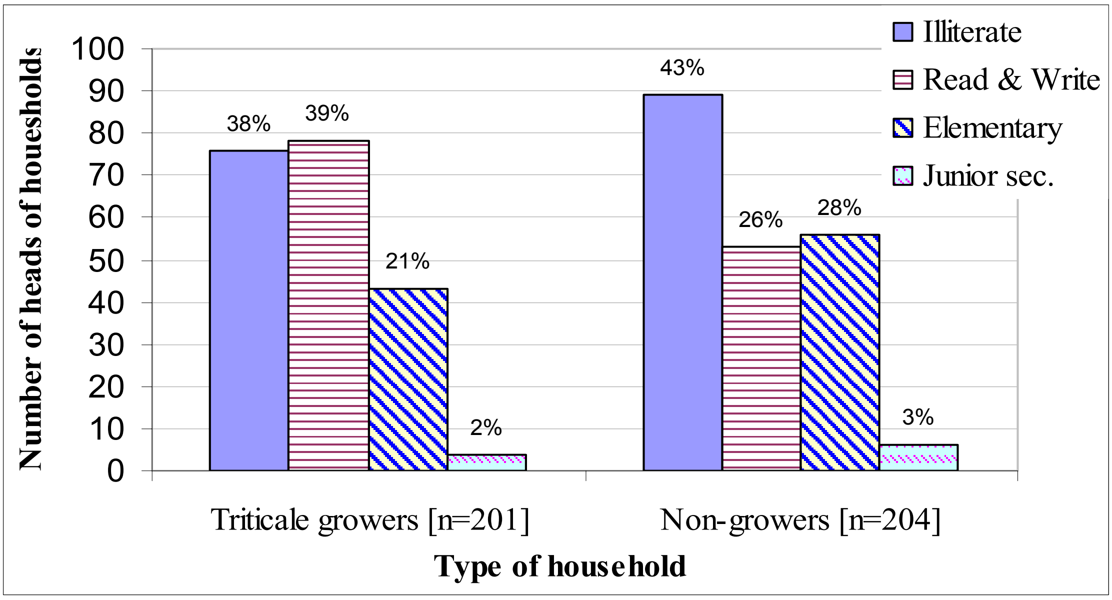
| **Variable** | **Triticale growers** (n=204) | | **Non-growers** (n=204) | | |
|---|---|---|---|---|---|
| ***Wereda*** | **Number** | **Percent** | **Number** | **Percent** | **$X^2$ value** |
| Estie | 131 | 64.2 | 117 | 57.4 | |
| Farta | 73 | 35.8 | 87 | 42.6 | |
| **Gender** | | | | | 1.06 (ns) |
| Male | 149 | 73 | 154 | 75.5 | |
| Female | 55 | 27 | 50 | 24.5 | |
| **Education** | | | | | 2.03** |
| None | 76 | 37.8 | 89 | 43.6 | |
| Read & write | 78 | 38.8 | 53 | 26 | |
| Elementary | 43 | 21.1 | 56 | 27.5 | |
| Junior sec. | 4 | 2 | 6 | 2.9 | |
| **Labour** <br> for livestock care | | | | | |
| hh labour | 166 | 81.3 | 162 | 79.3 | 1.25 |
| hired labour | 38 | 18.7 | 42 | 20.7 | 0.10 (ns) |
| **Labour** <br> for crop farming | | | | | |
| hh labour | 171 | 83.8 | 158 | 77.5 | 2.32** |
| hired labour | 33 | 16.2 | 46 | 22.5 | 1.08 |

Note: ns = not significant; ** = high significant at $p<0.05$

Source: own survey

Since Ethiopia is undergoing a major transition in its education infrastructure since the early 2000's, the sector has shown a remarkable improvement even in the pastoral areas. A government report to UNESCO (FDRE 2004) indicated that improvements in access and coverage of primary education were achieved, and gender rural-urban disparities were reduced over the years. Nevertheless, school children have to travel a long distance as schools are scarcely available in short distances, and, as a result, the number of out-of-school children is reported to increase in the study areas. In this regard, households were asked at which distance from their residence schools are available to their children. The comparative analysis results are shown in Table 4.6. Most triticale growers (nearly 29% of total) reported that their children walk about 7 km daily. This was not so much higher than reported by non-triticale growers (23.5%). "We want the children to assist at the household or in the field after school but as they travel too long distance to and from school, they don't arrive on time to take up some responsibilities like weeding, looking after animals and fetching of water" said one respondent in one of the peasant associations in Farta district. Some of the key informants in Estie were also of the opinion that though, they had seen a number of primary schools opened in their respective areas, there is still a long way to go to narrow the gap of disparities in school availability among the different districts in the study areas.

Figure 4.3. Education level of heads of triticale growing and non-growing households



Source: Based on data from the survey

Table 4.6. Distribution of sample households regarding distance of school from the family residence (km)

| | Triticale growers | | Non-growers | | |
|---|---|---|---|---|---|
| **Distance to school** | **N** | **%** | **N** | | **%** |
| 1-3 | 17 | 8.3 | 40.0 | | 19.6 |
| 3.5 -5 | 44 | 21.6 | 39.0 | | 19.1 |
| 5.5-7 | 26 | 12.7 | 27.0 | | 13.2 |
| 7 and above | 59 | 28.9 | 48 | | 23.5 |
| No school in my village | 38 | 18.6 | 37.0 | | 18.1 |
| Don’t now | 20 | 9.8 | 13.0 | | 6.4 |
| | **Mean** | **Std** | **Mean** | **Std** | **T-value** |
| | 2.44 | 1.45 | 3.21 | 1.58 | 5.13*** |

Note: *** = very high significant at p<0.01 level

Source: own survey

### 4.1.3 Availability of labour and its impact on the decision to grow triticale

The total labour capacity in a given household was hypothesized to influence households’ decision to adopt triticale. The capacity of households to employ external labour varies from group to group and point of time external labour is needed. In the study, about 18.7% of triticale growers and 20.7% of non-growers acquired hired labour for livestock care, compared to 33% and 22.5% for crop production respectively. This difference was statistically not significant. For both, triticale growers and non-growers the main activities for men within the household included land preparation, sowing, fertilizer and pesticide application. Women, children and hired labour (if any) were mainly involved in weeding, harvesting, threshing, grain transport from field to household's residence and storage. The household labour availability for crop production was (83.8% for growers and 77.5% for non-growers), which is about 6% higher for triticale growers and is significant at the 5% level of (t = 2.32, p<0.05) significance.

## 4.2 Institutional and other factors influencing the decision to grow triticale

Important institutional services, such as distance of rural roads to the *wereda* agricultural offices, where the farmers can acquire farm information, agricultural extension services, availability of farm credits and access to markets are important institutional services through which the farming community may require to increase its agricultural productivity by adopting new technologies and research findings. The study predicts that the probability of adopting triticale as a new crop by farmers will increase with access to all-weather roads, farm information, market- and credit-accessibility which will enable them to purchase farm inputs, such as seed and commercial fertilizer to enhance yields.

### 4.2.1 Road distance to the Wereda Office of Agriculture and Rural Development

Availability of all weather roads (RODSTNCE) is an important service to farmers as this is crucial to transport farm inputs and sell own farm products. However, this variable in this study was considered only in relation to the time it takes the farmer to reach the WOARD by foot, as public transport in the area is almost non existent, except from the capital cities of the respective districts to the zonal capital, Debretabor and vice versa. Subsequently, farmers were only asked how many hours they are supposed to trek from their farm to WOARD. The variable represents the distance it takes in hours from the farm to the respective WOARD, where the farmer can acquire agricultural inputs and technical assistance. The factor road is hypothesized to play an important role for the farmer in deciding whether to use a new technology, such as triticale and other improved crops. The longer the distance, the higher the costs of acquiring the seed is, and the more difficult for receiving information about its characteristics and management requirements could be. This is also consistent with findings in other studies on the adoption of new technologies, for example (Sain and Martinez (1999-2004). In an inverse relationship, farmers located further from WOARD are hypothesized to have a smaller probability of adopting triticale.

From among the total triticale growing respondents (n=194), 40% responded to have been trekking an average of 3-4 hours to reach their respective WOARD, which they say is relatively less tiresome nowadays as compared to some 5 years ago when they were supposed to travel several hours to consult agricultural officers. With regard to non-growers, about 18% of the total respondents (n=193) were to this opinion. Nearly 15% of triticale growing and 13.2% of non growing farmers had to travel by feet just 3 hours. The percentage and frequencies of the comparative analysis is presented in Table 4.7. As the descriptive analysis (t=3.51, p<0.01) suggests, the mean difference between growers and non-growers with regard to the road distance from households' farm lands to the WOARD is statistically very high significant at the 1% level. This difference between the two households implies that triticale growing farmers are more likely to receive more intensive field assistance or information from WOARD about new technologies as the time required for the farmer to reach WOARD is relatively shorter and less tiresome.

Table 4.7. Distribution of sample households regarding road-walking distance from crop fields to WOARD

| | **Triticale growers** | | **Non-growers** | |
|---|---|---|---|---|
| Distance from farm land to the WOARD | **N** | **%** | **N** | **%** |
| Up to 3 hours | 30 | 14.9 | 27 | 13.2 |
| Within 3.5-4 hours | 81 | 40.1 | 37 | 18.1 |
| Within 4.5-5 hours | 24 | 11.9 | 45 | 22.1 |
| Within 6 hours | 24 | 11.9 | 25 | 12.3 |
| No all-weather road at all | 28 | 13.9 | 50 | 24.5 |
| Don't now | 15 | 7.4 | 20 | 9.8 |
| | **Mean**<br>2.92 | **Std**<br>1.53 | **Mean**<br>3.46 | **Std** **T-value**<br>1.58 3.51*** |

Note: *** = very high significant p<0.01 level

Source: own survey

### 4.2.2 Access to agricultural extension services

Apart from the support obtained from the agricultural experts of the GTZ specially with regard to the implementation and expansion of triticale crop, agricultural extension services provided by the Ministry of Agriculture and Rural development are the major sources of information in both, Farta and Estie districts. Numerous studies associate extension service (EXTNSON) positively or negatively to technology adoption. For example, Polson and Spencer (1991) find the level of extension services to be positively related to the adoption of improved cassava in Nigeria. On the other hand, a number of studies find no statistical relationship between outside links and adoption of new technology. For example, Abd-Ella, Hoiberg, and Warren (1981) find the scale of extension contact to be insignificant in the adoption of recommended farm practices in Iowa State of the United Sates of America. Kaliba et al. (1998) also find extension contact to be insignificant in the adoption of inorganic fertilizer for maize production in western Tanzania, and Neill and Lee find extension to be insignificant in the adoption of cover crops in Honduras. In the present study, extension is assumed to play a significant role in the decision by farmers to grow or adopt triticale crop. Subsequently, both, triticale growers and non-growers were asked if they contacted the extension officers in 2005 cropping seasons and if yes, how frequently they contacted them. The survey result suggests that 95.4% (185 hhs - households) of total triticale growing sample farmers had access to agricultural extension services compared to 85.5% (165 hhs) of the total non–grower respondents in the study areas. The mean difference in access to extension service (t=3.45) was significant at the 1% (p<0.01) level. Also the mean difference in contact frequency (t = 3.37) was significant at p<0.05 level. The result is consistent with the hypothesis on the importance of agricultural extension on triticale adoption. The comparative analysis on extension services is shown in Table 4.8, and illustrated in Figure 4.4.

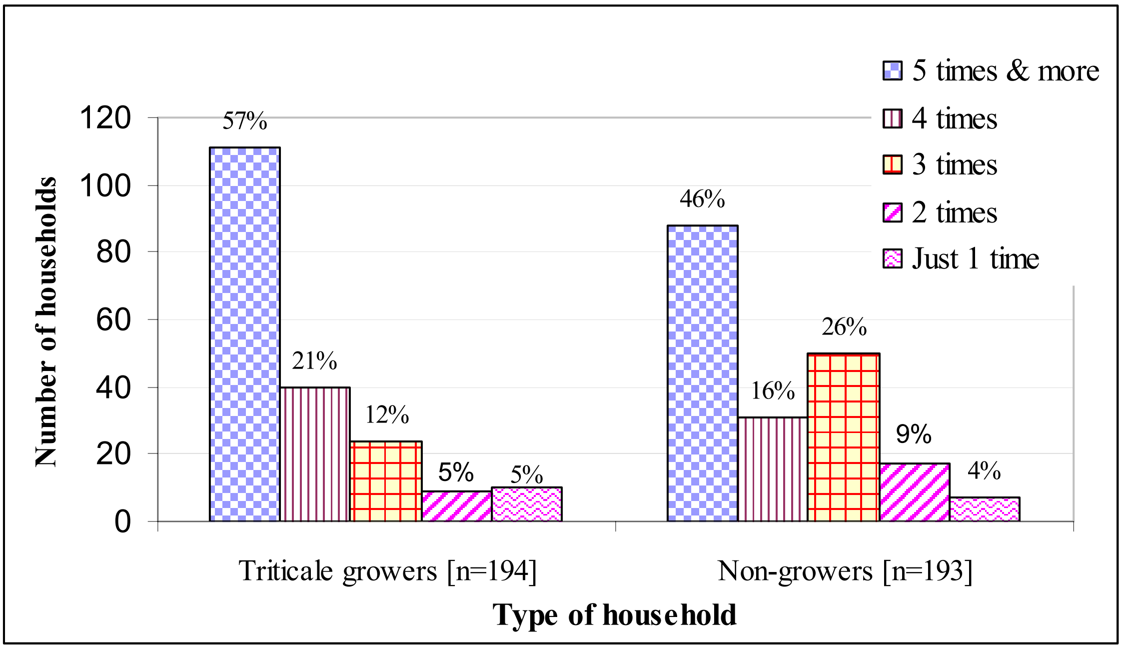
Table 4.8. Distribution of sample households frequency of contacts with extension service agents per cropping season

| | **Triticale growers** | | **Non-growers** | | |
|---|---|---|---|---|---|
| **Does hh receive** | | | | | |
| **Extension** Yes | 185 | 95.4 | 165 | 85.5 | |
| No | 9 | 4.6 | 28 | 14.5 | |
| | **Mean** | **Std** | **Mean** | **Std** | **T-value** |
| | 1.05 | 0.21 | 1.15 | 0.35 | 3.45* |
| **Contact frequency** | **N** | **Percent** | **N** | **Percent** | |
| 5 times & more | 111 | 57.2 | 88 | 45.6 | |
| 4 times | 40 | 20.6 | 31 | 16.1 | |
| 3 times | 24 | 12.4 | 50 | 25.9 | |
| 2 times | 9 | 4.9 | 17 | 8.8 | |
| Only one time | 10 | 5.2 | 7 | 3.6 | |
| | **Mean** | **Std** | **Mean** | **Std** | **T-value** |
| | 1.80 | 1.45 | 2.09 | 1.18 | 3.37** |

Note: **,* high significant at 5% and very high significant at 1% level, respectively

Source: own survey

Figure 4.4. Distribution of sample households frequency of contacts with extension service agents per cropping season



Source: Based on data from the survey

### 4.2.3 Access to market centres and marketing

Farmers in the study areas often have little market outlets for their returns, and they often get discouraged not to buy fertilizer or adopt other recent technologies. Therefore, intra-district and intra-regional markets need to be developed so that farm products can be moved from where they are produced to where they are needed. In Ethiopia, it is common to see one part of the country with surplus production, where the farmers do not know how to store the excess produce, and another part (for e.g. the study areas) where people are lacking daily meals.

Improved marketing can help alleviate rural food insecurity and boost farmers' incomes. As is the case elsewhere in the country, private wholesalers are the main marketing intermediaries linking, both, producers and consumers, in the study areas. Marketing in the areas includes selling and buying of agricultural goods, live animals and other basic commodities. Long market distances (Table 4.9) and scarcity of all weather roads, absence of storage facilities and the squeezed market for perishable crops were among the most fundamental market related constraints mentioned by both, triticale producing and non producing households in the study districts. As a result farmers are usually obliged to bring out their produce to the market for cheap prices during harvest seasons. In cases of some high crop potential districts of the Amhara Region, prices paid for agricultural products can be at least half times lower than they are few months after harvest seasons. With regard to perishable crops, such as potatoes, tomatoes and cabbages, farmers often have no other alternative than selling them at any given price, otherwise they may have to leave it at the market in order not to pay high transport fees. Some farmers have reported during the survey that they sometimes had to empty their potato sacks at the market as the value of the sack and transport exceeds the price of the goods during harvest times. This has indeed, a discouraging effect on farmers' decision to produce potatoes and other easily perishable crops. Obviously, the wholesalers are the ones in the bargaining position, who are thus usually making profit at the cost of poorer households.

Table 4.9. Distribution of sample households regarding market distance from their residence

| | **Triticale growers** | | **Non-growers** | | |
|---|---|---|---|---|---|
| Market distance from hh's residence | **N** | **%** | **N** | **%** | **T-value** |
| About 4.5 km | 106 | 53 | 79 | 38.7 | |
| About 5.3 km | 29 | 14.5 | 43 | 21.1 | |
| About 35 km | 65 | 32.5 | 82 | 40.2 | |
| | **Mean** | **Std** | **Mean** | **Std** | |
| | 1.8 | 0.9 | 2.01 | 0.89 | 2.47** |

Note: ** = high significant at 5% level

Source: own survey

As is indicated in Table 4.9, for the majority of triticale growing farmers, the market is within 4.5 km from their residence, while many others have to travel as far as 35 km to come to the biggest open market in the area. About 40% of non-growers have also responded that they travel as far as 35 km, while almost similar number of people can reach the market within 4.5 km distance.

### 4.2.4 Availability of and access to farm credits

One critical factor behind continuing poverty and food insecurity in the study areas can be the lack of access to start up capital, either in cash or in kind that would allow subsistence households to accumulate a working capital to start up off-farm activities as sources of income. Access to credit was hypothesized to have an important contribution towards growing triticale by farmers. In the study districts, 27.9% and 30.4% of growers and non-growers respectively, obtained cash credits from money lending individuals and other informal sources; out of which triticale growers (63.2%, 36.8%) and non-growers of triticale (59.7%, 40.3%) reported to have obtained cash loan from the Amhara Credit and Saving Institute (ACSI) and private money lenders respectively. The chi-square analysis, however, did not show a significant relationship between triticale growers and non-growers and access to farm credits (Table 4.10). The assumption was that both, categories of farmers with access top credits will have a greater probability to purchase agricultural external inputs, such as triticale seed and chemical fertilizer. However, both groups of households who obtained farm credits from ACSI reported that the purpose of the credit was to purchase mother-sheep for further multiplication with the hope that this would allow them to accumulate assets that they can resell or consume, for example, during food shortages.

Table 4.10. Distribution of sample households by access to cash loan, grain loan, seed loan or gift, and agricultural extension service

| | | **Triticale growers** (n=204) | | **Non-growers** (n=204) | | |
|---|---|---|---|---|---|---|
| **Access to resources** | | **Frequency** | **Percent** | **Frequency** | **Percent** | **$X^2$-value** |
| **Cash credit** | Yes | 57 | 27.9 | 62 | 30.4 | |
| | No | 147 | 72.1 | 142 | 69.6 | |
| | Total | 204 | 100 | 204 | 100 | 1.11 (ns) |
| **Source of credit** | | | | | | |
| | Individual | 21 | 36.8 | 25 | 40.3 | |
| | ACSI | 36 | 63.2 | 37 | 59.7 | |
| | Total | 57 | 100 | 62 | 100 | (nc) |
| Grain loan/gift | Yes | 38 | 38.2 | 32 | 15.7 | |
| | No | 166 | 61.8 | 172 | 84.3 | |
| | Total | 204 | 100 | 204 | 100 | 1.14 (ns) |
| Seed loan/gift | Yes | 78 | 38.2 | 68 | 33.3 | |
| | No | 126 | 61.8 | 136 | 66.7 | |
| | Total | 204 | 100 | 204 | 100 | 1.06 (ns) |
| **Seed loan** | BoA | 28 | 35.9 | 35 | 51.5 | |
| | CfW, FfW | 50 | 64.1 | 33 | 48.5 | |
| | Total | 78 | 100 | 98 | 100 | (nc) |
| Food aid | Yes | 27 | 13.2 | 34 | 16.7 | |
| | No | 177 | 86.8 | 170 | 83.3 | |
| | Total | 204 | 100 | 204 | 100 | 1.22 (ns) |
| Access to extension | | | | | | |
| | Yes | 185 | 95.4 | 165 | 85.5 | |
| | No | 9 | 4.6 | 28 | 14.5 | |
| | Total | 194 | 100 | 193 | 100 | 2.84** |

Note: nc, ns, ** = not calculated, not significant and high significant at 5% level, respectively

Source: own survey

The most important problem with regard to taking up credits was that farmers were often forced to repay their loan, also if crop had failed due to drought, pests and diseases or had very low prices during harvest. This was reported by both, triticale growers and non growing farmers in the study areas. Previous surveys, for example from Devereux (2000) show that no grace periods or write-offs were given in drought years and farmers are forced into selling their agricultural production at low cost harvest prices to pay back their credits.

### 4.2.5 The availability and role of irrigation water for triticale adoption

Irrigation is naturally a critical component in reducing climate risk and improving crop production. Reducing climate risk can also help to induce the use of modern inputs, such as fertilizers and improved seeds, thereby further enhancing agricultural productivity and ensuring food security. As of 2003, irrigated area, in Ethiopia totalled about 200,000 hectares, slightly more than 2% of the total crop area (IFPRI 2005). With a long history of famine and food insecurity, and where rural poverty is a major concern in Ethiopia, developing irrigation schemes of any scale could be one essential element that the rural community can benefit from. Alongside with the adoption of improved technology, expansion of irrigation schemes is seen as an important stimulating input for farmers to increase agricultural production, thereby reducing the problems of food insecurity and alleviating rural poverty. According to the IFPRI report from agricultural sample surveys, the yield gap between irrigated and rainfed crop production was 40%, meaning that, on average, irrigation would potentially increase cereal yields by up to 40%.

Triticale in Estie *wereda* was more widely adopted than in any other district in Ethiopia during the 2005/06 main crop season. Triticale seed was not only acquired from the SUN-Amhara project but also multiplied in own plots with irrigation during the dry season. The *wereda* has also managed to purchase additional seeds despite its quite limited financial resources. As the author was told by the agricultural extension team leader of Estie *wereda*, the office obtained up to 4.8 tonnes of grain per ha from own multiplication fields which were then further disseminated to the surrounding farmers, which could be seen as exemplary to other *wereda*. A previous report indicated that from irrigated plots of 0.75 ha, up to 2.4 tonnes of grain was harvested. The high motivation of the farmers, and the *Wereda* Agricultural and Rural Development Office, is attributed to the fact that the agriculturalists were convinced of the merits of the crop to multiply it on their own trial fields so as to supply the seed to the farmers in time without waiting for seeds from the GTZ/SUN-Amhara project office.

## 4.3 The socioeconomic profile and food security situation of the sample hhs

### 4.3.1 Basic household needs in the study areas

Increased agricultural productivity is assumed to enable farmers to grow more and diversified food crops, which can translate into diversified diets and into higher farm incomes. Von Braun et al. (2004), for example, argued that with more money available, farmers are more likely to diversify production and grow higher-value crops, benefiting not only themselves but the economy as a whole. This income and asset security helps to build a solid foundation for economic growth by enabling people to work free from the debilitating effects of hunger and undernutrition. These authors further claim that faster agriculture based growth rates, favourable macroeconomic and trade policies, good infrastructure, access to credit, access to land, and markets must be put in place to achieve food security, which they believe would give farmers incentives to adopt new and sustainable technologies and diversify production into higher-value crops that raise incomes and lift households out of poverty.

There are different conceptual approaches to the indicators of human welfare at household level. Household surveys are thought to be most important sources of data for comparing food security and level of poverty, which can tell us directly about the living conditions or standard of living of the studied households. In similar studies, Ravallion (1992) pointed out that the most common indicators of standard of living are based on household consumption expenditure and household income. Some studies collect both variables namely, consumption expenditure and income. In our survey, both variables were considered important to indicate the food security and the overall living conditions of the households in the study areas. Consequently, the household heads were asked how frequently the adults and their children have been eating during the “worst dry” and “normal” seasons; the availability of clean drinking water in comparison to some ten years ago; how many times the family buys clothes per year; how much money the households spends for food and non food items, and whether the household possess a grass- or metal-roofed house, the latter being assumed to show a relative sign of household prosperity or wealth.

#### 4.3.1.1 Availability of food and clean drinking water

The availability of clean drinking water was used as a further basic food security indicator. Subsequently, households were asked to list their water sources ten years ago and their availability in the last twelve months. The water infrastructure, particularly in the study areas and the region as a whole, is poorly developed. 210 respondents reported that river streams and ponds were the major sources of their drinking water ten years ago, whereas this number has trimmed by more than half (98 households) in the last twelve months. Out of a total of 395 respondents, 197 households reported that they had access to public water in the last twelve months, while ten years ago there were only 148 households with access to public tape water. 100 and 38 people respectively, have reported that they were using hand dug wells ten years ago up until 2005 and during the last twelve months (Table 4.11).

Table 4.11. Comparison of water sources and improvement in the last 10 years

| **Water source** | **10 years ago** | | **Last 12 months** | | **Difference** | | |
|---|---|---|---|---|---|---|---|
| | **N** | **%** | **N** | **%** | **(%)** | **Mean** | **T-value** |
| Public tap/stand pipe | 148 | 37.4 | 197 | 49.9 | 12.5 | | |
| River, streams, ponds | 210 | 53.0 | 98 | 24.8 | -28.2 | | |
| Hand dug well | 38 | 9.6 | 100 | 25.3 | 15.7 | | |
| Total | 396 | 100 | 395 | 100 | | 0.03 | 0.61 ns |

Note: ns = not significant

Source: own survey

Though the mean difference between clean water availability ten years before and in the last 12 months did not confirm a significant improvement, the number of people using public tape water has increased from nearly 37% ten years ago to nearly 50% in 2005, implying that there is 12% increase in clean water availability in the study areas. Most importantly, the number of people that were fetching their drinking water from rivers and water ponds decreased from 53% ten years ago to about 28% in the survey year. As a result of an increment in availability of hand dug wells, the number of people that obtain water from this source has also increased accordingly. Nevertheless, in terms of irrigation water availability and access, there was no single respondent who engaged himself in irrigation activity from both, triticale producers and non-producers in both study districts. This indicator implies that though, there were some encouraging results in terms of safe drinking water accessibility, attention needs to be paid also to irrigation infrastructure.

In the entire study *wereda*, agriculture is non-irrigated and depends almost entirely on rainfall stored in the soil profile, which is only possible on areas where rainfall distribution ensures continuous availability. However, as steep slopes and mountains dominate the study areas, rainwater harvesting not only provides more water for the crop but can also add to groundwater recharge and help to reduce soil erosion. Other methods are based on collecting water from the local catchments and either relying on storage within the soil profile or else local storage behind bunds or ponds and other structures for use during dry periods. A 2003 Report on Food and Water Studies by FAO (2003) indicates that conservation agriculture practices, such as conservation tillage, have proven to be effective in improving soil moisture conservation from which the Ethiopian farmers can benefit.

Availability of irrigation water could facilitate a possible shift from monoculture crops, like tef to other crops, such as maize, vegetables, and fodder legumes that could help the rural households in food self-sufficiency and enhance additional income. Since water is a key ingredient to food security, the lack of it can be a major cause of famine and under nourishment, specially in the study areas where almost all people depend on subsistence agriculture for consumption and source of income. Also, the FAO Report on food and water indicates that people who have better access to safe water tend to have lower levels of undernourishment, and the population shift from rural to urban environments might increase the competition over water with pressures and problems associated with food security. Availability of irrigation water with a combination of high-yielding crops, such as triticale, plant nutrition and pest control will undoubtedly increase the volume of production and diversify the type of goods consumed. A strong majority of key informants in Farta *wereda* stated during a group interview, that development and management of water resources, particularly in rural *kebele* of their respected *wereda* was very limited. They further reported that this was the key for improving food security and reducing poverty, specially in the Amhara highlands, including Farta to which, the stakeholders so far have paid little attention to.

#### 4.3.1.2 Availability of non-food basic household needs

The ability of households to satisfy there overall food and non-food needs, particularly in the Amhara highlands, may have a significant influence on the estimates of the relative level of well-being and income distribution.

One feature of our particular interest in integrating this data (non-food basic needs) was to estimate the absolute level of poverty line and its linkage to food security in the study areas.

An absolute poverty line can be calculated based on the household income required to satisfy a set of minimum requirements, such as daily meal intake frequency, access to safe drinking water, sanitation and shelter. According to Sainz (2003) absolute poverty is defined more broadly as “a condition characterized by severe deprivation of basic human needs, including food, safe drinking water, sanitation facilities, health, shelter, education, information and access to social services".

In our study, about 75% of the households participating in the field survey indicated that they have grass-roofed houses. Nearly 45% of them have reported, however, that to have adequate amount of money for purchasing food and non-food items was more important than the problem of housing which to them is minor in comparison. The advantage of this indicator is that the interviewers were able to observe the houses directly, rather than elicited from the respondents.

Households with metal roofed houses and those with two or more grass-roofed houses were considered as not poor in relative terms. Households who are, for example, unable to provide a separate shelter for their animals, unable to maintain their houses against rain and unable to meet their basic needs, like food and shelter were considered by the study as absolute poor. Almost all (90%) the respondents also reported that up to 80% of their household income is usually spent for food related goods, rather than for non food or housing improvement, indicating that the households are too poor to accumulate assets either in cash or in kind. Entertaining tax duties and farm input debts mainly for chemical fertilizers are reported to be the second important household expenditure. About 70% of the respondents have also reported that they buy clothes once a year, sometimes twice for the children during the time of harvest or Christmas (*gena*).

### 4.3.2 Indicators of food security in the study areas

Certainly, there are various food security indicators specific to a particular geographical region and for what purpose these indicators are meant for. For example USAID (2002) reported that food security indicators appropriate in the humid tropics of Latin America may have little validity in the semi-arid areas of Sub-Saharan Africa, and indicators which are useful for on-going programme monitoring progress may not be appropriate in the context of an impact evaluation. Similarly, different organisations and government agencies may have different food security indicators in relation to their primary objectives. For regional and global assessments, per capita food intake per day in kilocalories is used as the indicator for food security. This indicator is derived from agricultural production and trade statistics. For example, according to FAO (2003) at the national level, a per capita food intake of less than 2,200 kcal/ day is taken as indicative of a very poor level of food security with a large proportion of the population affected by malnutrition. A level of more than 2,700 kcal/ day indicates that only a small proportion of people will be affected by undernourishment. However, it must be stressed that per capita food intake in terms of kilocalories is only an indicator of food security: adequate nutrition requires in addition to calories, a balanced diversity of food including all necessary nutrients.

In this study, basic food security indicators are used to gauge the extent to which the growing of triticale causes changes in food security conditions of triticale growing households as compared to their non-triticale growing counterparts.

The possible impacts of triticale adoption on household food consumption improvement for the sample households will be discussed on the basis of self-assessment questions. During the survey, information on several aspects of basic household needs were asked and that include: (1) the frequency of daily meal intake during the worst dry and normal seasons as basic food security indicator using self-assessment evaluation; (2) frequency of daily meal intake before and after growing triticale and (3) availability of household energy and clean drinking water.

The availability and utilisation of alternative household energy to firewood in the study areas may not fit into the categories of household food security; it may rather be seen as an indication for relative well-being since almost all the households use firewood or cow- dung as major household energy source. However, some farmers (for example, in Farta *wereda*) had better access to firewood from their own compound – indication of being better-off, whereas others have either to purchase from better-off farmers or travel quite a long distance to collect it from community eucalyptus plantations. It was therefore believed that the capability of purchasing charcoal and kerosene as alternative household energy source to firewood could indicate a relative well-being among both, triticale producers and non-producers.

#### 4.3.2.1 Frequency of daily meal intake during "worst dry and normal seasons"

Both, triticale growing and non growing respondents were asked if they suffer from any food shortage during the worst dry season (i.e., if there was no rain for at least two consecutive crop seasons including the survey year (2005/06)), and for how long it lasted. Although the question was asked separately for triticale producers and non-producers, the result was defined as a single indicator due to the fact that the mean difference between the two groups for this particular question was minimal. Both, the mean and t-values indicated no systematic differences in terms of number of "months of food shortage" during worst dry season and normal seasons for both household groups.

At the time of the survey 183 households (45.2%) reported to have had a food shortage and were unable to meet their basic daily diet. For these households the food shortage lasted from one to eight months or for an average of three months. Nearly 222 (54.8%) of the respondents reported that there was no food shortage for their households in 2005/06. However, they also reported that they were "just doing okay", indicating that they were still at risk of food shortage and may still need food assistance. At this point, it should be noted that respondents might misreport or exaggerate their family hardship status if they assume that the survey is linked to GTZ FfW provision programme. Therefore, cross-checking this qualitative indicator against more quantitative indicators derived from the next questions was primordial. Subsequently, respondents were asked how many times themselves and their children ate during the latest drought season and at the time of the survey (i.e. normal) season. Since the 2005/06 cropping season was relatively good throughout the study areas and the country as a whole, the severity of that year's seasonal food insecurity is expected to reflect households' underlying poverty rather than a short term harvest failure.

From the total sample of 408 households, 181 of them (44.8%) reported that their adult members consumed two meals per day during the "worst dry season", and during the "normal season", only 58 households (14.4%) had two meals per day. 167 respondents (41.3%) consumed three meals per day and 58 respondents (nearly 14%) had only one meal per day during the worst dry season in their areas. During the normal season, 183 respondents (nearly 83%) were able to manage to take three meals per day; whereas 10 respondents (2.5%) had just one meal per day. However, if the physical appearance of the respondents is taken into account, there was no clear indication that there were plenty of adult members who consumed no food at all periodically during the dry worst season.

As illustrated in Tables 4.12 and 4.13, 60.3% (243 children) of the sample households ate three times per day during the worst dry season, compared to 83.1% (335 children) during the normal season. Further 6% (24 children) ate just one meal per day, 33.7% (136 children) ate two meals during the worst dry season, and nearly 17% (68 children) ate two meals during the normal season. During this period all children of the sample households had two meals per day with some snacks (*kollo* or *nifro*, i.e. roasted and boiled grains, respectively) between the meals. Since the question was asked for adults and their children separately, parents reported that they cut their own meal during severe food shortages in order to protect the consumption of their children.

Table 4.12. Number of meals per day for adults as an indicator of basic hh food security

| Category/ classification | Indicator | Adults | | | |
|---|---|---|---|---|---|
| | | Worst dry season | | Normal season | |
| | | N | % | --- N | % |
| Afflicted | 1 meal/ day | 56 | 13.9 | 10 | 2.5 |
| At risk | 2 meals/ day | 181 | 44.8 | 58 | 14.4 |
| Viable | 3 + meals/ day | 167 | 41.3 | 183 | 83.1 |
| Total | | 404 | 100 | 251 | 100 |

Source: own survey

Table 4.13. Number of meals per day for children as an indicator of basic hh food security

| Category | Indicator | Children | | | |
|---|---|---|---|---|---|
| | | Worst dry season | | Normal season | |
| | | N | % | N | % |
| Afflicted | 1 meal/day | 24 | 6 | 0 | 0 |
| At risk | 2 meals/day | 136 | 33.7 | 68 | 16.9 |
| Viable | 3 + meals/day | 243 | 60.3 | 335 | 83.1 |
| Total | | 403 | 100 | 403 | 100 |

Source: own survey

In conclusion, the indicator for *adults* did not as adequately capture the real trends of the sample households in the study areas as it was originally assumed. The assumption was that the number of the *afflicted group* would be significantly higher than that of the *at risk* group, because a severe food insecurity scenario is more likely (represented as afflicted group) and can be normally expected during a "worst dry season". Therefore, the result from the proxy indicator of daily meal intake for adults does not necessarily reflect the actual food security situation of the households. In our context, "afflicted" adults can be those that experienced six to twelve months of severe food shortage with just one meal per day. This group is in need of food aid without which, its life could be endangered. The "at risk" categorised group are those that experienced four to eight months slightly severe (two meals/day) food shortage. This group may need comparably less external food aid than the *afflicted* group for a limited period of time. The last group "viable group" is the better off category that had "only" occasional (up to six months) food shortages, though the sustainability of this status quo during the typical food shortage season (July-September) remains unclear.

#### 4.3.2.2 Frequency of daily meal intake before and after the cultivation of triticale by the sample households

Out of the total of 408 sample households, 192 (47.1%) reported to have planted triticale crop in the 2005 in both, Farta and Estie districts. Subsequently, the question '*how many times per day did your household eat before and after cultivating triticale'* was directed only for these respondents. The question was expected to generate intuitive and credible information about the contribution of triticale crop for the sample households after the adoption of the crop. This indicator is recorded in Table 4.14 and Figure 4.5.

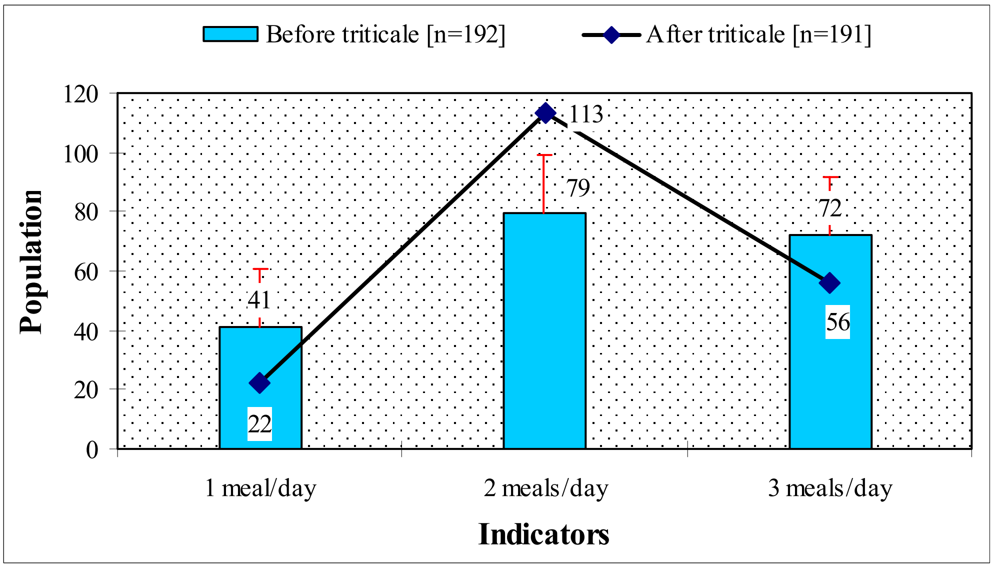
Table 4.14. Frequency of daily meal intake before cultivation of triticale by sample hhs

| **Indicator** | **Before triticale** (n=192) | | **After triticale** (n=191) | |
|---|---|---|---|---|
| | Frequency | Percent | Frequency | Percent |
| 1 meal/ day | 41 | 21.4 | 22 | 11.5 |
| 2 meals/ day | 79 | 41.1 | 113 | 59.2 |
| 3 meals/ day | 72 | 37.5 | 56 | 29.3 |

Source: own survey

According to this indicator (Table 4.14 and Figure 4.5), 41 households (nearly 21%) had one meal per day before applying triticale compared to 22 households (11.5 %) after the cultivation of triticale. This shows a reduction of households that had only one meal per day by nearly 45%. There were further 113 households (59%) compared to nearly 41% before triticale) who were able to eat twice per day as the result of triticale production. This suggests that the adoption of triticale has indeed improved food self-sufficiency for many households in the study areas. However, as indicated in the table, the size of households with three meals per day (before triticale adoption) has reduced by about 8% which could be perhaps due to the fact that farmers did not consume the triticale grain, they might rather preferred to sell it out after harvest for asset accumulation as the demand of triticale seed by farmers was high and hardly available on the market.

Figure 4.5. Frequency of daily meal intake before and after the cultivation of triticale by sample households



Source: Based on data from the survey

The official data from GTZ/SUN-Amhara (2006) show that triticale seed in the region was formally distributed for 15,000 households (about 10% of farmer to farmer dissemination rate) since its official release in 2002. Until 2006, GTZ was reported to have collected 4,925 qt of seed over the years. This figure was consistent with the crude figure obtained from the field expert interviews in Estie and Farta *wereda* which, however, has estimated for both, unofficial and official channels distributed among the households in both districts. This official data also signifies that by an average of 5 heads per household, over 75,000 family members throughout the Administrative Zone should have so far, profited from triticale cultivation through the official channels alone. The sensitivity analysis study of the agency reveals that this official data represents only 3 to 10 % of the farmer to farmer dissemination rate, which, on the other side, is also a reflection of consumers' acceptance of the crop both, in terms of grain yield quantity and product quality.

Also our field observation and agricultural expert interviews in Farta and Estie districts assessed that triticale should have reached, at least 15,000 households or 75,000 family members through both, the official and unofficial channels since its introduction in Estie and Farta *wereda* alone, and out of these 75,000 families, 16,050 (21.4%) are estimated to have had only one meal a day before cultivating triticale. If this expectation is true, the number will reduce to 8,625 families (-45%) after the adoption of triticale. The remaining 30,825 families (about 41%) are estimated to eat two times per day before the adoption of triticale; while after triticale cultivation, an additional

13,575 families (+18%) were expected to feed themselves in 2005/06 crop season (See also Table 4.15a).

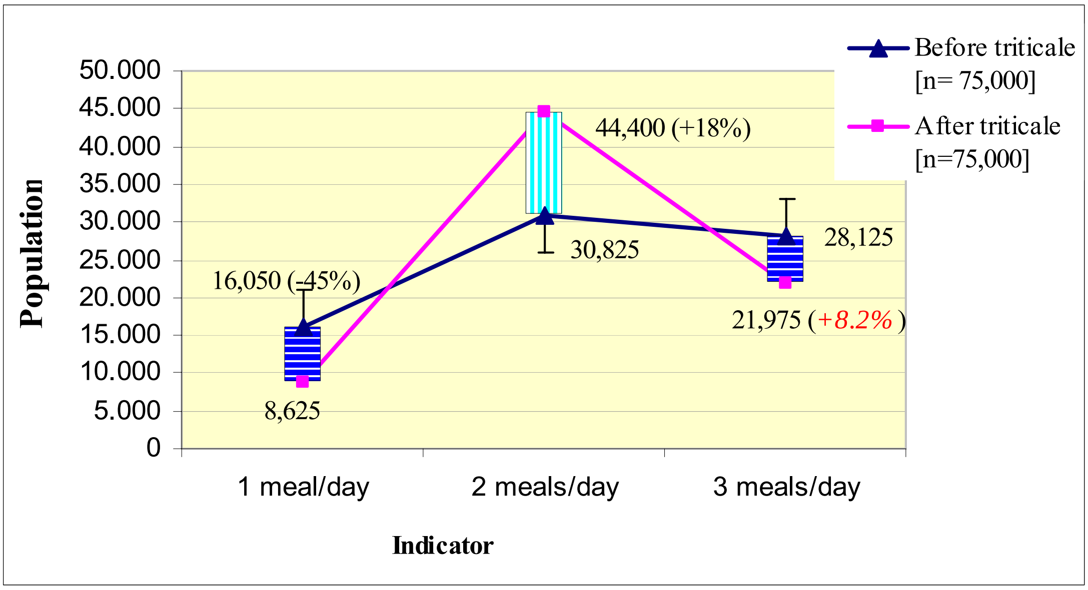
Table 4.15a.Frequency of daily meal intake before and after cultivating triticale (extrapolated)

| **Indicator** | **Before triticale** | | **After triticale** | | | |
|---|---|---|---|---|---|---|
| | **Population*** | **%** | **Population*** | **%** | **Change** | **%** |
| 1 meal/day | 16,050 | 21.4 | 8,625 | 11.5 | 7,425 | (-45) |
| 2 meals/day | 30,825 | 41.1 | 44,400 | 59.2 | 13,575 | (+18) |
| 3 meals/day | 28,125 | 37.5 | 21,975 | 29.3 | 6,150 | (8) |
| Total | 75,000 | 100 | 75,000 | 100 | | |

Note: * Total triticale growing households in the two districts (in 2005/06) is estimated at 15,000 out of 134,488 total rural households of both, Farta and Estie *wereda*

Source: own survey

Figure 4.6. Frequency of daily meal intake before and after cultivating triticale (extrapolated)



Source: Based on data from the survey

Transferring the sample data from Table 4.15a into the entire population of South Gondar, produces a crude estimate of approximately 276,000 people with just one meal per day; 1,420, 800 people with two meals per day and 703, 200 people with three meals per day out of the total population of about 2.4 million (Table 4.15b and Figure. 4.7).

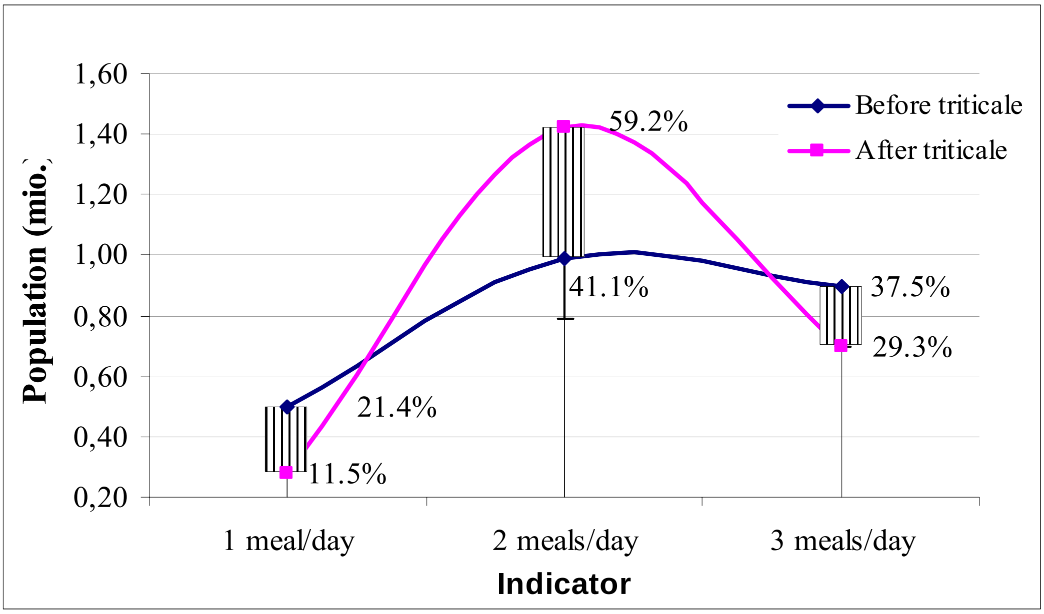
Table 4.15b. Frequency of daily meal consumption before and after cultivating triticale calculated for the total estimated of 2.4 million people of South Gondar

| | Before triticale | | After triticale | | | |
|---|---|---|---|---|---|---|
| **Indicator** | **Population** | **%** | **Population** | **%** | **Change** | **%** |
| 1 meal/day | 504,000 | 21.4 | 276,000 | 11.5 | 228,000 | (-45) |
| 2 meals/day | 984,000 | 41.1 | 1,420,800 | 59.2 | 436,800 | (+18) |
| 3 meals/day | 900,000 | 37.5 | 703,200 | 29.3 | 196,800 | (8) |
| Total | 2.4 million | | 2.4 million | | | |

Source: own survey

The findings in this context suggest that if the Amhara Region were to implement triticale throughout the region, upwards of 3.4 million (18% of its total population of about 19 million) people could be fed twice a day. This is nearly 33% higher than the estimated emergency food assistance requiring people of 2.3 (WFP/FAO 2007) million as identified by the *meher* Assessment Study of the Government in 2007. Thus, the identified analysis is expected to have a significant impact on triticale adoption ($Z_{GrowT}$) representing the importance of the crop for household food security hence, the result is seen as a significant determinant with respect to the decision by farmers to adopt it.

Figure 4.7. Extrapolation of daily meal intake before and after cultivation of triticale, calculated for the total population of approx. 2.4 million of S.G.)



Source: Based on data from the survey

The socio-economic impacts of triticale adoption for these households can be seen as encouraging, though the crop and its widespread advantages are yet to be fully explored, particularly in the region and the country at large. Specially those households who told to be recently formed and obtained triticale seed for the first time could not be verified if they have profited from triticale in terms of their household food security, as their crop was still on the field at the time of the survey. Nevertheless, the households reflected their optimism to obtain at least a two fold harvest over tef from triticale fields as a result of the outstanding performances of the crop which were already observable in the field.

Daily meal intake frequency was selected as the one and most important indicator of household food security which compares households' food intake situation before and after growing triticale. The determinants were identified using the regression and comparative analysis. The explanatory variables shown in Table 4.16, are hypothesized to influence the daily meal intake frequency of the involved households in one way or another. The result whether daily meal intake of the triticale growing hhs has improved after triticale cultivation or not, is based on the opinion of triticale growing sample households interviewed in both study districts, which was then compared with the responses of those who have not cultivated triticale at all.

Seed loan (SEDLON) is expected to influence the availability of food as well as frequency of daily meal intake positively. Before, the farmer to farmer exchange of triticale seed has been taking place, 15,000 households were said to be provided with starter quantities by the GTZ/SUN-Amhara project over the years (since the official release of the crop in 2002). This has enabled several farmers (including the sample hhs) to adopt triticale and led to the widespread dissemination of the crop in the study areas and beyond.

Livestock ownership (LVSTOCK) - apart from being a major source of important amino acids, animal products are used as secondary source of income for the farming community, next to crop production in the study areas. According to the respondents in our field survey, income from the sale of milk, meat, eggs and leather was useful to improve daily meal intake as well as to buy crop seeds and school uniforms for children. Traditionally, the farming community in the Amhara Region purchases animal to begin asset accumulation where this is possible. Particularly women tend to give priority to poultry flocks, specially egg laying hens, which provide short time income opportunities to meet their daily expenses. The lesson here is that households with more animal asset tend to be more food secure whereby the contribution of animals to food security is not largely from increased consumption of animal products but by the purchase of cereals from the income generated by sales of animals and their products.

Table 4.16. Expected independent variables used for the regression on the dependent variable

| Explanatory variable | Description | Expected sign of relationship |
|---|---|---|
| FAMSIZE | Number of persons living in the household | - |
| EDULEVEL | The level of education of the household head (0 = illiterate, 1= read and write, 2 elementary (grades 1-6), 3 = junior high school (grades 7-8) | + |
| FARMSIZE | The total size of cultivated land in 2005 crop season | + |
| LVSTOCK | Livestock ownership of the household | + |
| NOXEN | Number of oxen sample households own | + |
| EXTNSON | Availability of extension services to the sample households | + |
| PURINPUT | Purchase of fertilizer made in the 2005 crop season (survey year) | + |
| DMARKT | Distance of the nearest market from farmer's residence | - |
| HLABOR | The number of active working manpower in the household | + |
| OFRINCOM | If the household had off-farm income, such as cash for work activities, beekeeping, selling of *tella*, etc.) during the survey year | |
| | Food or seed grain (other than triticale seed) that was obtained as aid/ | + |
| GRAINAID | or loan during the survey year | |
| | | + |

Source: own survey

The average family size (FAMSIZE) of the sample households was about 7.9 persons per triticale growing family and 7.5 in non-triticale growing households, most of whose members were preschool children relying entirely on their parents' income. Therefore, due to the fact that the higher the number of members in the household (particularly if none working force exists), the higher the demand for food will be as this should be rationed among the family members and thus, less frequent meal intake is expected. As a result, the variable FAMSIZE was hypothesized to affect the frequency of daily meal intake negatively.

Higher education level (EDULEVEL) is assumed to have a positive effect on food security (daily meal intake), because households with some degree of education may diversify local food production, comprising vegetables and other food items. Additionally, if nutrient targeted food production accompanied by nutrition education should be provided in the study areas, basic education is primordial to carry out such programmes.

Land is the main resource endowment productive asset for a family that entirely sustains life from agriculture. With an increase in farm size, the family is likely to increase food availability and income. An increase in marginal productivity of labour is expected to enhance food production by renting or sharing more farmland and intensifying cultivation using high yielding crops, such as triticale. Thus farm size (FARMSIZE) as was hypothesized, it influences the food availability and consumption frequency positively, while smaller farm size may result otherwise. The variable in this context is associated with the daily meal intake at the 1% level of significance. While landownership is regarded as the most secure means of gaining access to land, there are other arrangements, such as sharecropping, tenant farming and use of communal lands that can ensure production based food production. These are, however, less reliable during times of crises according to the above authors. Renting in land is one possibility for the farming community to increase farm size and is argued to positively influence household food supply, providing them the chance to take up more meals per day than their counterparts without any access to land.

Limited draught power, such as oxen, coupled with diminishing acreage availability for cultivation per household will negatively affect crop production, resulting in less food availability. Oxen are the dominant traction power in the study areas. As most of the respondents have reported, the farmers who have just one ox need to agree up on other farmers who also have only one ox, to pair their ox in order to be able to cultivate. Thus having an ox or pair of oxen enhances the households to sharecropping or renting in land for food production, while having no ox may result otherwise. As Holden et al. (2001) reported, livestock wealth is a better indicator of household wealth than landownership. Particularly ox ownership signifies the farming capacity of households because according to the authors, the rental market for ploughing oxen was highly imperfect. Therefore, the variable NOXEN is predicted to positively affect food security.

Agricultural extension (EXTNSON) is another important factor hypothesized to have a positive impact on daily meal intake. If effectively implemented, extension certainly enhances food production in view of the fact that technological change and knowledge transfer promotes agricultural productivity, diversification of products as well as income generation opportunities for the farming community for a higher daily meal intake. Thus, the households begin to experience improved nutritional intake as a result of animal and crop production intensification or specialisation of their choice in agricultural activities through improved skills. Rivera and Qamar (2003) stress the importance of extension in helping to confront problems of availability, access, and utilization of food, and assist to enhance the productivity and consecutively the production of food as well as provision of opportunities for income generation. The authors further claim that extension generally provides improvement of nutritional advice through home economics programmes and enhances the quality of rural life by way of community development.

The average market distance from households' residence in the study areas was 14.9 km ranging from 1.5 km to 35 km. Most households reported that to exchange food grain and other items, they had to travel a long way that causes high transaction costs and time which could have been used for other activities at home or in the field. Therefore, long market distance (DMARKT) was assumed to have a negative impact on food security.

Food aid (GRAINAID) is surely necessary in situations of manmade or natural disasters or conflict to prevent hunger and malnutrition. But food aid also undermines the motivation of the farmers to strain themselves for more productivity and find a way to get out of the cycle of poverty they are tied with. Moreover, grain aid also endangers the local market by dumping the price of local agricultural products, as in most cases the food assistance ends up on the market at lower prices than locally produced goods. For example, IFPRI (2001) argued that unless the food is purchased locally, the dependence on it undermines local markets and in the longer term it says, throws greater numbers of people into poverty. Thus GRAINAID, in this analysis, is assumed to affect daily meal intake positively, despite the fact that a number of studies oppose food aid in its entirety. In this analysis, it is argued that food grain ration can be an income entitlement for many poor families enabling them to consume the aid grain thus reducing their food budget, or sell the grain and use the cash to meet other expenses.

The probability of improved household food consumption and food self-sufficiency is high with an increasing income from off-farm activities. Since there are greater numbers of people including small scale farmers who rely on food purchase, higher income improves the ability of the households to spend more on food items. However, the degree of their food security situation depends not only on income but also on prices as well as labour productivity. Income sources other than crop- and animal production, such as beekeeping, selling of wood, preparation and selling of *tella* are some of the activities which some farming households are practicing to improve their livelihood and food security situation. Thus, the independent variable other sources of income (OFRINCOM) in this analysis was argued to increase household food availability and daily meal consumption by purchasing additional food items with the cash made available from activities other than agriculture.

The purchasing and application of farm inputs (PURINPUT), such as fertilizer and spraying chemicals is an important factor to increase land productivity and increase food production, thus improving household food security. As land availability per household is falling in the study areas dramatically as population grows, and annual rainfall remains unpredictable, increasing land productivity by more external agricultural input is seen as a major pathway to get out of the poverty trap and food insecurity in the study areas. Therefore, PURINPUT is hypothesized to impact grain yield and daily meal intake positively.

Grain yield per unit area is the most important property of triticale crop which will have a direct and positive influence on food availability and increased rate of daily meal consumption frequency. As grain yield was a main focus of the research, adopting triticale crop will meaningfully improve household food availability as well as increased growth of benefits to the poor families. Therefore, it is estimated that grain yield is directly associated with the availability of an adequate quantity of food that every member of a household will have access to it for at least two times per day meal as a single indicator of food security.

Another important emphasis of the study is the triticale grain quality for baking, which is hypothesised to influence daily meal intake positively. Triticale growing sample households have witnessed the suitability of this grain for the preparation of a variety of food items including their main staple food *injera* and bread, and traditional beverages, such as *tella* and *areke*. The suitability of triticale grain for injera and bread baking is used as a major indicator of food quality, which is an important factor for the successful adoption of triticale in the study areas, since access to food over own production remains a central issue of concern to be food self sufficient. However, both of these variables (grain yield and grain quality) are omitted from the Probit regression model in order to avoid self-correlation.

As the results of Probit regression in Table 4.17 indicates, there are number of factors affecting daily meal intake in the study districts. The explanatory variables FAMSIZE, GRAINAID and HLABOR are significant at the 5% level of error probability. The variables FARMSIZE and OFRINCOM show a strong impact on daily meal intake which was significant at 1% level. A shorter market distance (DMARKT) from farmers' residence was assumed to encourage farmers to exchange goods, such as triticale seed and purchase of spraying chemicals and fertilizer, which will in turn affect grain yield positively and thus improved food availability. The Probit regression result of this variable on the dependent variable shows, however, no statistically significant impact on the dependent variable "daily meal intake" as it was initially argued. Nevertheless, the explanatory variable PURINPUT which has a direct linkage with markets, indicated a positive impact on daily food consumption frequency which was statistically just significant at the 10 % level of error probability. The other independent variables, such as LVSTOCK, EDULVEL and NOXEN show were hypothesized to influence daily meal intake positively which, however, show only weak level of significance on the dependent variable.

Table 4.17. The result of the Probit regression on daily meal intake frequency

| Variable | Estimated coefficient | T-value |
|---|---|---|
| FAMSIZE | -0.67512 | -2.045** |
| EDULEVEL | 0.04892 | 0.875 |
| FARMSIZE | -0.17228 | -2.304*** |
| LVSTOCK | -0.87715 | -0.756 |
| NOXEN | -1.53257 | -0.891 |
| EXTNSON | 1.05224 | 0.473 |
| PURINPUT | 0.11741 | 1.834* |
| DMARKT | -0.48175 | -0.750 |
| HLABOR | -0.00142 | -2.881** |
| OFRINCOM | -0.18631 | -3.234*** |
| Constant/Intercept = -2.53015<br>N = 395; missing values: 13<br>Pearson Chi-square = 266.37<br>Percent correctly predicted = 55.30 | | |
| Note: * Significant at 10% level<br>** Significant at 5% level<br>*** Significant at 1% level | | |

Source: own survey

### 4.3.3 Income composition of triticale-growing and non-growing households

#### 4.3.3.1 Major sources of income in the study areas

The primary source of income for triticale growers (47.3%) and non-growers (51%) was the sale of tef, wheat and barley followed by sales of animals and animal products. Nearly 10% of growers and 17.2% of non-growers had their major source of income from potato sale. Potato was mainly planted in Farta *wereda* as the respondents reported the area was suitable for potato crop. Non-growers of triticale obtained their income (14.5) from pulses (chickpea, field peas, garden beans) compared to 9.5% of growers. Nearly 10% of triticale growers had sold triticale seed to their neighbours, which, they said, was an important source of income, since triticale was sold for a price of up to 4 Birr (about $ 0.45 cent) per kilo due to shortages of triticale seed during the sowing season. This price was similar to that for white tef, which the highest market value than any other cereals in market. Details of crops and income source combinations from off-farm activities are shown in Table 4.18 and Figures 4.8 and 4.9.

Table 4.18. Major sources of  income of the sample households in the study areas

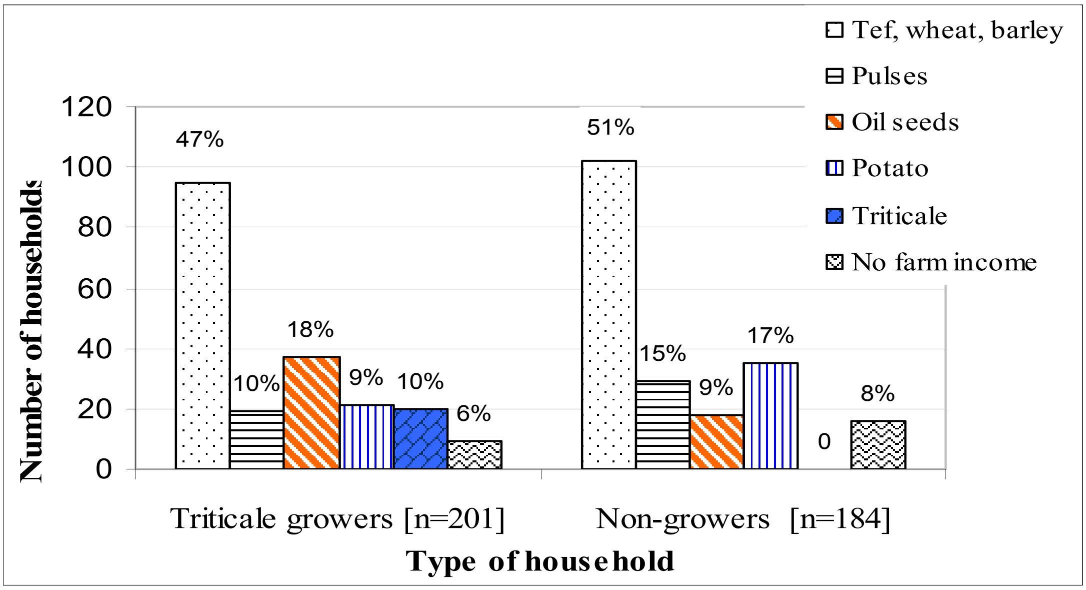
| | **Triticale growers** (n=201) | | **Non-growers** (n=200) | |
|---|---|---|---|---|
| **Source of income** | **Frequency** | **Percent** | **Frequency** | **Percent** |
| **On farm income** | | | | |
| Tef, wheat, barley | 95 | 47.3 | 102 | 51.0 |
| Pulses | 19 | 9.5 | 29 | 14.5 |
| Oil seeds | 37 | 18.4 | 18 | 9.0 |
| Potato | 21 | 10.4 | 35 | 17.5 |
| Triticale | 20 | 9.9 | --- | --- |
| No crop sell | 9 | 4.5 | 16 | 8.0 |
| **Off farm income** | | | | |
| Honey | 16 | 4.9 | 12 | 6.0 |
| Firewood | 29 | 14.2 | 33 | 15.6 |
| Eucalyptus /*atana* | 46 | 22.5 | 38 | 19.1 |
| Local beer /*tella* | 17 | 8.3 | 21 | 10.6 |
| CfW/FfW – GTZ | 27 | 13.2 | 33 | 16.2 |
| Daily labour | 18 | 8.8 | 9 | 5.9 |
| No off-farm income | 48 | 28.1 | 54 | 26.6 |
| Total annual mean income of hhs including livestock (Eth. Birr) | 1256.46 | | 1097.90 | |

Source: own survey

Rearing of animals is the second most important source of income next to cereals for both groups of households. Nevertheless, the households could not supply a reliable and separate data on income obtained from livestock sales because animals are often sold at times of hardship (for e.g. during dry seasons which causes shortage of fodder) and special occasions (such as during the Ethiopian New year's feast, Epiphany feast, *meskel – i.e.* "the finding of the true cross", Ethiopian Easter, etc.). Therefore, only the total average annual income was calculated and compared for significance between the triticale growing and non-growing farmers.

The first most important off-farm income source for growers was sale of wood poles from eucalyptus wood (*Eucalyptus spp.*) for house construction (locally called *atana*) (22.5%), followed by the sale of firewood (14.2%), CfW or FfW activities of the GTZ project (13.2%) and casual labouring (8.8%). Sale of eucalyptus wood contributed an income for 19.1% of non-triticale growers, while sale of firewood and CfW/FfW employment at the GTZ projects each generated income of 15.6 and 16.2% respectively, sale of *tella* (10.6%), and close to 6% of these households complemented their income from other casual labour activities, mainly during weeding and harvesting seasons. The total annual income obtained from sale of agricultural products and off-farm activities was significant at the 5% (t=2.56, $p<0.05$) level, implying that triticale growers had a relatively higher diversification of income opportunities than non-triticale growing households in both study districts. As can be seen in Table 4.18, triticale contributes for about 10% of the total income for triticale growers. Figure 4.8 and 4.9 respectively, show the percentage of sources of income from on-farm and non-farm activities.

Figure 4.8. Percentage of the major sources of farm income of the sample households

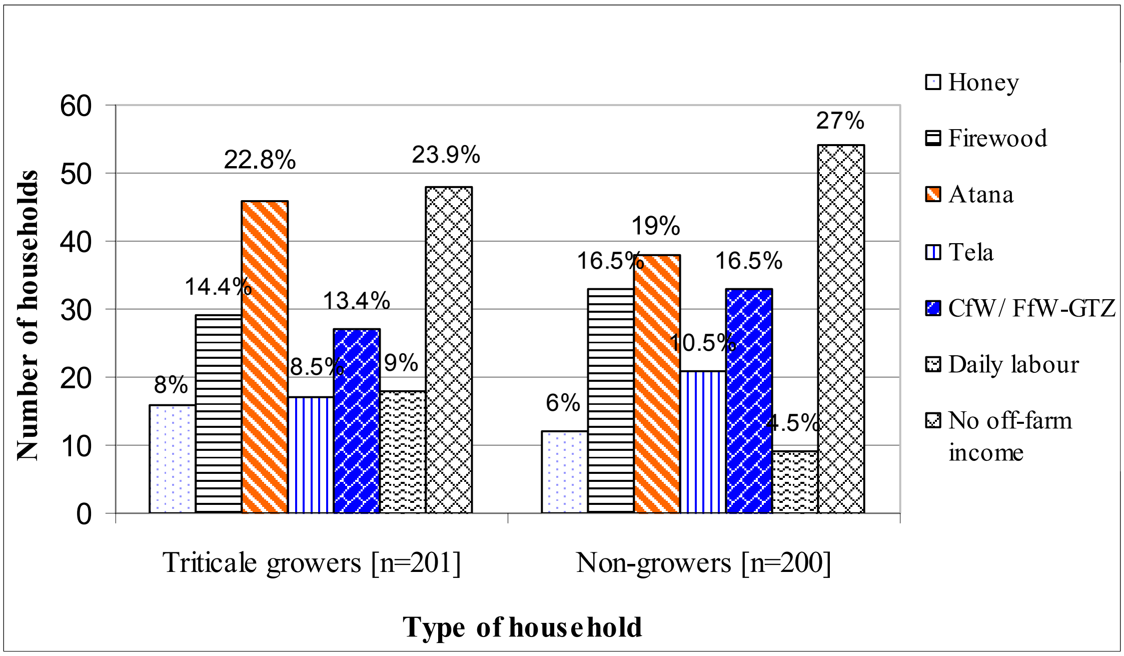


Source: Based on data from the survey

As shown in Figure 4.8, field crops, particularly cereals are the major crop produce followed by oil seeds for triticale growers and potato for non-growers in 2005/06 main growing season, and were thus, major income sources for both sample households in the study areas.

As indicated in Figure 4.9, 28% of growers and close to 27% of non-growers did not have off-farm income during the survey season of 2005/06.

Figure 4.9. Percentage of the major sources of off-farm income of the sample households



Source: Based on data from the survey

#### 4.3.3.2 Factors that may influence households' income in the study areas

After having identified and analysed the determinants of the decision by farmers to grow the triticale crop in the previous chapter, this sub chapter attempts to identify if the income and food security situations of the triticale-growing households in relative to non-growing ones, has improved or not. The variables in Table 4.19 related to the demographic, institutional and socio-economic situations of triticale-growing and non-growing households were hypothesized to influence the income of farming households in the study areas. However, the difference in household income and improvement of food security between growers and non-growers as a result of triticale adoption in Farta and Estie districts is expected not to be wide due to the fact that triticale production in Ethiopia is still at its introduction phase. The total income of triticale growing and non-growing farmers was analysed using the variables selected for the Probit regression model.

Table 4.19. Expected independent variables selected for the Probit regression on hh income

| Variable | Description | Expected sign of relationship |
|---|---|---|
| FAMSIZE | Number of persons in the household (con) | + |
| AGEHEAD | Refers to the age of the household head in years (con) | + |
| GENDER | Gender of the household head (dum) | + |
| MARSTAT | Marital status of household heads (con) | + |
| EDULEVEL | The level of education of the household head (con) | + |
| FARMSIZE | The total size of cultivated land (con) | + |
| PURINPUT | Purchase of fertilizer made in (2005) (dum) | + |
| EXTNSON | If farmers have access to agricultural extension services and information (dum) | + |
| RODSTNC | Time need to get from farm to next WOARD (con) | - |
| DMARKT | Distance of farmer's residence from the nearest market (con) | - |
| LVSTOCK | Livestock ownership of the household (con) | + |
| NOXEN | Number of oxen households own (con) | + |
| GRAINAID | If the household had received food or grain aid/ or loan in the survey year (dum) | + |
| CREDIT | Availability of credits to farmers (dum) | + |

Source: own survey

Based on the literature review, own observations during the survey and preliminary outcomes of the field research, the following independent variables that are thought to have significant association with the decision of growing triticale, are selected for the regression on income in consideration to triticale adoption. Some of the variables are briefly discussed in the following sub sections before the regression table is presented.

Family size - There are divided arguments about the impacts of family size on poverty and food security. Those who are pro increased family size assume that the higher the family members, the greater the probability could be to generate more household income. On the other hand, Greenspan (1992) for example, finds large family size negatively associated to family wealth. He argues that lower fertility translates into increased family wealth and educational attainment. In the Philippines, for example, households spend up to 10% of their household income to raise a single child and 18% for two children. Similarly, other studies suggest that children cost considerable assets of time and energy in addition to direct financial outlays in the household. Pernia (1982) relates family size negatively with the mothers' health and states "the mother's health is negatively affected by frequent and closely spaced pregnancies, and she is effectively prevented from actual or potential participation in development. It is to these less immediate and not directly observable disadvantages of a large family that parents must be sensitized so that they will realize the need to limit family size".

In this study, the determinant FAMSIZE is found to be positively associated with the household income as was hypothesized. As agricultural activities are typically dependent on family labour both, in Farta and Estie districts, it was hypothesized that larger families have the advantage to use family labour for agricultural production and thereby less capital disbursement is required for hiring external labour. As mentioned in section 4.1.1, family size is hypothesized to have a positive impact on farmers' decision to grow triticale, which in turn increases household food security and income since it provides at least twice as much yield as tef, wheat and barley in the study areas. The association between family size and household income is significant at the 10% level.

With respect to education (EDULEVEL), investing in education is one of the most effective means of reducing poverty and food insecurity. A report by the FAO (2006) shows that a higher level of education for women would yield good results in terms of food security. A similar study of the World Bank, cited in (FAO 2006) relates education with gender and concludes that if women received the same amount of education as men, farm yields would rise by between 7 and 22%. As the regression results in Table 4.20 suggest, the education factor is positively and significantly (at $p<0.01$) associated with the household income.

Livestock ownership (LVSTOCK) in rural economy like that of the study areas, plays an important role in households' income which can easily generate cash through the sale of crops or animals to meet cash demands for household expenditures. Though the exact figures on income from livestock sale is lacking, animal rearing is one major source of cash for both, triticale growers and non-growers in the study areas. Besides as source of cash incomes, animals' output, such as meat, milk and eggs can supply food for direct consumption and source of inputs to crop production (for e.g., manure and farm power in the form of animal traction). Wool and skins as sources of raw materials to make other goods are also an important aspect of livestock. Traditionally, households use animals as savings and investment through increasing the size of their herd, overseeing the quality. They also pay animals for their fresh married daughter or son as wealth start-ups for the bride. The variable is significantly ($p<0.05$) correlated with household income.

Availability of draught oxen was also hypothesized to influence hh income. However, the Probit regression model shows a weak level of correlation with no statistically significant impact.

Farm size (FARMSIZE), measured in (ha) is one indicator of wealth in the study areas. In addition to the farm size, the type of farming, if the farm is being irrigated or not, and the land tenure system are also considered to be the main determinants of net farm incomes and improvement of household food security. FAO and the World Bank (2001) consider farm size as one of the five major strategies (i.e. intensification of production; diversification of agricultural activities; increased farm size; expansion in off-farm income and complete exit from the farming system), which are judged to have the greatest potential for hunger reduction, alleviation of poverty and economic growth in the next decades. Farm size in our study is also positively associated with hh income and is statistically significant at the 10% level.

Distance of the household's residence from the nearest market (DMARKT) was predicted to influence household income negatively. The regression result shows that there is a significant association between market distance and household income, which implies that the higher the distance from household's residence, the lesser the chance would be to sell agricultural goods and the higher the transportation (transaction) cost may be to acquire agricultural external inputs.

Another significant factor is the time spent to reach the WOARD from household's farm, measured in hours (RODSTNC). This factor is negatively associated with income and is significant at the 5% level. This implies that the availability of all-weather roads plays an important role for contacting the extension officers more quickly, and easily transport farm inputs through which the farmer can increase yields. With shorter distances of district agricultural offices from farm areas, the farmer can also easily call for assistance in case of crop damage by pests and diseases or can purchase insecticides and pesticides more quickly, which otherwise would cause heavy harvest losses that in turn, negatively affects the household.

With regard to grain loan (GRAINAID, i.e. food or grain aid other than triticale seed), non-triticale growers were unanimous in that one important reason for not having sown triticale during the 2005/06 crop season was their inability to obtain triticale seed. Farmers' inability to obtain triticale seed prevents the attainment of increases in farm incomes that would result from the relative advantages of triticale, which include drought- disease- and hail-tolerance as well as high yielding capabilities. As the respondents indicated that there was more of a demand-side than a supply-side problem in purchase of triticale seed, farmers' inadequate cash reserves, and poor and non binding access to farm credits were the principal bottlenecks they had during the survey. Even though the descriptive statistic indicated no significant association between provision of grain loan-, aid or gift and adoption of triticale, this factor can implicate farm income significantly. However, the variable GRAINAID does not include triticale seed aid in order to avoid self-correlation in the regression.

Out of the predicted fourteen variables that we assumed to influence the total household income, six of the explanatory variables were found to have significant impact on the household incomes. The result of the Probit regression on income is presented in Table 4.20.

Table 4.20. The result of the Probit regression model on household income

| **Variable** | **Estimated coefficient** | **T-value** |
|---|---|---|
| FAMSIZE | 0.72974 | 1.910* |
| AGEHEAD | -0.06678 | -0.453 |
| GENDER | 2.87446 | 1.174 |
| MARSTAT | 0.05342 | 0.582 |
| EDULEVEL | 0.56221 | 2.025* |
| FARMSIZE | 0.38564 | 2.462* |
| PURINPUT | -0.08572 | -0.530 |
| EXTNSON | 0.90302 | 1.532 |
| RODSTNC | -0.58642 | -1.854** |
| DMARKT | 0.13303 | 1.691* |
| LVSTOCK | -0.52357 | -3.555** |
| NOXEN | -1.15456 | -0.534 |
| GRAINAID | 0.32433 | 0.667 |
| CREDIT | 0.36820 | 0.542 |
| Constant = 3.12402<br>Number of observations = 391; missing values = 17<br>$R^2$ (adjusted) = 0.48; Chi-square = 162.203 | | |
| Note: * Significant at 10% level<br>** Significant at 5% level<br>*** Significant at 1% level | | |

Source: own survey

### Impact of social networks on households' income and food security

There are a number of definitions and concepts of social capital, and the benefits that can be secured by being a member of social networks. Highlighted in this study are active involvement of households in nongovernmental development projects and other community based associations (for example, *idir* (funeral association), *mahber* (church festive group on saint days) and *debo* or *webera (*work festive group*)*. *Idir* provides families, for instance, with financial or material assistance they seek in times of emergency. Funerals and weddings associated with social events are some of the major emergency expenditures of the households of which the *idir* association frees the members. The members are required to organise and attend funerals. A strong integration of these associations to community development programmes, complemented with the provision of seeds and fertilizer, may enable households to diversify food production, and thus improve income and food security.

Nearly 30% of the sample households are involved in the SUN Amhara food security project activities, which include the erection of soil conservation structures, erection of tree multiplication sites (nurseries) and dissemination of triticale crop. The project employed farmers who usually obtain food grain in return for their labour in view of improving the food security situations of the FfW participants. A study by Ashenafi (2006) indicates that the short-term impact of the FfW programme on food security in South Gondar, paid in kind, showed an increase in household food consumption by about 30% of the daily calorie intake, which is recommended as a minimum requirement of 1,518 kilocalorie per person per day by the Ethiopian Nutrition Institute (UNDP 2002). However, there are number of other studies casting doubt on the effectiveness of food aid and its disincentive consequences for the recipient countries. For example, Del Ninno et al. (2005) reported that the benefits of food aid in addressing acute short-term food insecurity could be offset by the cost of reducing long-term food security and in meeting its objectives, including lack of timeliness and high cost of delivery to the recipient country, high administrative costs within-country, and leakages in the distribution of food aid.

Much of the sample households in the study areas have reported to be members of community based associations, such as *idir*, *mahber*. In our sample about 91% of the interviewees were members of the *idir* association in their respective *kebele,* and pay a monthly membership fee ranging from one to three Birr (about US $ 0.30 cent), including labour contribution in times of wedding or mourning. Being a member of such an association enables member households to be provided with assistance during hard times, in form of cash or grain loans if crop harvest fails due to circumstances beyond household's control, such as drought, hail, erosion, diseases and pests etc. With such assistance, the household can supply food for the family or purchase essential inputs like seed or fertilizer. Without such possibilities of community support and social interactions, farmers are often forced to sell their livestock to buy food grain, rent-out or sharecrop their farmland, which frequently leads them to extreme impoverishment and food aid dependency. The community is also an important source for exchanging and borrowing drought and pack animals, labour sharing in times of house construction, and exchange of information, for example about triticale crop in view of increasing household income and food security at household level.

### The impact of development projects on households' income and food security

Food security in the study areas is highly threatened by frequent droughts which make the majority of the population food recipient. As the availability of off-farm employment opportunities are quite limited, projects that can provide food aid through rural development based projects can be seen as one possibility to increase hh income in the study districts temporarily. The food aid in the study areas is mainly distributed either through food for work or food for cash projects, which primarily aims at preventing losses of life and undernutrition during drought seasons. The long term objective of cash for work programmes, for example operated by the GTZ, are meant to reduce natural resources degradation associated with soil erosion and nutrient depletion, which has a direct impact on agricultural productivity and thus food insecurity in the region.

Food aid supplied in kind by donors has been the most common mode of delivery for over three decades in Ethiopia which may continue to be an essential source of food supply and source of income for many, if no other options are available. There is, however, a growing criticism that, apart from trade and agricultural policy considerations, there are practical disadvantages associated with food aid supplied in kind from the donor countries. Local market price depression and high cost of transportation could be the major disadvantages of food aid, specially if its arrival coincides with the local harvest, which would become a disincentive to local production. In the study, it was revealed that 13.2% (27 hhs) of triticale producers and 16.7% (34 hhs) of non-triticale producers have been participating in cash for work (CfW) activities in the GTZ sponsored food security projects in both study districts. Food aid was assumed to increase farmers' decision to grow triticale, as a result of income diversification at household level. The chi-square ($X^2$=1.22) analysis, however, showed no systematic association between food aid and growing of triticale crop both, in Estie and Farta districts. This perhaps is explained by the fact that the food aid paid in kind or in cash was not large enough to be spent on purchase or exchange of agricultural inputs, such as triticale seed; instead it was directly consumed by the household. The samples were taken from farming communities participating in different CFW activities, such as construction of hillside terraces, planting of fodder plant species and households who are growing triticale crop.

#### 4.3.3.3 The role of livestock ownership on triticale adoption and food security

As a mixed farming system is practiced in the study areas, animal production is considered as an important element to affect the growing of triticale, since livestock products can be used as source of cash for purchasing farm inputs, such as triticale seed and chemical fertilizer on the one hand, and the purchase of grains for consumption on the other. Livestock ownership directly increases food supply by making livestock products available for household consumption, if farm households abandon cash income from sale of these animals, and indirectly, it can increase the availability of food by providing draught power for ploughing and other related activities like sowing, threshing and water lifting. This positive correlation between draught and crop production in the highlands of Ethiopia was also reported by Omiti (1995). Livestock also indirectly increases food availability by providing manure, the principal source of fertilizer available to a large number of small scale households. Though manure cannot replace all the soil nutrients extracted by crops, it recycles a significant proportion of them. It also provides organic matter to the soil, helping to maintain its structure, water retention and drainage capacities. Tangka et al. (2002) reported that the introduction of market oriented livestock technology; specially dairying is one of the principal means through which the welfare of food security in a mixed crop-livestock system, as widely practiced in Ethiopia, can be improved.

**Ownership of animals and their impact on farmers' decision to grow triticale, and household's income**

Total livestock ownership of triticale growers and non-growers is summarized in Table 4.21. Livestock holding, most importantly oxen and other plough animals in the study areas is used as productive assets that rural households often aspire to own when they have the opportunity to accumulate capital, however, in order to avoid auto correlations, livestock in this context does not include oxen. The different animal species were summed up using the Tropical Livestock Unit (TLU, equivalent to 25 kg of biomass), which is a scale calculated on the basis of the animals live-weight, specified for each animal species. Though the average weight of members of different species obviously differs between different areas according to the dominant breeds in each species and other conditions, the conversion factors of animal biomass measurement applied by ILCA (1990) for sub-Saharan Africa as a whole, are used in this study and is indicated in Appendix 3.

Table 4.21. Distribution of sample households by livestock holding

| | **Triticale growers** [n=204] | | **Non-growers** [n=204] | | |
|---|---|---|---|---|---|
| **Livestock ownership** (TLU) | **Mean** | **Std** | **Mean** | **Std** | **T- value** |
| Cattle (without oxen) | 2.20 | 1.00 | 1.93 | 0.87 | 2.71** |
| Horses | 1.47 | 0.58 | 1.86 | 0.86 | -3.21*** |
| Mules | 1.92 | 0.53 | 1.38 | 0.58 | 1.76 (ns) |
| Donkeys | 1.68 | 0.94 | 1.46 | 0.78 | 2.12** |
| Sheep | 3.00 | 1.37 | 2.71 | 1.33 | 2.08** |
| Goats | 2.89 | 1.20 | 2.65 | 1.51 | 1.01 (ns) |
| chicken | 2.19 | 1.35 | 2.15 | 1.19 | (nc) |

Note: ns = not significant, nc = not calculated, ** = high significant at 5%; *** = very high significant at 1% level

Source: own survey

As shown in Table 4.21, the mean number of cattle holding in TLU was significantly higher for triticale growers (2.2) than for non-growers (1.93) at ($t=2.71$; $p<0.05$). However, in terms of ownership of horses, non-growers had significantly higher (1.86) number of horses than triticale growers (1.47) at ($t=-3.21$; $p<0.01$). All in all, 93.6% of growers and 90.7% of non-growers had between 1 and 5 sheep, which was significant ($t=2.08$) at the 5% level. About 72.5% of growers owned donkeys compared to 64.7% of the non-growers. The average number of donkeys was significantly higher for growers (1.68) than non-growers (1.46) at ($t=2.12$; $p<0.05$). Both, in the study areas and the Amhara Region, equines are considered the most important animals next to plough oxen. Because these animals are the major means of transport for farm products to household's residence at post harvest and to market centres.

Livestock prices in the study areas like in the rest of the Amhara region, are highly seasonal and variable from year to year and season to season. Respondents indicated that markets in the study areas are hardly available during drought. All small scale livestock holders in the region transport their animals to open markets on the hoof for several hours, sometimes even for 2-3 days, which will have a marked impact on animals' price as the animals will loose considerable weight during the long trip. The animal transport was often observed while farmers drive their animals from South to North Gondar up to as far as Sudan, and towards the South as far as Kombolcha (South Wello Administrative Zone) where there is a meat processing plant.

### Ownership of draught and their impact on farmer's decision to grow triticale, and on household's income

Oxen are the most frequently used animals with ploughing as the principal activity in Ethiopia, which according to the World Bank (2003), has the largest draught oxen population in sub-Saharan Africa with some 14 million work oxen routinely used for cultivation. Wilson (2003) indicated that about 50 % of the world's population uses animal power to cultivate its croplands, and was estimated at a fossil fuel replacement value of US$ 6 billion in the mid 1990s.

Ownership of ploughing oxen, which is also used as an indicator of relative wealth of the household, is very important in the Amhara Region, particularly the study districts. The importance attached to oxen holding was also confirmed by key informants, such as *kebele* chairpersons, team leaders, experts at the respective *wereda* agricultural offices and other discussion groups. However, according to our survey results, these oxen only work for less than 100 days a year, which is mainly for periodical tilling and threshing both, in the major and short cropping seasons. In the rest of the time, the oxen are not used for productive agricultural purposes, whereas they are granted privileges in feeding more than solid-hoofed animals, such as horses, donkeys and mules, which are used as beasts of burden throughout the year in a variety of field tasks like ploughing and threshing. Unlike horses, mules and donkeys, the effectiveness and utility of oxen are limited by the fact that they are used only periodically and require higher quality feeding. In contrast, horses are flexible and can carry out a variety of tasks throughout the year. They can be fed with any types of crop residue, straw, hay, weeds and other fodder resources that are less suitable for draught oxen and other ruminants.

The number of oxen owned by the sample households in our study was considered as an indicator to influence farmers' decision to grow triticale. Distribution of the sample households by oxen-holding and ox (en) borrowing respectively, is shown in Tables 4.22 and 4.23.

Table 4.22. Distribution of sample households by ox (en) holding

| | **Triticale growers** | | **Non-growers** | |
|---|---|---|---|---|
| | **N** | **%** | **N** | **%** |
| Single ox | 44 | 21.6 | 63 | 30.9 |
| 2 oxen | 80 | 39.2 | 48 | 23.5 |
| 3 oxen | 39 | 19.1 | 27 | 13.2 |
| ≥4 oxen | 10 | 4.9 | 9 | 4.4 |
| Total | 173 | 84.8 | 147 | 72.1 |
| No ox at all | 31 | 15.2 | 46 | 27.9 |
| Mean | 2,09 | | | 1.88 |

Source: own survey

As indicated in Table 4.22, nearly 22 and 31% of triticale growers and non-growers respectively, had just one ox, and 39% of growers and 23% of non-growers own couple of oxen during the survey period. About 15 and 28% of growers and non-growers respectively had no ox at all. These implies that these households are either need to borrow a pair of oxen, to rent out their land (if any), or exchange labour with oxen holders for the cultivation of their farm plots. The mean difference in oxen ownership between the two household groups was significant at (t=2.13) the 5% level of significance. However, the mean difference in borrowing of oxen (Table 4.22) was not that significant as there were perhaps similar number of people from triticale growers and non-growers existed who borrowed an ox or pair of oxen during the survey cropping season.

Table 4.23. Distribution of sample households by Ox (en) borrowing

| | **Triticale growers** | | **Non-growers** | | |
|---|---|---|---|---|---|
| Ox borrowing | Mean | Std | Mean | Std | T- value |
| | 1.76 | 0.43 | 1.72 | 0.45 | 0.9 (ns) |

Note: ns = not significant

Source: own survey

### 4.3.4 Landholding and its role for triticale adoption decision and food security

Landholdings in the Amhara region, including the study districts are very small, soil fertility is low due to water erosion and the region is subject to sporadic and often severe droughts. Previous studies on land tenure in Ethiopia found out that average landholdings in the Amhara Region were 25% less than the national average at 0.75 ha compared to 1 ha nationally, which was lower than all regions except the Tigray Region (Berhanu & Samuel 2002:35).

The fragility of the natural resource base in conjunction with a constantly expanding population are seen by many observers as the major problems of poverty and food insecurity in Ethiopia. Sharp et al. (2003) reported that land tenure insecurity is seen as an additional constraint to peasant production, which may have a reduced impact on technology adoption and improved household food security. The Ethiopian constitution prohibits farmers from selling or mortgaging their land in the fear that land concentration may fall in the hands of a few elites who would buy up rural land at low prices from farmers when the latter face crises, such as drought.

Land management is equally important, as landholding and size; particularly in the study areas where land degradation is severe due to soil erosion resulted from deforestation, continued cultivation of steeply sloping terrain, mining of soil fertility without the application of sufficient chemical and natural nutrient sources to compensate losses. Therefore, finding solutions (for e.g. by terracing, limited cultivation on hillsides, reforestation and limited overgrazing) to the downward trend of land degradation, which in turn, causes rural poverty and food insecurity, requires identifying effective measures involving the farming community, civil society organizations and local governments so as to improve land management for enhanced crop productivity and thus ensure food security in the region.

#### 4.3.4.1 Land tenure system

Land ownership was one important factor respondents frequently mentioned in relation to the growing of triticale, and was expected to have a positive influence on the probability of adopting it in the study districts. As farmers who own land are relatively richer than those who do not, it is more likely that richer farmers will grow triticale and will conserve the land they own better than they rent. That means on rented lands, on the one hand, they may not practice long term investments, such as soil fertility management practices, soil conservation activities and planting of perennial trees, which in turn, can provide additional income for the household. But on the other hand, if they are long term owners and are totally dependent on their plot of land, they will most likely take care of it thoroughly. Beets (1990) for example, reported that the most favourable position for growing of trees is where land is privately owned, and where individuals hold a clear and unambiguous title to the land they farm. Other studies, such as that of Sain and Martinez, also indicate that a larger farm area is indicative of greater wealth and income, which in turn is highly related to the possibility of acquiring more and better agricultural inputs (Sain and Martinez, 1999-2004).

In the highland areas of Ethiopia, including the study districts, land size and quality is poor and land redistribution occurred frequently in the past decades. The country's constitution ensures the smallholders the right to use, to rent-in or rent-out the land they possess, but prohibits them from selling or mortgaging it. Many agricultural economists share the opinion that land tenure security is one of the key elements for rural development in an agrarian based economy, such as Ethiopia.

#### 4.3.4.2 Farm size of the sample households

Apart from other natural calamities, one major constraint to meet food demand for the majority of rural households in the food deficit areas of South Gondar administrative zone is the small and highly fragmented farm size available to the farmer. The national farm size, including permanent and temporal crops, averages measure only about one hectare (Berhanu and Samuel 2002:34). In the study areas, however, farm size averages only about 0.8 hectare. Cereal production yields are also lower than in the national average, further eroding food security in these areas.

The size of farms in the study areas is usually measured in *timad* or e*qa* (about 0.25 ha) and other local land measuring units. For this study, the international land measuring unit (hectare) is applied to measure the farm size. Numerous adoption studies, such as that by Sain and Martinez (1999-04), have included farm size as one determining factor in relation to adoption of new technologies. These authors further reported that the larger the farms, the smaller will be the financial and land restrictions for adoption of new technologies, and the greater the probability of adopting improved seed would be.

According to the Farta *Wereda* Office of Agriculture and Rural Development, a total of 31,388 hectare of land was cultivated in the *wereda* from which, a total of about 511,101 quintal (about 16 qt/ha) of grain was estimated to be harvested during the 2005/06 main cropping season. The landholding profile of the respondents from the study areas is shown in Table 4.24. Close to 95% and 94.6% of triticale growers and non-growers respectively, had cultivated in this cropping season, out of which 36.8% (75 respondents) of growers had shared crop or rented in land compared to 41.1% (86 respondents) of non-growers. The mean difference (t = 1.83) is significant at p<0.1 level. The total farm size for growers was slightly higher than for non-growers, which was not statistically significant (t= 0.16). About 30% and 29.1% of triticale growers and non-growers respectively, had shared crop or rented in land area of about 0.54 ha.

Table 4.24. Land holding and major crops grown in Farta and Estie districts

| | | **Triticale growers** | | **Non-growers** | | |
|---|---|---|---|---|---|---|
| **Farm characteristics** | | **Mean** | **Std** | **Mean** | **Std** | **T-value** |
| Own farmland | | | | | | |
| Shared or rented | | 1.1 | 0.29 | 1.12 | 0.33 | 0.64 (ns) |
| Total farm size | | 3.3 | 1.57 | 3.2 | 1.56 | 1.83* |
| (total cultivated,2005) | | 4.4 | 1.94 | 4.2 | 1.77 | 0.16 (ns) |
| | | | | | | |
| **Farm size (ha)** | | **N** | **%** | **N** | **%** | |
| Shared/rented in | 0.4 | 8 | 10.7 | 11 | 12.8 | |
| | 0.5 | 17 | 22.7 | 18 | 20.9 | |
| | 0.54 | 23 | 30.7 | 25 | 29.1 | |
| | 0.75 | 9 | 12.0 | 13 | 15.1 | |
| | 1.0 | 10 | 13.3 | 12 | 14.0 | |
| | 1.25 | 5 | 6.7 | 3 | 3.5 | |
| | ≥1.5 | 3 | 4.0 | 4 | 4.7 | |
| **Total** | | 75 | 100 | 86 | 100 | |
| **Total farm size** | 0.9 | 21 | 10.8 | 10 | 5.2 | |
| | 1.0 | 23 | 11.9 | 29 | 15.1 | |
| | 1.3 | 10 | 5.2 | 18 | 9.4 | |
| | 1.5 | 47 | 24.2 | 43 | 22.4 | |
| | 2.0 | 45 | 23.2 | 48 | 25.0 | |
| | 2.5 | 10 | 5.2 | 8 | 4.2 | |
| | ≥3 | 38 | 19.6 | 36 | 18.8 | |
| **Total** | | 194 | 100 | 192 | 100 | |
| **Major crops grown in 2005/06 *meher*** | | **Mean** | **Std** | **Mean** | **Std** | **T-value** |
| Tef | | 5.61 | 2.12 | 6.21 | 2.51 | 4.38*** |
| Wheat | | 5.58 | 2.76 | 5.58 | 2.65 | 0.27 (ns) |
| Barley | | 5.16 | 3.03 | 5.23 | 3.02 | 0.35 (ns) |
| Triticale | | 5.25 | 2.92 | 0.0 | 0.0 | (nc) |
| Pulses | | 4.89 | 2.02 | 2.09 | 2.09 | 1.29** |

Note: ns, nc, *,**,*** = not significant, not calculated, just significant, high significant and very high significant at 10%, 5%, 1% level, respectively

Source: own survey

Many respondents indicated that they rent out their plot due to either lack of access to draught power, lack of household labour or because the household is female headed. Sometimes the combination of all was mentioned as major reasons to rent out land to others. In most cases, the farmer who rented in the land is demanded to pay a certain amount of money for the plot in advance, for the case that crop failure may occur due to drought or mismanagement etc. Renting out land due to the above mentioned reasons is also a common practice elsewhere in Ethiopia.

Lack of adequate farm size, inadequate incentives (such as seed, fertilizers, irrigation water, credits) and transport infrastructure associated with farm tenure arrangements could be quite important factors limiting the rapid adoption of important innovations in the highlands of Ethiopia, particularly, in the study areas where land fragmentation is imminent.

As shown in previous studies on land tenure in the Amhara Region, the inadequacy of agricultural resources, such as land scarcity at household level, was identified as the most important determinant of destitution in the region.

As of the major crops grown in the study areas, tef, wheat and barley, the major staple foods in Ethiopia, were grown widely in their order of importance. As can be seen from Table 4.24, differences in crop types grown during the survey year by triticale growers and non-growers could be observed, implying that tef was planted more frequently by non-triticale growers than growers during the 2005/major crop season. The observed variation in growing tef was significant at the 1% level of significance with the t-ratio of 4.38, and could also be seen by the large standard variation of the two groups. Wheat and barley were nearly equally important for both groups. Triticale growers planted pulse crops, mainly faba beans (*Vicia faba*) and chickpea (*Cicer arietinum*), more than the non-growers which was significant at the 5% level. This observed variation can be linked to differences in land quality and poor soil property levels (*chincha meret* or Leptisol soils); because traditionally, pulses are often grown in low fertile areas, and more importantly, for better growth of the subsequent crops since pulses are known for the enrichment of natural nitrogen by means of mineralization using soil microorganisms.

# 5 THE SOIL CHARACTERISTICS, CROP PRODUCTION, TRITICALE CROP AND FOOD SECURITY IN THE STUDY AREAS

This chapter is based on the one hand, on a literature review on triticale adoption both, in the tropics and sub tropics. Practical farmers who grow triticale and who had never grown the crop, were on the other hand interviewed. The respondents were asked to explain the soil characteristics of their croplands and to share their experience on the adoption of triticale, and its baking quality.

## 5.1 The soil characteristics of the study areas

Since soil characteristic is one important aspect in crop productivity, it was found essential to go deeper into this topic. But, as scientific literature on soils of the study areas is lacking, the local names, farmers' perception on soil types and fertility characteristics listed in the table below, could not be supplemented with scientific verifications. Nevertheless, attempts have been made to assimilate the local definitions with that of FAO soil characteristics based on its nomenclatures of soils.

According to FAO/WFP (1995), dominant soil types of the Amhara Region include black vertisols (43%) and black non-vertisols (27%). Soils of South Gondar administrative zone vary greatly in their ecological properties, depending on parent substrate, grain size, composition, humus contents, relief profiles and depth to groundwater. The GTZ food security project report (2004) indicated that cambisols, regosols, lithosols and andosols are the predominant soil types of South Gondar. These soils are generally reported to be poor in fertility, shallow and highly degraded. Both, triticale growers and non-growers specially in Estie district have also reported that the soil fertility loss in their area was extremely severe, which is considered among the highest in Ethiopia due to soil erosion, low application of manure, extensive farming or over-utilisation, deforestation, burning of dung and crop residues as firewood and lack of investment on the farm. As shown in Figure 5.1, the study areas are losing their cropland base due to soil erosion at a rate that is undermining its long-term productivity which may result food insecurity. In view of this, there is an urgent need to realign national priorities in the region in order to preserve the cropland base and thus increase the adoption of improved agricultural practices, such as triticale that will enhance food production. The soil characteristics of the study areas are described in the following sections based on the farmers' perception.

Figures 5.1. Showing the severity of land degradation caused by soil erosion in the study areas

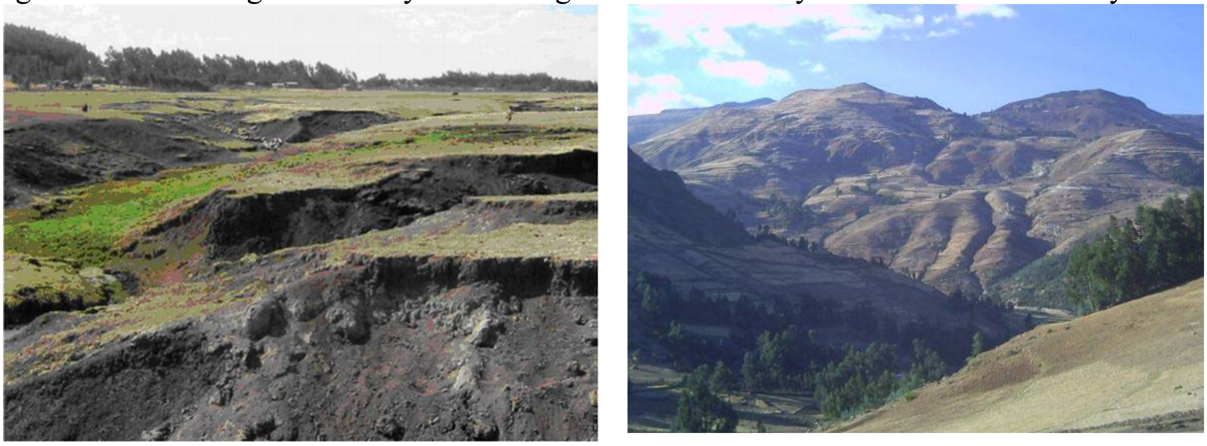


Photo: Author

### 5.1.1 Farmers' perception of the soil characteristics in the study areas

As part of South Gondar, the agricultural soils of the study districts are considered as poor in fertility due to complete removal of crop residues, insufficient application of both, organic and inorganic fertilizers and high nutrient losses, particularly by water erosion. As a result of high population concentration in the areas, most of the cultivable land has been continuously ploughed for a long period of time without leaving a chance for the land to regenerate itself.

Because of scarcity of firewood, animal dung is universally used as fuel for cooking rather than manure to maintain the soil fertility. As noted by many respondents, this inadequate supply of soil nutrients in conjunction with top soil removal by water during the rainy seasons, and fragmented farmlands, are some of the major constraints of low crop productivity, which they said is the primary cause of their poverty and food insecurity.

Households were asked how they do classify their farm plots in terms of soil fertility. Accordingly, they characterise the soil as described below.
Important parameters how farmers characterize the soil properties on the basis of its potential to produce crops are: *wofram meret* (literally means *fat land*), *sis meret* (thin land), *dingayama meret* (stony/gravely land), *mekakelegna meret* (moderately fertile land). Farmers classify the soils based on the physical characteristics and the soils ability and potential to produce good yield. Additionally, the soils are classified on the basis of their easily observable and recognisable characteristics. The depth of the soil, topography, colour and texture, stone content, water holding capacity and yield are important criteria for farmers to classify their crop fields. Most importantly, farmers consider their land to be very fertile (*wofram*) according to the yield they obtain.

Locally, "fat soils" refer to fertile soils that have high yielding potential, topographically moderate in water holding capacity, relatively rich in soil nutrients, low in stone content and deeply rootable soils. The opposite of fat soil is "thin soil" which is less fertile in organic matter with moderate stone content, dry and compact in nature since it doesn't hold water properly for a longer time. *Sis meret* or thin soils are also sometimes called *yeshimbra meret* - literally translated to "chickpea land" and means that these types of agricultural lands are usually sown with legumes, such as chickpea, field peas and beans before they area used for other crops (e.g. tef, wheat, barley, finger millet and sorghum) and land regeneration takes place. *Dingayama meret,* or stony soils, are soils with high occurrence (deposit) of stones, as their name indicates, and less fertile than thin soils. These soils were mostly observable in parts of Farta district and all along the way to Estie town where water erosion is enormous due to the sharply sloppy nature of the geographical relief. Based on respondents' views and own observations, remarkable parts of crop lands, specially in Estie district, fits into this soil category. *Mekakelegna meret,* or moderately fertile soil types, are those between fat and thin soils, which are moderately rich in mineral and stone content, gently sloppy and relatively less water logged. Nevertheless, unlike the thin types, these soils were reported to provide more crop yield per unit area and are relatively better aerated than the so-called *yeshimbra meret* or chickpea lands.

Farmers also use another local system of classifying their soil types according to the colour, texture, compaction, drainage and other physical characteristics, which has a certain degree of correlation with soil fertility characteristics. The local soil classification and fertility characteristics in correlation with FAO soil classification system is presented in Table 5.1.

Table 5.1. Local soil classification and fertility characteristics based on farmers' opinion and in assimilation to FAO soil nomenclatures

| **Characteristics** | ***Wofram*** (fat) | ***Sis*** (thin) | ***Mekakelegna*** (moderate) | ***Nechate*** **or** ***Baha*** (dusty) |
|---|---|---|---|---|
| Soil type: local [a]→<br>(FAO) [b]→ | *Walka*<br>**(Vertisol)** | *Chincha*<br>**(Leptisol)** | *Keyate*<br>**(Luvisol)** | *Amedma*<br>**(Cambisol)** |
| Texture | Heavy, clayey | Medium | Medium | Medium, fine |
| Rock content | Variable | High | Variable | Medium |
| Fertility (org. sub.) | High | Low | Medium | Low, medium |
| Slope | Level, gentle | Slight gentle | Gentle | Steep |
| Erosion: | Moderate, water | High, water | Moderate, both | High, both |
| Wind/water | Deep | Shallow | Medium | Deep |
| Depth | Very high | Slight | Medium | Slight |
| Cracking | Black | Light brown | Red | White |
| Colour | Relatively high | Low | Low | Low, medium |
| Moisture retention | Good | Good | Moderate | Moderate |

Source: [a] = based on farmers' perception and on the basis of own observation; [b)] = based on FAO nomenclatures

### 5.1.2 Local soil classification systems

The local soil classification systems in the study areas are also reflections of the difficulties of the soil to be tilled with the traditional *maresha* (ox drown plough) and limited moisture availability during cultivation. Other studies, for example by Corbeels et al. (2006), indicate that local systems of classification focus on the soils' depth that certainly reflects the limited availability of water. The study also noted that soil depth affects the availability of soil moisture and its texture which determines its workability and water holding capacity. Physical properties of soils, such as colour, texture and workability are most common criterions noted in studies on local systems of soil classification for example in that of Talawar and Rhodes, (1998). Habarurema and Steiner (1997) also noted that farmers are well acquainted with these characteristics through their daily observations of soils, and, particularly of their surface.

Farmers' local system of soil classification is based on their experience of the potentials and constraints associated with their farms. Both, triticale growers and non-growers in the study areas distinguish between different soil types mainly on the basis of soil colour and texture. The texture of the surface layer has some influence on many other soil properties and gives farmers a clear indication as to whether a soil can be cultivated during the heavy *meher* rainy season. For example, *walka* or black cotton soils were mentioned to be sticky during tef and wheat field preparations in June and July. Other soil texture-related physical characteristics mentioned by the farmers are soil compaction, cracking pattern, stoniness, drainage, ability to retain moisture and water logging, which are the main criteria for classifying soils as per households' farm experience and observations. As the households were asked to put these criteria in their order of importance, they put crop yield as the most important criterion for soil classification or ranking, followed by topography, soil colour, depth, texture, stone content and water holding capacity.

In the farmers' perception, soil classification is significantly associated with the soil fertility and productivity. Mitiku (1996) and Corbeels et al. (2000) have reported that the soil classification in use only partially reflects soil nutrients, as farmers perceive that the level of nutrients is only one of several factors determining the soil fertility, which implies the importance of farmers' knowledge of soil classification and its relation with fertility and productivity.

As of the soil pH and chemical characteristics, it proved difficult to find reliable sources of research due to lack of experiments undertaken on soil related studies on the study areas. However, according to the informant group discussions carried out during the survey, about 60% of the soils in the study areas have pH values ranging from 5.8 to 7.5. As crops response to phosphorus (P) and nitrogen (N) fertilisation is concerned, the informants reported that there was a marked response for most crops to P and N fertilisers. Significant P response was said to have been observed for tef, bread wheat and barley at field trials in South Gondar.

**Vertisols** (deep black clay soils, often known as "black cotton soils") cover 8 million ha of the Ethiopian highlands. They account for about 70% of all highland soils with slopes between 0 and 8% (Jutzi 1998). Vertisols occur on a wider slope range and may extend up to 10-15% (Jutzi et al., 1998) (similar to the altitudes of the study areas), though it is claimed by others (for example, by Mohr et al.,1972) that these soils occur on slopes that are less than 3% or those that do not generally exceed 5% slope. Mesfin (1998) also reported that the high cation exchange capacity which is associated with the expanding lattice clay is one of the outstanding features of Vertisol soils. As was mentioned by some of the sample households and key informant groups in the study areas, water stands on the surface of flat fields for extended periods of time during the rainy season, causing a significant decrease in crop productivity. This was also observed quite frequently during field visits in the short rainy season (*belg*), particularly in the Fogera plain, which is one of the major rice producing areas of Ethiopia bordering one of the study (Farta *wereda*) districts. Berhanu (1985) also mentioned that the average crop yields on these soils are very low mainly due to waterlogging in the growing period, caused by high rainfall and by the high content of swelling clays in these soils. The high clay content of the Vertisols is often reported to be responsible for their heavy waterlogging in highland areas with abundant rainfall and relatively low evaporation rates. This, according to Jutzi (1988), imposes severe restrictions on the traditional agricultural use of these soils and only 25% are cropped in Ethiopia, mainly using residual moisture. Much of this land is left fallow and subject to erosion during the heavy rains. According to him, there are evidences suggesting that there would be substantial increases in crop yields on vertisols, if excess surface soil water were drained off and if appropriate cropping practices were used. However, apart from using appropriate draining systems, substantial fertilization will be necessary as the available phosphorus in these soils is limited. Finck and Venkateswarlu, (1982) reported that next to N, P is the most limiting nutrient in vertisols, which holds true for Ethiopian soils. According to the International Livestock Center for Africa Report (1988), yields of wheat increased from 0.8 mt ha$^{-1}$ using traditional ridge and furrow systems to 1.1 mt ha$^{-1}$ when modern management practices were used, and increased to 2.2 mt ha$^{-1}$ when improved soil management practices were augmented by fertilizer (NP) application. This shows that a slight improvement in the drainage mechanisms on vertisol areas or a good vertisol management system can increase yields by 42% in both, fertilized or unfertilized fields compared with traditional practices.

With regard to N response of the soils in the study areas, one agronomist in Gayint *wereda* Office of Agriculture and Rural Development (Personal com.) claimed that a fertilizer experiment carried out in the *wereda* on a silty clayey textured cambisol or *amedma meret* showed that the N response, particularly for tef, bread wheat, barley and niger seed was high. According to him, maximum grain yields of 1.8 and 2.4 t ha$^{-1}$ of tef and wheat respectively, was obtained with 90 kg N ha$^{-1}$. Barley grown at the same agricultural climate in the same *wereda* gave a significant grain yield of 2.8 t ha$^{-1}$ with 50 kg N application per hectare of land. Noug gave the maximum yield of 0.92 t ha$^{-1}$ with 40 kg N ha$^{-1}$ application. The agronomist further indicated that the C/N ratio of these soils was 17 and the organic matter of 8.5% was measured with a pH value of 5.4. On these soils the lime requirement was 7.8 g kg ha$^{-1}$ soil.

## 5.2 Crop production and land productivity

In both, study districts tef was the most preferred and widely cultivated crop by both, triticale growers and non-growers. Growing wheat was equally preferred by both, growers and non-growers after tef, and followed by barley. The mean difference for pulse crops (chickpeas, field peas, faba beans) ($t=1.29$; $p<0.01$) indicates that triticale growers had preferred to grow these crops more than the non-growers do, which was highly significant at 1% level. This may also imply that the triticale growing households possess relatively less fertile crop lands than the growers since less fertile soil (*chincha meret*) is usually sown with pulses (in order the soil to regenerate itself) before it is used for cereals. As shown in Table 5.2, a higher yield was obtained from triticale fields compared to wheat with or without application of chemical fertilizers and compost in Estie. According to the *wereda* extension team leader, up to seven more quintals of grain was harvested in some of the fields where about 20 qt $ha^{-1}$ compost was applied, implying that increased food availability could be achieved by the increased and efficient use of compost in composition to per hectare fertilizer use, which is very low due to the high level of poverty and fertilizer debt problems in the study areas. According to Mulat Demeke et al. (1998), the absence of an effective peasant institution coupled with the penalties, which may include the sale of assets (e.g. oxen and/ or other animals) by the authorities for all those who failed to repay immediately after harvest are some of the problems related to fertilizer use. A shortfall in fertilizer use can imply a shortfall in food production and availability, unless the latter is compensated from surplus food producing areas whose price, however, can be much higher than the local produce as a result of high transport costs.

Table 5.2. Comparison of yield (qt $ha^{-1}$) of triticale and wheat grains with and without fertilizer at the $F_3$-generation stage (*akababi zer*) of triticale seed in Estie

| **Crop** | **With DAP & urea (NP)** | **Without DAP and urea (NP)** | **With compost** |
|---|---|---|---|
| Wheat | 13 | 11 | 13 |
| Triticale | 22 | 16 | 20 |
| Difference | 9 | 5 | 7 |

Note: DAP = Diammonium phosphate; N = Nitrogen; P = Phosphate

Source: Estie WOARD, (personal com.)

In all visited *wereda* of the North and South Gondar Administrative Zones, triticale out-yielded the major cereals (tef, wheat and barley). As the average yield comparison between the major cereals in the four *wereda* of South Gondar shows (Table 5.3), triticale yielded higher in all of the four *wereda*, particularly in Simada and Farta *wereda*. The adoption rate and area coverage, however, was estimated the highest in Estie at 3,564 ha with a total estimated yield of over 78,000 quintals during the survey year. This implies the widespread acceptability of the crop by the farmers on the one hand, and on the other hand, the strengthened efforts made by the WOARD to acquire and disseminate large quantity of triticale seeds to the wider peasant associations in a bid to enhance food availability and improve household incomes.

Table 5.3. Total estimated area and yield comparison of triticale with major crops grown in 5 districts of South Gondar Zone in 2005/06 *meher*

| **Crop** | **Est. total cultivated area (ha)** | **Es. yield (qt/ha)** | **Est. total yield (qt)** | **Wereda** |
|---|---|---|---|---|
| Tef | 5,784 | 7.9 | 45,887 | Tach Gayint |
| Wheat | 2,116 | 12 | 25,120 | |
| Barley | 2,610 | 12 | 31,534 | |
| Triticale | 66 | 20 | 1,320 | |
| | | | | |
| Tef | 16,952 | 6.5 | 110,299 | Simada |
| Wheat | 3,825 | 8.7 | 33,568 | |
| Barley | 2,998 | 10.8 | 32,384 | |
| Triticale | 73 | 25 | 1,825 | |
| | | | | |
| Tef | n.a | n.a | n.a | Estie |
| Wheat | 11,534 | 13 | 147,268 | |
| Barley | n.a | 10.6 | n.a | |
| Triticale | 3,564 | 22 | 78,408 | |
| | | | | |
| Tef | 6,505 | 13 | 87,084 | Farta |
| Wheat | 7,239 | 16 | 120,197 | |
| Barley | 6,234 | 11 | 70,942 | |
| Triticale | 103 | 25 | 2,575 | |

Note: na = not detected

Source: The respective WOARD (Personal com.)

As Table 5.4 shows in Lay Gayint, the WOARD estimated a total yield loss of 11,883 quintal (about 11.9 t) grain from tef, wheat and barley fields by insects and diseases, weeds, hailstorms and drought in 2005 main crop season. The Office does not expect a major yield loss from triticale fields, as according to them, triticale better resists the aforementioned biotic and/or abiotic yield reduction constraints. Meanwhile, the yield reduction in Farta was estimated even higher at 239,501; 35,090; 14,154 and 3,135 quintals by insects and nematodes, weeds, hailstorms, drought and diseases respectively. This comprises a total yield reduction of 53,119 quintals or about 53 mt at a plus/minus contingency of 3-4% in the same season.

Table 5.4. Comparison of triticale with major crops grown in Lay Gayint *wereda*, and estimated yield reduction by drought, hailstorm, disease, weeds, insects and nematodes

| **Crop** | **Total cultivated area (ha)** | **Yield (qt/ha)** | **Total yield (qt)** | **Yield loss (qt)** |
|---|---|---|---|---|
| Tef | 3,937 | 7.0 | 27,590 | 1,460 |
| Wheat | 3,521 | 7.6 | 26,568 | 4,207 |
| Barley | 4,284 | 13.0 | 55,772 | 6,216 |
| Triticale | 72.0 | 17.5 | 1,260 | na |

Note: na = not available

Source: Lay Gayint WOARD (personal com.)

The agricultural sector in the South Gondar zone is characterised by low level use of agricultural inputs, traditional farm practice and management, and poor soil fertility. According to Mesfin (2005), tef and barley being the leading cereal crops in the zone, wheat, sorghum, maize and finger millet (in their order of importance) share a high proportion of the cultivated area (about 70%). Pulses, oil seeds and vegetables make about 20%, 7% and 1% respectively.

### 5.2.1 Fertilizer application

Farmers use specific soil fertility management strategies for different parts of their farms (FAO 1998b). They grow mainly permanent crops and vegetables near their homestead and on more distant fields. Applications of manure and inorganic fertilizers reflect this differentiation (see for e.g. Tilahun et al. (2001). In the study areas, it was noted that DAP (diammonium phosphate) and N (urea) were the only chemical fertilizer types known by the farmers and the application of fertilizer was carried out without any prior soil investigation due to lack of experts and laboratory facilities. Also Amare (2005) reported that DAP and urea were the only chemical fertilizers applied by smallholders in Ethiopia. In this study, respondents of both, triticale growers and non-growers reported their use of both, DAP and urea fertilizers once a year, but very low quantity. The rate and frequency of fertilizer use highly varies from area to area and from farmer's income. The amount of urea and DAP use per farmer ranged from 40 to 90 kg ha$^{-1}$ year$^{-1}$ for growers, while for non-growers it ranged from 30 to 80 kg ha$^{-1}$ year$^{-1}$ for both, types of fertilizers. On average, close to 86% (167 hhs) of triticale growers and 78.2% (151 hhs) of non-growers applied 60.8 kg ha$^{-1}$ year$^{-1}$ and 59.07 kg ha$^{-1}$ year$^{-1}$ urea and DAP respectively, during the 2005 main cropping season. The mean difference (t = 1.96) in urea use by both groups was not statistically significant. In terms of DAP, the same number of households from both groups applied 63.36 kg ha$^{-1}$ year$^{-1}$ and 58.47 kg ha$^{-1}$ year$^{-1}$ of DAP fertilizer respectively, during the sated crop season. The mean difference was highly significant at ($t = 3.67$; $p<0.01$)

level. In this case, triticale growers applied more DAP than the non-growers, reflecting that inorganic fertilizer was a little more accessible and affordable to triticale growers than to non-growers. Also, growers used a little more compost (~1.48 t $ha^{-1}$ $yr^{-1}$) than 1.42 t $ha^{-1}$ $yr^{-1}$ for non-growers. However, the average in compost use did not show a significant difference (t = 1.07). Both, growers and non-growers, applied significantly less than the recommended rate of 100 kg $ha^{-1}$ for both, urea and DAP. The use of inorganic fertilizers and compost by triticale growers and non-growers is summarised in Table 5.5. The fertilizer types (DAP and urea), applied area and amount of fertilizer for the *meher* crops of private holdings are shown in the Appendix 1 and 2.

Table 5.5. Fertilizer use and other soil fertility management practices used by sample households in Farta and Estie districts

| | **Triticale growers** (n=194) | | **Non-growers** (n=193) | | |
|---|---|---|---|---|---|
| **Input type** | **N** | **%** | **N** | **%** | **T-value** |
| **UREA** Yes | 167 | 86.1 | 151 | 78.2 | |
| No | 27 | 13.9 | 42 | 21.8 | |
| Mean (kg) | 60.84 | | 59.07 | | 1.96 (ns) |
| **DAP** Yes | 167 | 86.1 | 151 | 78.2 | |
| No | 27 | 13.9 | 42 | 21.8 | |
| Mean (kg) | 63.36 | | 58.47 | | 3.67*** |
| **Compost** Yes | 173 | 89.2 | 184 | 95.3 | |
| No | 21 | 10.8 | 9 | 4.7 | |
| Mean (kg) | 1484.51 | | 1415.82 | | 1.07 (ns) |
| **Other soil fertility practices** | | | | | |
| - Shifting cultivation | 2 | 1.0 | 2 | 1.0 | |
| - Leguminous crops | 87 | 44.8 | 78 | 40.6 | |
| -Green manure/compost | 28 | 14.4 | 31 | 16.1 | |
| - Animal dung | 19 | 9.8 | 21 | 10.9 | |
| - Crop rotation | 58 | 28.9 | 60 | 31.3 | |

Note: ns, * = not significant and significant at p<0.01 respectively

Source: own survey

Generally, urea is chemically composed of 46% of N, and DAP contains 18% of N and 46% of phosphorus, which is also mentioned by the FAO (2000). Nitrogen uptake by crops following fertilisation rarely exceeds 50% of the applied amount. Poor fertilizer use efficiency is due to leaching and denitrification in wet climates, and N evaporation in dry climates (Synder 1995).

### 5.2.2 Other soil fertility management practices

The most important alternative soil fertility management practices in both, Farta and Estie districts were: exchangeably growing leguminous crops, using crop rotation, applying compost and animal dung, this order of importance.

**Shifting cultivation and crop rotation:** Shifting cultivation in the study areas is generally absent, reflecting the land shortage to be left idle for regeneration. Nearly 47 % (87 hhs) of triticale growing respondents and close to 41% (71 hhs) of non-triticale growing farmers reported to have been growing leguminous crops in exchange with tef, wheat and barley in view of the fact that crops planted on post leguminous fields provide higher yields. For nearly 14% of the total triticale growing farmers and 16% of the non-growing ones, using compost (prepared from green matters, ash and animal dung) was the third best alternative to chemical fertilizers in the study districts. Close to 29% of growers practiced crop rotation during the survey, compared to 31.3% for non-growers. Most of the triticale growers rotated tef, with wheat, faba beans, triticale and sometimes barley respectively; whereas, non-triticale growers rotated barley with tef, chickpeas, field peas or faba beans and wheat. Niger seed was planted mainly in mixture with tef or planted at field edges simultaneously with other cereals by both, triticale growers and non-growers. This phenomenon was mainly reported in Estie *wereda*, while potato was planted more frequently in Farta *wereda* by both, triticale growers and non-growers.

**Incorporation of weeds:** It is a universal practice that farmers in the study areas use weeds for animal feed and as soil fertility alternatives. The weeds are uprooted and put aside for decaying on field edges for latter dispersion. Some respondents have expressed the use of weeds as one alternative measure to chemical fertilizers for soil fertility in the following way:

> *"In the past, we, small scale farmers, maintained soil fertility by practising shifting cultivation or applying some chemical fertilizers on our fields. But nowadays, conditions have changed rapidly over the last few decades due to overpopulation, which resulted in land fragmentation. The situation forced us to apply every possible practice including the use of weeds which we used to burn away before, as soil improvement measure"*,

said a farmer in Estie district, indicating the land scarcity situation in the area. Another farmer explained: "for example, the land owned by five people today was cultivated by one person 30 years ago (where the Ethiopian population was estimated at about 27 million) leaving a room for shifting cultivation or for fallowing". The farmers are familiar with weeds, such as *Snowdenia polystachya* (Fresen.) Pilg. and *Avena fatua* (L.), locally called as *muja* and wild oats, respectively. Wild oats is sometimes also called *sinar*. Wild lettuce and similar wide-leafed weeds were also reported to be spread over their fields during and after growing periods. The farmers have also reported that the weeds emerging in the cropping system were also used as fodder for animals specially for milk cows and small ruminants, which has a competitive effect for them when they use weeds as soil fertility alternatives.

Few other farmers, who do not suffer much from shortage of animal fodder and household fuel crises, try to leave residues of crop in the field and mix it in the soil in order to increase the soil fertility level. Niger seed stem, wheat and tef straw, safflower (*Carthamus tinctorius* L.) and sesame stem are generally left over for decaying and mixed in the soil after animals have been kept on the field for some time after harvest. Triticale straw is usually uprooted and after the soil has been removed from the root system and dried, it will be pilled up for latter use in roof-thatching.

### 5.2.3 Weeds-, pests and disease control

A wide range of weeds, such as the root-parasitic weed striga (*Striga* spp.), wild oat, broad-leafed weeds and various grass species are reported to be highly prevalent and constrain crop production in the Amhara Region on many food crops. Despite the fact that, the problem of striga weed was neither reported by the respondents nor observed in the study areas during the field survey, the pre-harvest assessment report of the Farta WOARD indicates that an estimated 35,000 (personal com.) quintals of crop yield would be lost due to weed infestation, including striga in the 2005/06 main crop season. Hand-weeding is a common practice in the study areas, and none of the sample households reported to have applied herbicides during the survey year.

Pests and diseases are also a major concern in the study areas, often causing a considerable crop loss, which significantly reduces the amount of food available for human consumption. According to pre-harvest yield loss estimation of the Lay Gayint WOARD, a total yield reduction of 11,883 quintal (about 11.9 mt) grain was expected from tef, wheat and barley fields due to both, biotic and abiotic stress factors, such as pest insects and diseases, weeds, hailstorms and drought in 2005/06 main crop season (see also Table 5.4, p.109). Yield loss for triticale crop due to such stress factors was not expected). According to Mathre (2000), wheat, barley and oats are the major hosts for the take-all disease [*Gaeumannomyces graminis* (ascomycota)] whose early infection symptoms occur on young seedlings. The fungus attacks the plant roots causing stunting and yellowing with consequent decline in cereal production and thus food insecurity.

Chemical control, crop nutrition balance and crop rotation could limit damage from the disease, these possible mechanisms, however, are determined by the agro-ecological production potential of the land, by the available production technologies, as well as input and output markets and, most importantly, by the socio-economic capabilities of the farmers for purchasing the necessary agricultural inputs. A report by the Institute of Science in Society (2004) indicated that application of pesticides in Ethiopia had developed very little, except for controlling migratory pests which include armyworm and local swarms, such as Pachnoda beetles (*Pachnoda* spp.) on sorghum and the endemic Wello Bush Cricket (*Decticoides brevipennis* Ragge) on cereal crops.

Since the introduction of triticale in the *wereda*, there was no registered major incidence on triticale fields making it an alternative crop to wheat, barely or oats specially in that it is an easy crop to grow with considerably less management operations (for e.g. application of herbicides, pesticides and insecticides) compared to these cereals. Triticale's greater disease resistance as compared to wheat or barley is a major advantage. Its suitability to lighter and more marginal soils makes it a worthy crop for a replacement of wheat where the "take-all" disease infection is a major problem (Hackett and Burke, 2003).

### 5.2.4 Constraints of fertilizer use in the study areas

Considering their geographical exposure to land degradation and nutrient depletion through soil erosion, the study districts and other large parts of the Amhara Region face major challenges to achieve food security in a sustainable manner. Higher population growth than growth of agricultural productivity, limited availability of cultivable lands and water resources in suitable conditions for irrigation, and low socio-economic performance of the households that can limit fertilizer application are some of the major constraints affecting crop productivity and thus food security in the study areas and the bordering districts. According to IFA-FAO (2003), to meet the food demand of such a growing population, efficient plant nutrition management is essential to ensure enhanced agricultural production and better conservation of natural resources. But the existing economic environment and the basic education level of the sample households, and possibly, the economic and land policy of the government may limit the farmers to carry out an optimised local resources management for intensified crop production and thus improved food availability and access.

In our sample, about 39% and 22% of triticale growing households and non-growers respectively, reported not to have sufficient money to purchase commercial fertilizer. High risk aversion towards credits was the second important constraint for fertilizer use, which was reported by nearly 31% and 37% of triticale growers and non-growers respectively. A case study on Integrated Pest Management (IPM) in Ethiopia shows that farmers who had taken loans to purchase the more expensive improved seeds and agrochemical inputs found themselves with huge debts. Under heavy pressure to repay debts, some had been forced to sell off livestock (PAN 2002).

A substantial number of respondents indicated that high price inflation coupled with persistent droughts was another major factor for the low input pattern in the 2005 main crop season. The result of the descriptive analysis with regard to fertilizer use constraints is shown in Table 5.6.

Table 5.6. Major constraints in fertilizer application in Farta and Estie Districts

| | **Triticale growers** (n=194) | | **Non-growers** (n=193) | |
|---|---|---|---|---|
| **Constraints** | **Frequency** | **Percent** | **Frequency** | **Percent** |
| Lack of money | 76 | 39.2 | 43 | 22.3 |
| Price instability (inflation) & drought | 52 | 26.8 | 68 | 35.2 |
| High risk averse of farmers for credits | 60 | 30.9 | 72 | 37.3 |
| Other reasons | 6 | 3.1 | 10 | 5.2 |

Source: own survey

## 5.3 The triticale plant and its characteristics

Triticale (X *Triticosecale* Wittmack) is a result of chromosomal addition of wheat (*Triticum* spp.) as a female parent and rye (*Secale cereale* L.) as the male parent (pollen donor). Its genomic constitution (AABBDR or AABBRR) is an artificial cereal crop genus from these two cereal crops. The resulting hybrid is sterile and thus has to be treated with the alkaloid chemical colchicines to make it fertile and thus able to reproduce itself.

Since the early days of triticale, the overall objective of its development has been to combine the best agronomic features of the parental species, most importantly to combine the vitality and robustness of the rye plant in terms of disease and drought tolerance, and adaptation to poor soil conditions with the superior grain quality characteristics of wheat. Originally, numbers of obstacles were encountered, such as floret infertility, susceptibility to nematodes like ergot (*Claviceps purpurea*), shrivelling of grain and late maturity. However, these obstacles, according to Broicher (1999), were gradually overcome, which made triticale a significant crop in many countries, such as Poland, Germany & Australia.

Kim et al. (2001) also reported that the advanced lines showed the highest degree of Aluminium (Al) tolerance in acid soils containing high levels of Al in Brazil. According to these authors, Al toxicity has been limiting plant growth on over 1.6 billion ha worldwide.

Crops grown in acid soils, due to Al solubility at low pH, exhibit a variety of nutrient deficiency symptoms inhibiting proper root growth and function, which in turn, result in severe crop yield losses with a consequent effect on food security. Due to the lack of literature on relevant fields with regard to the study areas, it was difficult to disclose how severe Al toxicity currently (at the time of the study) affects crop production and yield losses.

As experiments of Al tolerance on cereals indicate, triticale was found to be less susceptible to $Al^{+3}$ concentrations than Al tolerant barley and many wheat varieties. For example, Mugwira et al. (1976) reported that Al-tolerant wheat and rye varieties being less susceptible, triticale tolerates $Al^{+3}$ concentrations higher than Al-tolerant barley followed by Al-susceptible barley and wheat varieties as in the following order of tolerance:

Least susceptible --------► Most susceptible

Al-tolerant wheat and rye-varieties ➔ triticale ➔ Al-tolerant barley ➔ Al-sensitive barley and wheat varieties

## 5.4 Agronomy of triticale and its introduction in the study areas

### 5.4.1 The agronomy of triticale

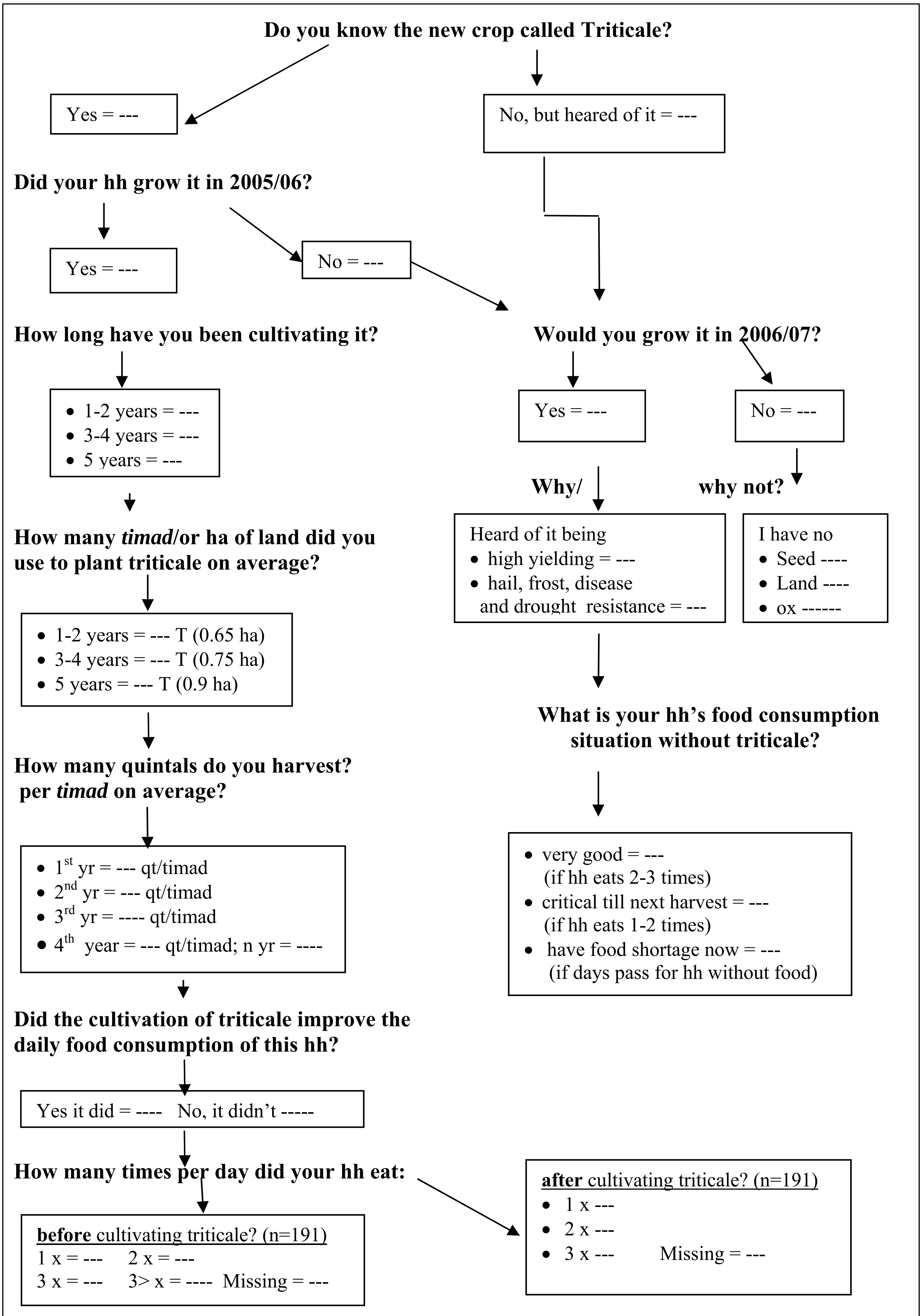
According to several studies on triticale crop, the first triticale cultivars were characterized by low yields, tall and weak straw, shrunken and shrivelled kernels, and high susceptibility to ergot. These poor characteristics were mentioned as major reasons to abandon the crop in Ethiopia after its first introduction in the 1970s from Mexico. The advantage of high protein and high lysine in swine and poultry rations were nullified by the poor yield performance and the high incidence of ergot. However, triticale cultivars released in recent years have improved agronomic traits including high yields, resistance to lodging and ergot, plump kernels, and lysine levels higher than other cereal grains (Skovmand et al. (1994). The higher yield potential and plumper kernels of modern triticale cultivars, according to Stallknecht et al. (1996), have resulted in lower kernel protein levels which are similar to common bread wheat cultivars.

The second attempt to introduce the crop for Ethiopian farmers was made by the IFSP-South Gondar in 1998 with the cooperation of the University of Stellenbosch in South Africa. After the performance of the crop was satisfactorily tested in the IFSP trial sites, two major varieties (Maynet and Sinan) were distributed among 50 cooperative farmers, from which the project had received only 350 quintals of seed from a total of 50 ha in exchange of wheat and /or tef (Metz and Tesfaye, 2003). According to these authors, the official release of the two varieties in 2002 by the Ethiopian authorities paved the way for the larger scale multiplication and dissemination of the crop within and beyond the IFSP project areas.

Since its introduction, the crop is expanding significantly not only within the project area, but also beyond in the Amhara Region. As was reported by the IFSP during the 2002 crop season the project distributed seeds of these two varieties for 600 selected farmers in its six project districts including the study *wereda*, assuming that up to 3000 small scale farmers in South Gondar alone would have access to triticale seed for further expansion in 2003 through unofficial channels. In this same year, nearly 380 quintals of triticale seed were supplied for a total of 1310 households in the six project districts through the WOARD. The actual number of triticale growing farmers is estimated to be much higher than it is estimated, as many of them obtained seed from markets and through farmer-to-farmer exchange schemes is difficult to comprehend.

Based on the flow chart in Figure 5.2, a total of 408 respondents were interviewed whether or not they knew the triticale crop, out of which, 94.4% of the respondents knew about it directly or indirectly, but only 194 households had cultivated it in 2005/06 *meher* season, and 5.6% (23 hhs) had heard of the new crop in its nick name *addisu sinde* and *logaw shibo,* meaning, "the new wheat", and "tall and elegant" respectively. As these groups of farmers were asked if they would grow it in the 2006/07 crop season, they responded "yes, why not? if we get seed". Though it was in small plots, some farmers have been growing it since the year 2000. The first group of farmers planted triticale on a total average farmland of about 2.6 *timad* (0.65 ha) from which they harvested 28 qt (2.8 tonnes) of grain per ha of land. In the second and third years, they cultivated nearly the same surface of land (3 *timad* or 0.75 ha) and harvested on average 26 qt of grain per ha, which was a little less than the yield of the first two years. This could be explained by the fact that the amount of fertilizer input was less than the application in the first introduction years. As discussed in section 5.2.1, the amount of fertilizer use ranged from 40-90 kg ha$^{-1}$ year for both, urea and DAP and averaged 60.8 kg ha$^{-1}$ year for all cereals by triticale producers, which is far below the recommended average of 100 kg ha$^{-1}$ for both fertilizer types. Twenty farmers have planted triticale for the fifth time on 3.5 *timad* or 0.9 ha of land and yielded on average 32.6 quintal grain per ha (i.e. about 3.3 tonnes). During our visit in Lay Armacheho and Debark *wereda* (North Gondar) project officers reported that some farmers had harvested 32 and 34 quintals per hectare respectively, which was also broadcasted by the Amhara Radio Programme. The pre-harvest average yield estimated by the Farta WOARD, was 25 qt ha$^{-1}$ (personal com. Jan. 2005).

Figure 5.2. The guideline flow chart concerning questions on triticale adoption



**Note**: hh = household= *timad (~0.25 hectare)*; qt = quintal

Source: own survey

### 5.4.2 Land preparations

Salmon and Jedel (1995) reported that most cultural techniques for growing wheat could be directly transferred to triticale. Consequently, the fertilisation, land preparation, seeding depth and seeding methods used for wheat are acceptable for triticale. Farmers in the study areas prepare the seedbed just before planting. They accomplish final land preparation and planting while there is still enough moisture available for seed germination. The interviewed farmers responded that seedbed preparation for triticale was not different from other cereals except from that for tef. The number of cultivation trips for tef is more than any other crops, as this is a small and sensitive seed, when compared to coarse corned crops, and enough soil particle uniformity needs to be obtained so that a proper seed placement can be achieved. They further explained that they do not accomplish the final seedbed preparation too far in advance of planting, as this may cause excessive and untimely moisture losses from the field.

The intensity of cultivation or other land preparation necessary to achieve these goals will vary depending on the type of soil, moisture conditions, and other factors, but preparation of a good seedbed will usually require two or more trips over the field with the traditional plough (locally called *maresha*). Tef requires three to four trips, whereas, for example, wheat, triticale, maize and sorghum require “only” two trips depending on how often the field has been in use. The more frequently the field is in use, the less intensive trips over it are required. In Estie, several respondents described that tef fields need to be prepared as fluffy as possible so that the tef seed can out-compete the weeds, which otherwise would reduce the availability of plant nutrients in the soil. However, in many vertisol soils (*walka meret*) it was observed that water remains standing more frequently on tef fields than on any other crop fields, which could lead to a lesser air movement to a breakdown of soil structure and cause the soil to crust badly. This can be attributed to excessive land preparation during which a high soil compaction can occur.

### 5.4.3 Soil nutrient management

Soil nutrient depletion is rarely directly linked to food shortage, as it is a gradual process unlike natural calamities (Amare et al., 2005). Nevertheless, several studies (e.g. Sanchez 2002) have revealed that a lack of plant nutrients is one of the principal causes for low agricultural productivity and food insecurity in Africa. With Ethiopia's population of over 76 million growing at a rate of about 2.3% per year (CIA 2007 est.) and a chronically lack of foreign exchange, the existing agricultural production needs to accelerate in order to keep up with the population growth and an ever increasing demand for food. In most cereal growing areas of the Amhara Region, particularly in the study districts, the problem of low phosphorus and nitrogen availability has been reported. Though households in these areas could overcome this problem through nutrient management practices, such as the application of chemical fertilizer, and also by adopting new species and varieties that are responsive to low phosphorus and nitrogen levels, they are financially very limited. It is therefore in these areas where farmers will benefit most from the triticale crop, which utilizes, for example, the low levels of P availability in the soil efficiently. Gerloff (1977) classified triticale and durum wheat (*Triticum turgidum*) genotypes as phosphorus efficient and responsive cultivars, meaning that higher yields could be obtained under lower phosphorus supply than other cultivars.

Triticale is well known for its deeper and more extensive root system than wheat and barley, and thereby, is more capable to access to nutrients at deeper levels of the soil profile than other grains. Research reports indicate that this deeper root system ensures that the greater amounts of organic matter remain in the soil that contribute to increased microbial activities and a greater pH buffering capacity (Feldner et al., 2003). Earlier studies by CIMMYT and Varughese et al. (1966) also indicate that triticale accumulates more nitrogen during heading and physiologic maturity than wheat does; and this variation in N accumulation is highest under low levels of N application, indicating that triticale is a better crop for soils with low nitrogen fertility. Comparisons between the typical balance between nitrogen added in fertilizer and nitrogen removed in the harvested produce have revealed triticale to absorb more nitrogen from the soil than wheat (Sylvester-Bradley 1993).

A shortage of nitrogen is said to significantly reduce yield. The primary nitrogen deficiency symptom on cereals is a plant disorder or appearance of leaf chlorosis (e.g. leaf yellowing) and necrosis (i.e. death) starting with older leaves and latter with younger ones (Richter 2005). When this happens, the plant foliage produces insufficient chlorophyll and, as a result, the leaves may be pale green, yellow, or yellow-white. However, according to Richter, leaf chlorosis/ necrosis symptoms on cereals can also occur as a result of phosphorus and potassium (K) nutrient deficiencies.

Chemical fertilizer (DAP and urea) and compost (organic manure) application by sample households in the study areas is discussed in section 5.2.1 and summarised in Table 5.5. The sample households reported that there was no variation or differentiation in fertilizer application between different cereal crops for the survey season except that cereals are privileged to receive more fertilizer than any other crops. During the survey period, there was no single farmer from the sample who applied any type of fertilizer for legume crops. Risk factors, such as moisture stress and high probability of drought occurrence, were often mentioned as major determining challenges for the households to apply fertilizer, particularly through farm credits.

### 5.4.4 Weed, pest and disease management of triticale

As reported by some of the triticale-growing households, the most common weeds which appeared on triticale were the same weeds that occur on wheat fields, including annual weeds, such as wild oats and broad-leafed weeds, particularly on water logged places. Shroyel et al. (1996) revealed that weeds were most likely to cause problems in triticale fields with poor growth environments. According to these authors, production practices that encourage quick establishment and a healthy uniform stand of triticale can result in early canopy development and may eliminate the need for any additional weed control practices.

Triticale growers in the study areas explained that triticale fields were hand-weeded and treated under the same conditions as tef, wheat and barley and an average yield increase of about 75% was observed in 2004/05 main crop season, reflecting that triticale tends to be more robust and competitive with weeds than other cereals. This can be mainly attributed to triticale’s ability to grow faster and taller than the infesting weeds, particularly during the early growth stages, making it more competitive and resistant towards the other cereals. A similar argument was reported by the respondents in terms of the resistance of triticale to hailstorms. As one of the farmers commented, “when heavy rain containing hails occurs, triticale, unlike tef, wheat or barley, generally has reached a higher phase of growth, where it can withstand the hail better than it would do if it were at its early stages”.

In terms of disease tolerance, there were no reports on disease incidence from any of the sample respondents in the study areas or registered by research institutions so far except from one agricultural expert in the Farta WOARD, who has reported the incidence of *Septoria* (locally called *bicha wag*) which does not appear to be a serious pathogen problem on triticale, as many authors are reporting a high level of resistance (Mileke 1995). In other studies, such as that by Shroyer et al. (1996), one of the most significant diseases of triticale (for e.g. in Kansas State, USA) was reported to be ergot, which attacks the heads and produces purplish-black, horn-shaped, hard sclerotia in place of developing kernels. However, the report also notifies that on average, triticale had better resistance to all these diseases than wheat, and no special controls were recommended. Concerning pests and diseases occurring on triticale, different levels of resistance have been reported in various country specific studies.

According to Wolski (1991a), most triticale strains under study, were highly resistant to rusts and mildew, and where attacks occurred, according to him, they were generally “late and slow rusting type” which was less damaging than those observed in wheat. In other reports Singh and Saari (1991) stated that triticale appeared to have a higher resistance to several bread wheat diseases and pests, such as rusts (*Puccinia Pers*. Ex Pers. Spp.), smuts, bunts powederly mildew (*Erysiphe graminis*), cereal cyst nematode (*Heterodera avenae* Wollenweber) and Hessian fly (*Mayetiola destructer*). Also a study in South Africa (2004) reported the occurrence of leaf rust infections on previous resistant cultivars called Tobie, Rex and Usgen 19. This was assumed to have been due to the development of new rust race. Nevertheless, as triticale is generally considered to be more resistant to diseases and pests damage than wheat, the report does not recommend spraying pesticides unless severe cases are recorded. In Ethiopia, no disease or pests infestation was officially recorded so far. The South African version “Usgen 19” is a long-maturing variety which according to GTZ/SUN Amhara project, was, legally released in 2002 as “*maynet*” and is, particularly suitable to South Gondar highland areas, including our research *wereda*. Along with the *maynet*, the short-maturing variety named “*sinan*”, was also released in the same year.

The triticale-growing sample households in the study areas indicated the superiority of triticale in terms of hardship resistance, such as disease resistance, frost, hail, drought tolerance, compared to other cereals in the respective peasant associations. Subsequently, the households were asked to compare triticale with tef, wheat and barley in terms of diseases and pests, frost, drought and hail resistance. About 46.6% (89 hhs) explained that even though there was no disease occurred on their fields, they heard that triticale might resist diseases and pests better than tef, and about 29% (55 hhs) of them believe that triticale did not differ from tef in terms of disease resistance.

### 5.4.5 Frost, hail and drought tolerance

The main cultivars of triticale in Ethiopia currently are the *sinan* and *maynet* varieties. Reports by Feldner et al. (2003) indicate that the *sinan* variety may supplement tef in moisture deficit areas and in places where there is a late onset of rains, whereas, the long season triticale, *maynet*, shows a superior performance over wheat and barley under meagre environmental conditions (such as depleted soils, irregular rainfall, waterlogged, hail-prone and high altitudes). In confirmation to this, CIMMYT in its annual report (2001/02), concluded that triticale is tolerant to drought, frost, and problem soils, which can be grown in seasons and places where other crops will not grow so well, and in such adverse conditions, triticale yields more biomass and also more grain than competing crops. The fast growth behaviour of triticale is one of the unique properties of the crop to escape frost damage. According to the interviewed households, frost generally causes severe damages on cereals at the early stages of growth, but in case of triticale, as it grows faster, it escapes heavy hailstorms, falling during the rainy season (June to September).

During our field to Adet Agricultural Research Centre (AARC), researchers have also observed the excellent performances of triticale on marginal, mainly acidic and highly degraded areas in east Gojam Administrative Zone, where farmers usually cultivate oats (called *sinar* in some places) with least yield harvest. *"Triticale is an ideal crop specially for these areas where farmers had no well adaptable crop alternatives under such poor soil conditions"* said one research officer at AARC in a personal discussion during our visit of the Centre (Dec. 29.2005). According to him, the early maturing *sinan* variety was better threshable but with relatively lower yield, and farmers' acceptance of triticale in these locations he said, was very high. In 2005 there were two other varieties at verification level for release in the Centre and other trials were underway in Injibara area (East Gojam Administrative Zone). The long season variety *maynet* was reported to provide more grain yield than the short season variety *sinan*. This is consistent for example, with the yield trial research results of 86 and 81 qt ha$^{-1}$ (2001 on-station trial) for *maynet* and *sinan* respectively, which was carried out by SUN/Amhara (2006) under controlled conditions. Therefore, as drought is one major cause of crop failure in the Ethiopian highlands including the study areas, triticale may be seen as a highly prospective plant that can ensure improved food security even when planted on a smaller farm area which most Ethiopian farmers own today. As triticale provides a higher crop yield per unit area as compared to tef, wheat and barley, food self-sufficiency at household level can be improved substantially if farmers are given the option to grow more hardship tolerant triticale cultivars, particularly in areas where rainfall is erratic and economic factors restrict access to agricultural inputs, such as fertilizer, pesticides and insecticide sprays.

In the study districts, about 54.5% of triticale-growing farmers in Farta *wereda* have reported that triticale and tef do not vary from each other in terms of drought tolerance. In terms of hailstorms and frost resistance, however, about 53% of them indicated that triticale has more ability to withstand frost and hail than tef (based on the farmers' observation in Gassay village where a severe hailstorm and frost had occurred, which was also observed during the survey). It was astonishing that some non-growers were also well informed in some aspects. This can be attributed to the fact that non-triticale-growers were well concerned over the crop because of their anticipation to grow it in the upcoming season (2006). Moreover, during the time of the field research, it was witnessed that frost, for example, in some places of Farta district was a major issue of concern, which was to be seen when passing by the crop fields. After a heavy hailstorm and subsequent frost, a triticale field in Gassay village was observed untroubled by the heavy hail, whereas the nearby crops, specially the pulse crops, had suffered heavily. According to Stanley (2003), with oats being least susceptible followed by rye, barley tolerates frost more than triticale with the latter being less susceptible than wheat. The ranking of these crops in terms of their susceptibility to frost is listed in the following order.

Least susceptible ----------► Most susceptible
(Oats, rye, barley → triticale → wheat)

However, it should be pointed out that this ranking may change if the sowing times of the crops relative to one another changes, and according to varieties of each crop. On the other side, frost damage on crops heavily depends on several factors. Stanley indicated the following factors among others:

a) *Soil types and soil moisture* – light, poorly consolidated soils will reach lower minimum temperature with greater risk of frost damage than the heavy, well compacted soils,
b) *Topography* – mean temperatures fall as altitude increases. In an undulating country cold air flows downhill, filling the valleys. Frosts are therefore, more common and severe in low-lying areas situated at high altitude, which partly holds true to the agro climatic conditions of the study areas,

c) *Stage of crop development* - this is also an important factor in frost injury of crops. Crops are more susceptible to frost damage when they begin stem elongation and thus the developing head (plant shoot) moves away from the protective effect of the soils,

According to our survey result and expert interviews, triticale was less susceptible to frost so far in the study areas as it grows faster than other cereals thus escapes frost injury at the early stage of development.

d) *Potassium uptake by plants* (content of available potassium in the soil). The more potassium (K) is available in the soil, the more the plants tolerate frost.

### 5.4.6 Seed dissemination, expansion and acceptance of triticale by farmers

#### 5.4.6.1 Dissemination and acceptance by farmers

During the field survey, it was observed that triticale dotted the landscapes of Farta, Estie, Lay Gaint, Simda and other visited *wereda* of South and North Gondar Administrative Zones from far distances (due to its special colour), even on mountain sides. As discussed in section 5.4 triticale has been spreading very fast, particularly in the study areas and in the Amhara Region as a whole. A good indicator for this is that according to the GTZ experts, farmers had been withholding the bulk of their harvest of triticale (contrary to their agreement with IFSP to return the seed after harvest) for possible exchange with other farmers, and trading on the market for high prices. As shown in Table 5.7, the distribution of triticale seed to farmers through various development bodies has reached the five major Regional states since its reintroduction in the country. As can be figured out from the Table, over 78% (4 in 5 quintals) of the seed remained in the Amhara Region and nearly the whole rest was sent to the Oromia region. The shaded area within the Table shows the total annual provision (quintal/year) of the study districts, which were among the first beneficiaries of the seed provision among the Amhara *wereda*. The official seed distribution, according to the SUN-Amhara project survey, represents only 3 to 10% of the farmer-to-farmer dissemination rate.

Table 5.7. Annual triticale seed supply to Regions and the study districts

| **Region/ *Wereda*** | **Year (% of ann. total supply); Total (qt) and Total percent** | | | | | | |
|---|---|---|---|---|---|---|---|
| | 2002 | 2003 | 2004 | 2005 | 2006 | Total (qt) | Ann. total supply (%) |
| Amhara | 98.4 | 69.1 | 72.4 | 79.3 | 79.9 | 3850 | 78.2 |
| Farta<br>Esite | 63<br>30 | 37<br>30 | 73<br>20 | 192<br>24 | 170<br>30 | 534<br>134 | -----<br>----- |
| Oromia | 1.6 | 22.9 | 18.0 | 12.0 | 19.6 | 818 | 16.6 |
| Tigray | 0 | 5.4 | 5.5 | 8.7 | 0 | 199 | 4.0 |
| SNNP | 0 | 2.5 | 3.7 | 0 | 0.5 | 55 | 1.1 |
| Benishangul | 0 | 0 | 0.4 | 0 | 0 | 3 | 0.1 |
| Total | 100 | 100 | 100 | 100 | 100 | 4 925 | 100 |

Source: GTZ / SUN Amhara (2006)

#### 5.4.6.2 Dissemination paths of the crop in South Gondar

**Seed supply by the IFSP and the WOARD**

The GTZ /IFSP in the Amhara Region has distributed triticale seed to the WOARD for its redistribution to individual farmers and cooperatives in the respective *wereda* with the agreement that the full harvest would be handed over to the IFSP in exchange for an equivalent amount of wheat and/ or tef. The farmers were supplied seed and fertilizer for a half a hectare of land for seed multiplication purposes. According to Feldner et al. (2003), contrary to the agreement, less than one-third of the harvest was returned to the programme for exchange. As the authors indicated, this was regarded by the programme as the first clear indication of the acceptance by farmers of the merits of the crop. Other non-governmental organisations have been also purchasing seed from IFSP, which they distribute to farmers in various parts of the Amhara Region. One of this is the Austrian food security programme office in North Gondar (Debark *wereda*), which was visited during the field survey in order to have an insight in the expansion of triticale in other parts beyond the study areas. According to the programme officer, triticale in Debark was first introduced in 2003 and farmers who obtained seed from his office had obtained 2-3 fold yields (up to 34 qt $ha^{-1}$) of the local crops, i.e. barley and wheat.

**Farmer-to farmer-exchange**

Triticale growing farmers were requested for seed by non-growers in advance before harvest, and this was seen as one of the most important and primary dissemination path by the IFSP. Metz and Tesafye (2003) reported that there were slight differences to exchange triticale seed for wheat and tef, which was 1:1 (triticale: tef) and 2:3 (triticale: wheat). Since the seed was insufficient supply due to the wide acceptance and strong desire by farmers to cultivate triticale, the cost of triticale was higher than that of wheat during the sowing season of 2005/06 *meher*.

**Acquiring seed from markets**

Another way for the farmer to obtain seed is to buy it from the market. However, this was not always the case everywhere in the study *wereda* markets in the past, as triticale was not widely available during sowing seasons.

In all visited *wereda*, the acceptance by farmers and their desire to obtain seed for the 2006 season was remarkably high. All of the respondents knew about the crop, but with other nick names, such as *logaw shibo* (tall and elegant) in Farta and Estie, *mogn aibelash* ("crop not for lazy farmers", indicating its high effort requirement, particularly during threshing) in Amba Giorgis, *tekalign* ("my substitute"), *addisu sinde* (i.e. "the new wheat") and according to Metz and Tesfaye (2003), "*wassie* and *kibre*" meaning "my insurance and my pride", respectively.

### 5.4.7 Limitations and constraints of growing triticale

Threshing and the comparatively weak quality of injera from triticale flour were the major problems that the triticale-growing farmers reported to have faced in the beginning of triticale adoption. However, they said that from the second year on, these were no longer major problems as they make get experienced with the crop. As shown in Table 5.8, 37% (72 hhs) reported that triticale was difficult to thresh, nearly 32% (62 hhs) said that triticale needs other cereals to obtain good holed or eyed injera, and nearly 31% (60 hhs) of them said that the injera from triticale was weak compared to tef.

Table 5.8. Major constraints of triticale at the beginning of adoption in the study areas

| **Triticale growing households** | | |
|---|---|---|
| **Constraint** | **Number of hhs** | **Percent** |
| - Threshing was difficult | 72 | 37.1 |
| - Triticale flour without tef did not give good holed (eyed) injera | 62 | 32.0 |
| - Triticale-injera without tef blend is weak when compared with tef | 60 | 30.9 |
| Total | 194 | 100 |

Source: own survey

In some areas there was a concern by agriculturalists as to the possibility of mono cropping of triticale with the expulsion of other cereals, which, as a result, brought some farmers in a dilemma about the growing of triticale. A number of farmers in some of the visited *wereda* reported that discouraging information disseminated by individuals about triticale's alleged "aggressive" nature in reducing soil fertility had led them to confusion and to refrain themselves from growing this crop. The lack of triticale seed and lack of information about the crop were most frequently mentioned by non-growers, as a big limitation withholding them to grow triticale during the survey season. Some growers were also relying on other farmers who grew triticale earlier and offered seed to them for expensive prices of up to 3.10 Birr per kg or exchanged them at 1:2 (triticale: wheat) exchange rate ratio.

#### 5.4.7.1 Harvesting

Triticale is harvested in the same way as wheat. Williams (1995) recommends not to delaying the harvest in order to avoid grain sprouting under wet conditions. In some of the visited places, farmers explained that they prefer to harvest triticale at the end of collecting other cereals. This was because of triticale's ability to withstand extreme sun, unlike other crops, and they let it dry completely on the field in order to make threshing easier. As respondents were asked why triticale was still standing on the field while all other crops were gone, they said that priority is given to other crops because, on the one hand, though the spikes look dried on the field, in reality it is still moist internally which would make threshing hard and the chaff does not break up easily to release the grains, and on the other hand, the kernels of other crops, such as wheat and tef will drop as a result of weather changes unless harvested on time. Generally in the study areas, triticale is mowed or chopped with a sickle by hand leaving, about half of the stem standing on the field which will be uprooted latter and kept stocked for thatching roofs. This is not a common phenomenon in wheat harvesting. In the cold highlands, barley straw is used for thatching. This reflects the suitability of triticale straw for roof thatching for those farmers who can not afford to build a house with iron sheets. Universally, farmers thresh their crops by oxen trampling and as some of them explained they additionally need to pound it with sticks besides threshing it with animals after spreading it out on the threshing yard (locally called *awdma*).

#### 5.4.7.2 Post harvest

According to FAO/WFP (2006), the post harvest losses of crops in Ethiopia is estimated at about 2.4 million tonnes based on post harvest loss rates ranging from 3% for tef to as high as 25% for maize and pulses, and have averaged at about 14% of the total 2005/06 *meher* harvest. Post harvest loss for triticale was not a major problem for triticale growers, however, one farmer in Estie mentioned that triticale was attacked by some insects while it was stored for about one year and said that for that reason he had increased the seed rate. But as the study areas generally lie on altitudes over 2400 metres above-see-level and are relatively cold, triticale grain can be stored for longer time without greater fear of insect damage.

## 5.5 Attributes that farmers value in growing triticale

There is a number of specific properties of triticale that make it a good alternative cereal for abrasive growing conditions in the study districts and beyond. Some of the properties cited in the literature were confirmed by subsequent experiments of SUN-Amhara and district agriculture offices in the study areas: The impressive yield potential even on agronomically stressed environments, including its outshining characteristics on acid, sandy and alkaline soils compared to other cereals; its significant resistance on insect and disease infested soils, its capability to tolerate hail and frost are the primary advantages of triticale as compared to other cereals that influence farmers positively for growing triticale. Yield comparisons made in Estie *wereda* for example showed a 100% yield increase for triticale over wheat, barley and tef with or without fertilizer, implying triticale's superiority over the major cereals in terms of yield that farmers in the study areas may value most.

Apart from its impressive physiological characteristics and adaptability under adverse environmental conditions, triticale grain quality and suitability to the traditional *injera* and bread making is the second prominent concern that households may extensively review before adoption. In terms of grain quality, many households were becoming increasingly aware of the benefits of triticale, including the variety of food stuffs they can meet from triticale grain like bread, *injera*, *areke, tella*, *kita* (unleavened bread), *nifro* (boiled food from cereals or legume crops) and *kollo* (roasted food from cereals or legume crops). Grain yield, grain quality and other related attributes are briefly discussed in the following sections.

### 5.5.1 Grain yield

The ability to provide a high grain yield even under adverse growing conditions, such as drought, pests and diseases, frost, hail, acidic soils or heavy competition by weeds is the unique characteristic of triticale that farmers might choose to grow it. Land degradation by erosion in the study areas leads to increased farmers' vulnerability to drought and thus, to greater risk of food insecurity by reducing soil depth and moisture-holding capacity. This, combined with other factors, lock poor households in the cycle of poverty and environmental degradation which is often observable in most parts of South Gondar. Triticale is known to reduce soil erosion and capture excess soil nitrogen often lost from other crop systems because of its strong rooting structure. Also Gibson (2006) indicates that triticale is an ideal crop for producers utilizing sustainable agriculture practices and organic farming techniques due to its excellent nutrient, water and energy use efficiencies, and requires few if any pesticide inputs.

As research reports, for example, by Hede (2000) evidenced that triticale requires approximately 30% less water to produce the same amount of biomass as wheat, sorghum oats or rye. On acid soils with highly soluble aluminium content which is toxic to cereals, recent triticale varieties yield at least 30% more than wheat or barley. Similarly, experiments on sandy (low nutrient soils) from North Africa show that triticale outyields wheat and barley by about 33%. On saline soils triticale was reported to yield about 10% more than durum wheat, but according to Hede, it is not quite as much productive as barley.

In our field survey, about 70%, 52.3% and 50.5% of triticale growers have witnessed the superiority of triticale over tef, wheat and barely respectively, in terms of yield during the 2005/06 crop season. Also a report by Metz and Tesfaye (2003) indicates that triticale outyields wheat and barley with or without fertilizer application. About 80% of triticale growers have revealed their aspiration to grow triticale further due to its superiority in yield over tef and its better frost and hail resistance ability than wheat respectively. Given that triticale can be grown with reduced levels of inputs and that it can out-perform other cereals in marginal agricultural environments, the farmers can have a competitive advantage over other cereals in terms of production costs, such as fertilizer, insecticides and fertilizer.

As shown in Table 5.9, eight variables hypothesized to influence triticale crop yield, were extracted from the survey data to illicit information on factors affecting triticale yield in the study areas.

Fertilizer use (PURINPUT) by smallholder farmers in Ethiopia varies from region to region, particularly after the removal of subsides by the government and market liberalisation. As the survey result suggests the farmers in the study areas apply very limited chemical fertilizer even though access to credit in kind was prevalent from the Regional Agricultural and Rural Development Bureau branch offices. But as many of the interviewee reported, they often refuse to credit provisions from the government in order not to put themselves into huge debts.

NOXEN – It is a common phenomenon for smallholders in the study areas to exchange, rent or borrow traction power. Those with single ox exchange with others and households without any oxen, particularly women headed families, rent-out their farmland for two or more oxen holders and better financial capability farmers. Higher number of oxen availability is therefore assumed to increase the use of improved technology, such as triticale, and thus increased grain yield and food availability.
EXTNSON, agricultural information is mainly disseminated to farmers by means of extension services from the Ministry of Agriculture and Rural Development in Ethiopia. Lack of such information certainly affects crop productivity, let alone to try new technologies, such as triticale adoption. Previous studies, for example from Evenson and Mwabu (1999), stress that there exists, a strong correlation between farm productivity and extension, whereby a larger number of extension workers per farm is assumed to intensify the effectiveness of the extension service delivered to farmers. Thus, in this analysis, we also assume that extension will have a significant impact on crop yield.

Farm education (EDULEVEL), is another crucial factor that can affect crop yield. However, other studies, for example, that cited by Wu (1977), did not establish a significant association between yield performance and farm education, which may suggest that farm education and crop production studies are yet at an early stage of development. Nevertheless, the present study assumes that basic education of farmers is positively associated with farm productivity in view of the fact that household members with basic education may acquire and interpret information, and allocate farm inputs more efficiently than those farmers without any basic skill in education. Moreover, increased education may influence the decision making by farmers to apply new techniques as well as improved variety of crops and new species with higher yield possibility.

Table 5.9. Explanatory variables predicted to influence triticale yield over tef, wheat and barley

| Variable | Description | Expected sign of relationship |
|---|---|---|
| FAMSIZE | Number of persons in the household (con) | + |
| EDULEVEL | The level of education of the household head (con) | + |
| FARMSIZE | The total size of cultivated land (con) | + |
| PURINPUT | Purchase of fertilizer made in (2005/06) (dum) | + |
| DMARKT | Distance of farmer's residence from the nearest market (con) | - |
| EXTNSON | If farmers have access to agricultural extension services and information (dum) | + |
| NOXEN | Number of oxen households own (con) | + |
| OFRINCOM | off-farm income households earned in 2005/06 (con) | + |

Source: own survey

Out of the hypothesized eight explanatory variables to influence triticale yield over tef, wheat and barley, four are found to be significantly associated with it, out of which two are continuous and other two are dummy variables (i.e. extension and fertilizer).

The relationship between FAMSIZE and triticale yield appeared to be strong which is significant at $p<0.01$ level, implying that an increased number in family size improves crop productivity, hence higher number of people in the family can be a good source of labour to share farm activities, such as weeding, harvesting and looking after animals.

Since household income in the study areas is generally dependent upon agricultural activities, an increasing size in cultivated land (FARMSIZE) is expected to increase crop yield and availability of food at household level. However, farm size in this analysis shows only weak significant relationship (i.e. significant at less than 10% level) to grain yield. Crop productivity does not depend on farm size alone but also on other factors, such as fertilizer use, quality of land, use of improved seed and availability of rain water.

Fertilizer (PURINPUT) and extension (EXTNSON) are found to be significant to triticale yield each at $p<0.05$ level.

The regression result shows a negative association between market distance (DMARKT), and crop yield, which is very high significant at the 1% level. The result is in consistent with the assumption that long market distance will have a negative impact on crop yield and the contrary scenario otherwise. The results of the Probit regression model regarding to triticale yield are listed in Table 5.10.

Table 5.10. The result of the Probit estimate regression on triticale yield

| Variable | Coefficient | T-value | Mean |
|---|---|---|---|
| FAMSIZE | 0.64065 | 2.422* | 7.05 |
| EDULEVEL | -0.05912 | -1.283 | nc |
| FARMSIZE | -0.40856 | -1.485 | nc |
| PURINPUT | -0.31274 | -2.130** | nc |
| DMARKT | -0.14542 | -3.109*** | nc |
| EXTNSON | 0.70543 | 2.894** | nc |
| NOXEN | 0.54759 | 1.391 | 2.11 |
| OFRINCOM | 0.26151 | 1.804 | 489.38 B |

Constant = -2.55262
N = 387; missing values = 21
Pearson Chi-square = 334.413
Percent correctly predicted = 48.67 B = Birr ; nc = not calculated

Note: * Significant at 10% level
** Significant at 5% level
*** Significant at 1% level

Source: own survey

### 5.5.2 The grain quality for baking

Ecological and economic factors in human food selection always provide a context within which sensory and socio-cultural factors come into play. According to Pelto et al. (1986) socio-cultural factors must always be considered in calculating human food selection in economic terms. Food selection can be governed by a number of sensory characteristics, such as *appearance, smell, texture, taste and colour*, whose exact dimensions as well as degrees of acceptance or preference could differ among cultures. Before conducting an experiment to assess the suitability and test for consumer preference of food from triticale flour, triticale growing households were asked to describe their experience of the crop in terms of the above sensory and visual characteristics. Households were first asked if they were able to prepare the foodstuff they usually prepare from other cereals. Consequently, except 19 households, all triticale producing farmers (175 hhs) had prepared various types of food, such as *injera*, bread, *kita*, *kollo* and *nifro*, while reporting triticale was extraordinarily suitable for *tella* and *areke* from either flour or wholegrain. The grain quality assessment in this chapter is based on the judgement of the farmers.

### 5.5.2.1 Colour and appearance

Colour and appearance of baked products from triticale flour were some of the major features assumed to influence the acceptance of the crop by farmers. Because the main staple food in the study areas is injera and bread from tef and wheat respectively, the people distinguish the quality of a given product (also among tef varieties and colours) by observing its physical appearance, colour and texture as summarized in Table 5.11. Out of 194 respondents 118 hhs (60.8%) found the appearance and colour of triticale injera *very good*, and just 7 hhs (3.6) found it *very poor*. A total of 24 hhs (19.1%) did not know about the baking quality as they had cultivated triticale for the first time (was still on the field) and have not yet tested it. Some 45 hhs (23.2%) classified bread baking quality of unmixed triticale flour as *good*, 35 hhs (18.0%) *very good*, 40 hhs (20.6%) *poor*, 37 hhs (19.1%) *fair* and 25 hhs (12.9%) *very poor*. The respondents also said that triticale flour gives the best bread and *injera* qualities specially in terms of texture and taste in mixture with wheat and tef flours respectively.

Table 5.11. Subjective evaluation of injera and bread by farmers in terms of colour, appearance and taste

| | **Colour and appearance** | | | |
|---|---|---|---|---|
| | **Injera** | | **Bread** | |
| **Score** | **No of hhs** | **Percent** | **No of hhs** | **Percent** |
| Very good | 118 | 60.8 | 35 | 18.0 |
| Good | 39 | 20.1 | 45 | 23.2 |
| Fair | 8 | 4.1 | 37 | 19.1 |
| Poor | 10 | 5.2 | 40 | 20.6 |
| Very poor | 7 | 3.6 | 25 | 12.9 |
| I do not know | 12 | 6.2 | 12 | 6.2 |
| Total | 194 | 100 | 194 | 100 |
| | **Taste of injera and bread** | | | |
| | **Injera** | | **Bread** | |
| **Score** | **No of hhs** | **Percent** | **No of hhs** | **Percent** |
| Very good | 79 | 40.7 | 106 | 54.6 |
| Good | 34 | 17.5 | 31 | 16.0 |
| Fair | 33 | 17.0 | 24 | 12.4 |
| Poor | 17 | 8.8 | 9 | 4.6 |
| Very poor | 19 | 9.8 | 12 | 6.2 |
| I do not know | 12 | 6.2 | 12 | 6.2 |
| Total | 194 | 100 | 194 | 100 |

Source: own survey

According to some men respondents an experienced woman can prepare good bread and *injera* from triticale flour without any mixture. Colour as one visual characteristic of *injera* and bread often influences the people in food selection more than a reputed nutritional value. Generally, in the tef-injera “eating society” in Ethiopia, for example, eating white tef is seen as a sign of wellbeing or prestige, since they believe that white tef *injera* looks and tastes better than *injera* from purple tef despite their assumption that purple tef has a higher iron (Fe) content than the white one, which is not scientifically confirmed. White tef therefore, is more expensive on the market than purple or the mixture of both. Wohwinkel et al. (2002) indicated that there was not more iron in brown seeded-tef than in the white one. The iron content in tef grain is higher compared to other cereals, which, according to these authors is not due to contamination during the threshing process but the result of a high iron uptake and translocation within the tef plant.

#### 5.5.2.2 Taste of injera and bread

Taste is another important element that households give emphasis, and judge the suitability of triticale flour for bread and *injera* baking, which can significantly influence the decision to adopt the crop. As indicated in Table 6.5, 40.7% and 54.6% respectively, said it is *very good*, whereas nearly 17.5% of them found triticale injera *good*, compared to 16 % for bread. About 12% of the respondents rated triticale bread as *fair* compared to 17% for *injera*, and nearly 9 and 6%, respectively rated both injera and bread from triticale as very poor.

#### 5.5.2.3 Shelf life of triticale grain and baked products

Storage of triticale as whole grain was rated as very good by 58.8% and good by 21% of the respondents, but nearly 7% of them rated the storability of triticale as whole grain as only fair, explaining that the stored triticale seed was damaged after about eleven months of storage by granary weevils (*Sitophilus granarius* L.). The weevil, whose larvae develop inside the grain kernel, likes a warmer climate, and both, adults and larvae feed on many varieties of grain, specially sorghum and maize. Weevil is common in wider Ethiopia.

In terms of shelf life of bread and *injera* of triticale flour, 80% of the respondents expressed their satisfaction with the shelf life of *injera*. The storage ability of bread and *injera* prepared from triticale flour was said be not different from other cereals. But, in terms of its advantage in digestibility, the respondents reported that particularly when children eat triticale *injera*, they do not fill hungry very fast because it digests less quickly than the injera from tef.

### 5.5.3 Nutrition value of triticale flour compared to tef and other major cereals

As shown in Table 5.12, triticale has higher protein content than maize, tef, barley, rice and sorghum. Triticale has also higher starch content than tef. Cereal grains including tef are low in total protein compared to legumes and oilseeds. Nutrient values of triticale and other major cereals are indicated in Appendix 4.

Table 5.12. Nutritional value of triticale compared with other cereals (value per 100 grams)[1)]

| **Nutrition** | **Tef**[a)] | **Barley** | **Wheat** | **Triticale** | **Rye** | **Maize** | **Rice** | **Sorghum** |
|---|---|---|---|---|---|---|---|---|
| Proteins | 12.3 | 10.50 | 13.70 | 13.18 | 14.03 | 6.93 | 7.23 | 11.30 |
| Fats | 2.6 | 1.60 | 1.87 | 1.81 | 2.69 | 3.86 | 2.78 | 3.30 |
| Fiber | 3.5 | 10.1 | 12.2 | 14.6 | 22.6 | 7.3 | 4.6 | 6.30[2)] |
| Starch | 73.0 | 74.52 | 72.57 | 73.14 | 68.74 | 76.85 | 76.48 | 74.63 |
| Inorganic matter (ash) | 3.0 | 1.28 | 1.60 | 1.85[b)] | 3.47 | 1.45 | 1.54 | 1.57 |
| Water | 6.9 | 12.11 | 14.2 | 10.0 | 11.07 | 10.91 | 11.97 | 9.20 |
| Energy, kcal | 347[3)] | 345 | 339 | 338 | 324 | 361 | 363 | 339 |
| Sugar, total | 0.0 | 0.80 | 0.41 | na | 1.04 | 0.64 | 0.85 | na |

Note: 1) Nutrient values and weights are for edible portion, na = "not available"

2) Total dietary fiber value is for white sorghum. For other types it range from 8.8 to 11.1 g/100g

3) This figure was obtained by dividing 1452 KJ to 4.183 (conversion factor)

Sources: USDA (2006)

a) Soil and Crop Improvement BV (2006)

b) Richter, C. reports an inorganic value of 2.2 g /100g (personal com.)

Tef is an important highly regarded cereal in Ethiopia, although, it gives the lowest yield per unit area among cereals. The nutritive value of tef is similar to that of other cereal grains, except that it is richer in iron and calcium, which may be an important reason why iron deficiency – anaemia, is rarely reported in large areas of Ethiopia where tef is highly consumed. Nevertheless, lysine, the first limiting essential amino acid in human consumption, is higher in triticale, wheat, barley and rye than in tef. Rye contains a higher amount of lysine than all the other common cereals (wheat, barley, rye, triticale, sorghum, maize and tef). Other amino acids, such as *tyrosine, histide, arginine* and *phenylalanine* are also higher in triticale grain than in tef, whereas the latter contains a higher *metheonine* than the rest of these cereals including triticale. The essential amino acid tryptophan is limited in maize and rice protein. Table 5.13 illustrates the chemical composition of the major cereals.

Table 5.13. Chemical composition of triticale compared with other cereals (g/100 g proteins)

| **Amino acids** | **Tef**[a)] | **Barley** | **Wheat** | **Triticale** | **Rye** | **Rice** | **Sorghum** | **Maize** |
|---|---|---|---|---|---|---|---|---|
| Lysine | 2.80 | 3.91 | 3.78 | 3.69 | 4.86 | 2.76 | 2.29 | 1.95 |
| Isoleucine | 3.90 | 3.83 | 5.08 | 4.84 | 5.41 | 3.06 | 4.33 | 2.48 |
| Leucine | 7.40 | 7.13 | 9.26 | 9.20 | 9.70 | 5.98 | 14.91 | 8.50 |
| Valine | 5.00 | 3.01 | 6.18 | 6.15 | 7.03 | 4.24 | 5.61 | 3.51 |
| Tryptophan | 1.50 | 1.75 | 2.12 | 1.58 | 1.59 | 0.92 | 1.24 | 0.49 |
| Threonine | 3.40 | 3.56 | 3.95 | 4.09 | 4.86 | 2.65 | 3.46 | 2.61 |
| Histidine | 1.90 | 2.36 | 3.17 | 3.14 | 3.13 | 1.84 | 2.46 | 2.11 |
| Arginine | 3.40 | 5.26 | 6.42 | 6.78 | 6.35 | 5.48 | 3.55 | 3.45 |
| Metheonine | 2.50 | 2.02 | 2.12 | 2.06 | 2.09 | 1.63 | 1.69 | 1.45 |
| Phenylalanine | 4.80 | 5.89 | 6.46 | 6.44 | 7.10 | 3.73 | 5.46 | 3.40 |
| *Tyrosine* | *2.10* | *3.01* | *4.00* | *3.87* | *2.77* | *2.71* | *3.21* | *2.82* |
| *Cystine* | *na* | *2.32* | *3.17* | *2.78* | *2.77* | *0.88* | *1.27* | *1.25* |
| *Alanine* | *na* | *4.09* | *4.87* | *4.91* | *5.80* | *4.22* | *10.03* | *5.18* |
| *Aspartic acid* | *na* | *6.55* | *7.03* | *7.94* | *9.65* | *6.77* | *7.43* | *4.82* |
| *Glutamic-acid* | *na* | *27.41* | *43.25* | *40.48* | *39.15* | *14.73* | *24.39* | *13.00* |
| *Glycine* | *na* | *3.80* | *5.52* | *5.65* | *5.34* | *3.56* | *3.46* | *2.84* |
| *Proline* | *na* | *12.47* | *14.22* | *11.96* | *15.01* | *3.39* | *8.52* | *6.05* |
| *Serine* | *na* | *4.43* | *6.46* | *5.99* | *7.63* | *3.74* | *4.62* | *3.29* |

Note**:** Non-cursive figures are Essential amino acids, with the exception of Arginine and Histidine, which are essential only in certain cases

Sources: USDA (2006) a) Soil and Crop Improvement BV (2006); na = not available

## 5.6 Implications of triticale on food security in the study areas

Food security, interpreted largely as food self-sufficiency, is one of the most important government policies in Ethiopia today, where consumption needs of over 76 million people are estimated 14.3 million tonnes of grain for food (at 185 kg grain intake average per person per annum) and 565.000 tonnes for feed (FAO/WFP 2007). Therefore, the strong involvement of governmental and non-governmental bodies in triticale research and production, particularly in the highly degraded Amhara Region, is primordial in order to release recommendable, improved stress-tolerant varieties and to ensure supplies of seed at larger scale. The most impact of this will then be the wider adoption of the crop, which will improve food security and incomes of the resource-poor farmers in the study areas and the region at large. As population pressure on arable land has been increasing, high yielding triticale cereal can offer an alternative to the usual method of increasing production by expanding cultivated land.

Based on the results of the field research, it can be affirmed that triticale growing farmers have more frequent access to regular daily consumption than tef producers and sustain better during dry periods in view of the fact that triticale yields on average are twice as much as tef. In almost all districts visited, the agricultural experts reported that triticale yield was between 2.5 and 3.7 t $ha^{-1}$, whereas the highest average of tef yield registered was in Addis Ababa with 1.5 t $ha^{-1}$ followed by the Amhara Region with 1.2 t $ha^{-1}$ in 2006/07 (FAO/WFP 2007) main season. The yield average in the Amhara Region for wheat and barley during the stated season was 1.9 and 1.5 t $ha^{-1,}$ respectively, which is yet less at least by 50% than triticale. Grain yield average of 37 qt $ha^{-1}$ from seven farms (spread out over three districts) was also registered by the SUN-Amhara project[218] in the year 2000 without any particular treatment except the utilization of improved seeds. While with application of DAP and urea fertilizers, a three year grain yield average of about 9 tons or 90 qt $ha^{-1}$ was registered for seven different triticale varieties. There was also a similar study (for e.g., Baychev, 1998 and Grib, 1998), which reports a yield average of 100 qt $ha^{-1}$ for three best varieties including Maynet that compares with yield levels observed in other countries, such as Romania and Bulgaria. The high yielding capabilities and its widespread acceptance by farmers not only in the Amhara Region but also in the other major Regional States confirms the great potential of triticale in contributing to food security.

# 6 ASSESSINNG THE SUITABILITY OF TRITICALE GRAIN FOR INJERA AND BREAD, AND THEIR ACEPTANCE BY CONSUMERS

## 6.1 The injera and bread quality of triticale flour

There are several varieties of foods that can be processed from triticale flour. Considered here are the two major food stuffs, bread and injera with the later being the national dish of Ethiopia. The baking procedure was carried out in accordance with recipes and traditional baking methods to produce different varieties of injera and bread from sourdough. Injera is prepared traditionally and may vary from region to region, by type, size, processing method, and from culture to culture. In this study, the north Ethiopian traditional baking method is followed as triticale grain was successfully introduced to farmers first in this part of the country.

Injera preparation has a long and culturally diversified tradition in Ethiopia. It is prepared from cereals such as tef, sorghum, barley, finger millet, rice or the mixtures of these, and from triticale grain since its introduction in the end of 1990s. While tef is entirely milled for injera, triticale is milled for both injera and bread in home bakers. The baking quality characteristics of triticale grain for both injera and bread products are described on the basis of the traditional practices and procedures in comparison to tef-injera and wheat-bread respectively.

Basic ingredients for injera by percent are: 100% flour, 75-80% water (compared to flour weight) and 75g fermented fresh yeast per kg of flour. In traditional practices, the yeast for injera is a left over saved from the previous baking, but dry yeast could also be used instead. The yeast converts carbohydrates to ethyl alcohol and $CO_2$ during the fermentation process (Corell 2002). $CO_2$ is what causes the dough to rise and leavens the injera and bread. Injera and bread undergo at least three and two phases respectively, until the products end up on the table.

For bread the ingredients are: 100% flour, 55-65% water, 80g $kg^{-1}$ dry yeast and some salt if necessary (salt makes the bread crunchier but must be adjusted for personal taste buds).

This chapter addresses the question to what extent triticale is suitable for injera and bread baking, and to what extent food products made from triticale flour are acceptable by consumers compared to tef and wheat. In that context, baking experiment was carried out and evaluated by panellists using a sensory evaluation method in order to assess the suitability of triticale grain for injera and bread making, and the acceptance of these by the consumers.

## 6.2 Materials and Methods

### 6.2.1 Mixing ingredients and the initial dough formation

The suitability of triticale flour for injera and bread preparation was investigated in December 2005 in various mixture establishments in Debretabor town, Ethiopia. The baking experiment was conducted two days prior to a workshop organised in order to evaluate particularly, the sensory characteristics of injera and bread prepared from triticale flour in comparison with tef and wheat cereals by fifty two randomly selected panellists, consisting agronomists, extensionists, workers, farmers and one home economics expert. White tef and white wheat grains were bought from the local market and triticale was obtained from the GTZ/ SUN Amhara Region project. The selected grains were dried under direct sun for one day and all foreign particles such as weeds, stones and chaff were removed. After cleaning, the grains were independently milled to flour, sieved, mixed in various proportions and baked.

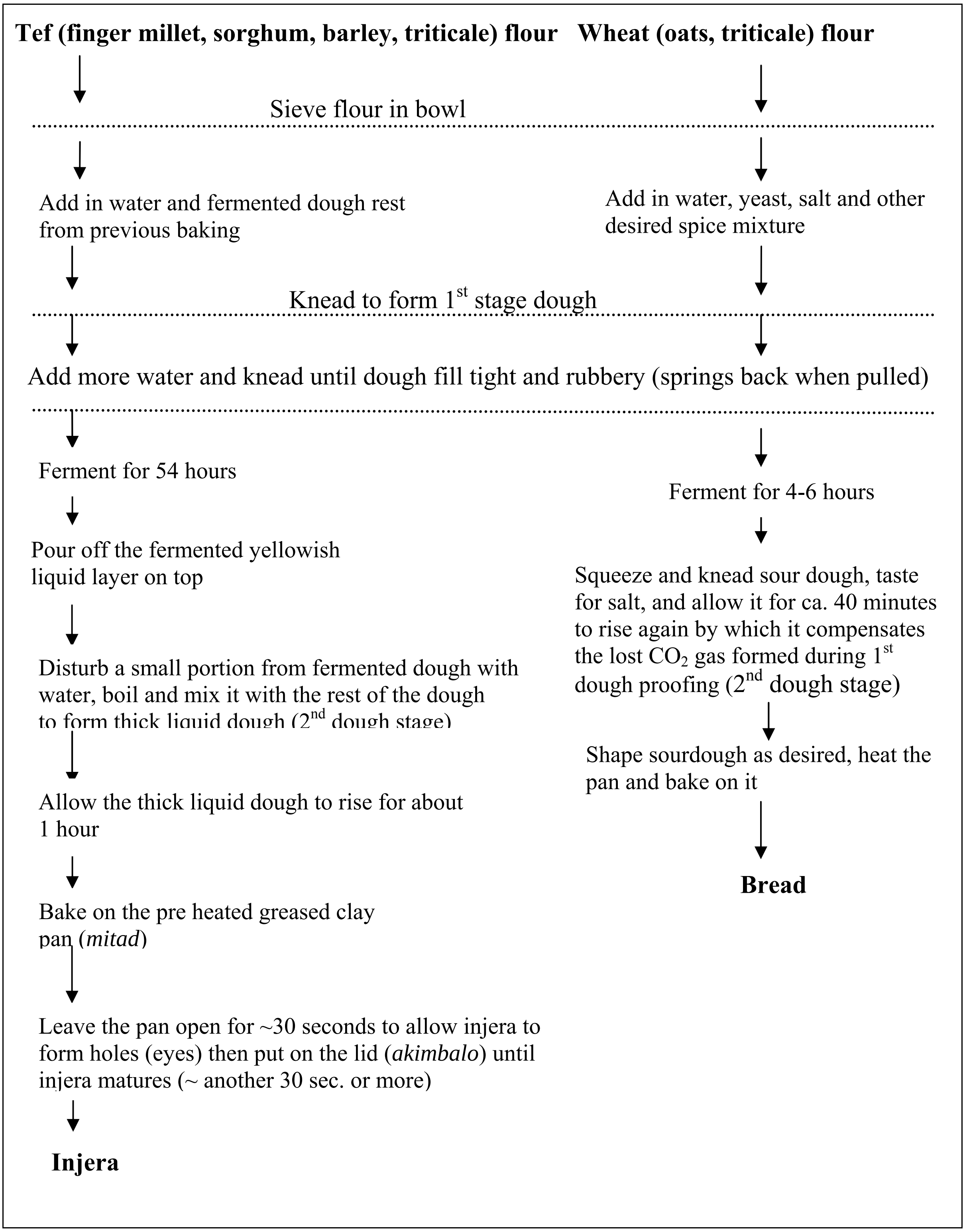
After baking, each panellist was served the various injera and bread portions along with a pre-formulated questionnaire to give his/her scores for the specific attributes, i.e. flavour, appearance, texture and taste. The coded injera and bread samples were presented in succession and the panellist was told to decide how he/she rates the product based on the appearance, texture, flavour and taste of the products, and to mark the scales accordingly. As indicated in Tables 6.1 and 6.2, the panellists rated all mixture varieties on a scale ranges of 1 to 4 (1.0-1.5 = excellent, 1.6-2.1 = very good, 2.2-2.7 = good, 2.8-3.3 = not so good or fair, 3.4-3.9 = only moderately acceptable, 4.0> unacceptable). The overall quality average score was therefore rated as excellent for 100% tef (coded as iX0) as expected, good for 25%, 50% and 75% (iX1-iX3) mixtures. A lowest score number in the scale shows the *most preferred ("best") quality* and the highest score indicates otherwise (e.g. iX0 contains no triticale so, according to the sensory results has performed best in the baking quality).

The food evaluation was carried out using a sensory testing method, i.e. sight, touch, smell, taste and hearing involving objective panellists. In this study, only subjective testing has been employed. The sense of *hearing* is only essential to test bread hollowness by tapping on it.

The bread and injera preparation experiment was carried out based on the north Ethiopian traditional baking procedure flow chart shown in Figure 6.1.

The injera preparation procedure, which can vary according to the grain types, traditions and the taste of injera (whether sweet, sour and moderately sour), is drawn on the basis of the North Ethiopian baking tradition for middle sour injera and bread types.

Figure 6.1. A flow diagram showing the traditional preparation of injera and bread



Source: Author's observation

#### 6.2.1.1 Preparation of injera

The proportions set up for injera were: 0% triticale (iX0), 25% triticale with 75% tef (iX1), 50% triticale with 50% tef (iX2), 75% triticale with 25% tef (iX3) and 100% triticale (iX4). The five mixtures set up were poured in big separate plastic bowls, and mixed with warm water and starter (fermented dough liquid rest saved from previous baking), then kneaded to obtain the first dough. The mixtures were thoroughly kneaded until thick liquid dough was obtained and left to rise outside the house, as the room temperature of 17.5°C was considered too low to accelerate the dough fermentation properly before the dough was baked. The exterior temperature stood at 26°C. The use of warm water may depend on the local temperature. In high altitudes, such as Debretabor town, warm water is preferred by many households in order to accelerate the rising of the dough, which may shorten fermentation period.

**The first fermentation and dough proofing**

Proper dough rise is the key for quality injera which results from fermentation. After the first dough has been gained by mixing the ingredients, the dough had to undergo a fermentation process in order to allow it to acquire the required properties such as dough rising and dough volume expansion, which are prerequisites of good structured injera. Corell (2002) described dough-proofing as the period during which dough is allowed to rise. To obtain these properties, the dough was allowed to rest and develop itself for 54 hours at room temperature. Senait et al. (1997) reported ninety six hours to be the optimum fermentation time, which, however, can vary from place to place as described above and according to the type of injera. For our experiment, this fermentation time was found to be good enough for a moderately sour injera. According to FAO (1999) three types of injera (from sorghum) are distinguished: (a) thin injera that is prepared from mixing a portion of fermented dough and the *absit* (i.e. hot thick dough fluid resulted from a mixture of small portion fermented dough with boiling water), which is in turn, mixed with a portion of the original fermented flour, (b) the sweet type that is prepared from dough and has undergone only a minimal fermentation of 12 to 24 hours and called thick injera, (c) the sour (locally known as *komtata*) type injera which is prepared from over-fermented paste with a quite sour taste. After fermentation, the yellowish liquid on the top layer of the dough was poured off and the rest was thinned with water and the *absit*.

### The second fermentation process

The second fermentation followed after the mixing of a portion of fermented paste boiled with 75% of water (proportion to flour weight) to yield the *absit,* which was poured to the rest of the dough and thinned. After the mixture was thoroughly stirred by hand, the thick fluid lukewarm dough was kept to stand for one hour at room temperature. As dough management is a continuous process, a dough proofing period was required and checking whether risen properly and a decision had to be made regarding whether to leave it for some more time or take it to a warmer place, as Debretabor is a high altitudinal and relatively cold town.

### Baking

At the end of the second fermentation process and final dough proofing, the clay pan (*mitad*) was heated, greased and smoothened with ground cotton seed, and the thick liquid sourdough was scaled up in small amounts which was then baked on the hot pan, left open for about thirty seconds until proper hole making was reached and then covered with the lid or *akimbalo* (a parabola shaped cover made from bamboo stems and smeared with cow dung or from the mixture of cow dung and tef straw) for another thirty seconds or more until "maturing or ripening". The injera was then piled and left for cooling up to five hours until it was served for the fifty two panellists. The injera was served with ground sharp lentil sauce and without sauce (the latter was in order to avoid taste adulteration of the injera).

### 6.2.1.2 Preparation of bread

The mixture proportions set up for bread were: 0% triticale (bX0), 25% triticale with 75% wheat (bX1), 50% triticale with 50% wheat (bX2), 75% triticale with 25% wheat (bX3) and 100% triticale (iX4). The wheat flour, the triticale flour and the mixtures from the two flour types were mixed with lukewarm water, yeast and salt independently in big separate plastic bowls and kneaded thoroughly until the dough became elastic and lengthy. It was then kept for five hours to obtain moderately sour fermented dough. As is the case in injera preparation, also in bread, there is a high variability in amount of ingredients, fermentation duration, intensity or rate of fermentation and kneading time.

### The first fermentation and dough proofing

Also in case of bread, proper dough rise is very important for good quality bread. After the first dough was gained by mixing the ingredients, it was allowed for five hours at room temperature for the fermentation and dough-proofing process. According to Corell (2002), fermentation is fastest in a moderately acidic medium (pH 4.0-6.0), but in our experiment no further dough additives were applied.

### The second fermentation process

After full fermentation was reached, the dough was once again kneaded, during which $CO_2$ that was formed in the first dough rising process was released while squeezing and kneading the sour dough. In order to compensate the lost gas the dough was shaped and evenly distributed on the baking pan and left for final dough proofing for forty minutes until the pan was lighted up with fire. During the baking process, the volume of the dough on the pan continued to increase. This is a good sign of obtaining light textured (highly preferred) bread and may reflect the suitability and good quality of the flour for bread. Kilcast (2004) describes texture as one of the most important attributes used by consumers to assess food quality. Light textured bread according to Stallknecht et al. (1996) can be made by using dough additives such as ascorbic acid, better known as vitamin C, as an oxidizing agent in order to increase the loaf volume and thus enhance the texture and freshness of baked products. However, they indicated that bread loaves produced entirely from whole grain flours of triticale, while having a range of pleasing flavours, they tend to have a heavy texture.

### Baking

After the end of the fermentation and dough-proofing process, the sour dough was apportioned and flattened in a rounded shape, and baked on the pan for one and half hours, until it gave a hollowly sound when tapped, implying that the bread loaf was lightly textured and ready.

## 6.3 Results and Discussion

Because some of the panellists had tried triticale before, they said triticale flour was not as easy as tef and wheat for injera and bread preparation respectively. Nevertheless, their overall view was generally good, and the score of each single attribute or factor for quality assessment of injera and bread from triticale suggest the great potential of the crop for use in injera and bread baking. Initially, the employed bakers were also not quite enthusiastic to guarantee us a light textured injera and bread from triticale, as the time provided to them was a little too short, hence triticale needs a somewhat longer fermentation period than tef and other cereals, particularly in colder areas like Debretabor.

### 6.3.1 Evaluating the injera quality

Flavour, appearance, texture and taste are the major factors that affect the baking quality, thus the food quality. When the panellists were asked to compare the injera prepared from the five mixture proportions on each single quality attribute, namely: *flavour, appearance, texture* and *taste*, they rated the injera from tef as "excellent" (most preferred) in all of the four attributes, followed by the 25:75 mixture ratio in terms of texture. The sensory evaluation test result is shown in Tables 6.1, 6.2, and Figures 6.2 and 6.3. The appearance of injera and bread is shown in Photos 6.1 & 6.2.

Table 6.1. Quality evaluation test of injera prepared from tef, triticale and their mixtures

| | **Injera** | | | | |
|---|---|---|---|---|---|
| | **Ratio of triticale flour in the triticale – tef mixture** | | | | |
| **Food quality attributes** | **iX0 (0:100)** | **iX1 (25:75)** | **iX2 (50:50)** | **iX3 (75:25)** | **iX4 (100:0)** |
| Appearance | 1,10 | 2,40 | 2,34 | 2,10 | 2,66 |
| Texture | 1,40 | 1,80 | 2,13 | 2,33 | 2,54 |
| Flavour | 1,30 | 2,30 | 2,11 | 2,30 | 2,43 |
| Taste | 1,70 | 2,22 | 2,20 | 2,60 | 2,57 |
| Overall quality mean (OQM) | 1,41 | 2,18 | 2,20 | 2,33 | 2,55 |

**Score ranges**

1) 1.0-1.5 = excellent 3) 2.2-2.7 = good
2) 1.6-2.1 = very good 4) 2.8-3.3 = not so good
5) 3.4-3.9 = only moderately acceptable
6) 4.0 ≥ unacceptable

**Legend definition**

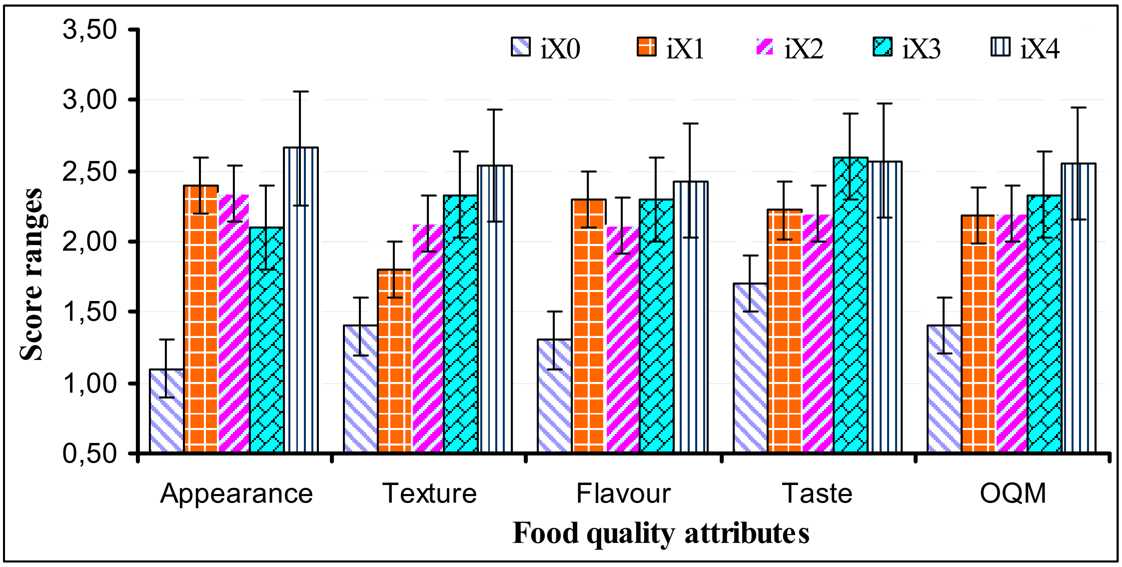
iX0 = 100% tef flour only
iX1 = 25% triticale with 75% tef flour
iX2 = 50% triticale with 50% tef flour
iX3 = 75% triticale with 25% tef flour
iX4 = 100% triticale flour only

Source: own survey

Triticale has also performed satisfactorily in terms of flavour with the 50:50 mixtures. In terms of appearance, flavour and taste in the 25:75 mixture was rated lower than in the 50:50: mixture ratio which could be attributed to the fact that fact that injera from triticale flour was prepared in the same and usual way as the households normally prepare it from tef and wheat alone, which would mean that triticale injera might have appeared differently if it were treated otherwise. As was explained by our bakers, the dough from triticale grain flour might need a higher fermentation period (influencing appearance and flavour) than that from tef grain.

The strength and dough elasticity, a prerequisite for light and good holed (eyed) injera, may also affect the injera quality. The four food quality attributes and their mean scores are illustrated in Figure 6.2.

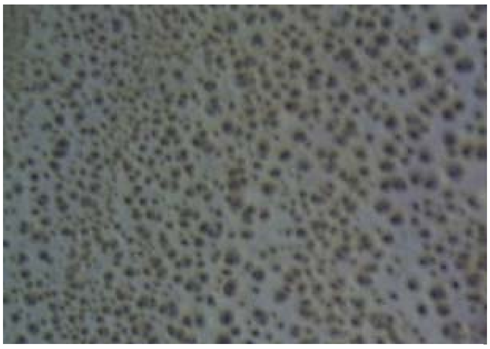
Figure 6.2. Quality evaluation test of injera prepared from triticale, tef and their mixtures



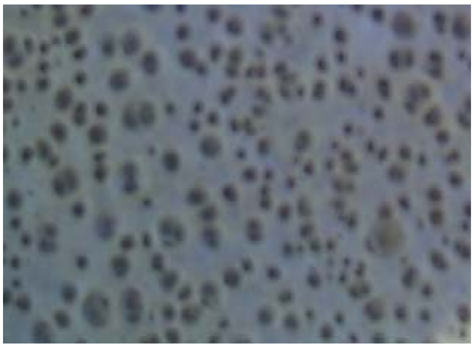
Note**:** A lowest score number in the scale shows the *most preferred ("best") quality* and the highest score indicates otherwise

Source: Based on data from the survey

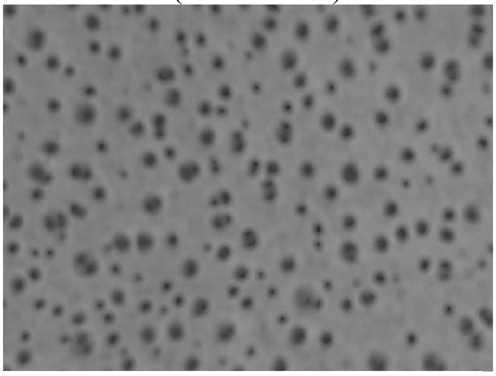
Photo 6.1. Types of injera prepared from tef, triticale and their mixtures



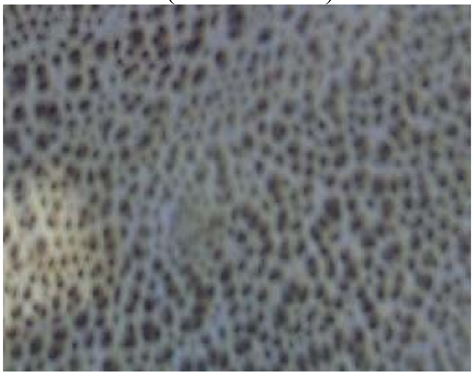
iX1 25:75 (triticale x tef)



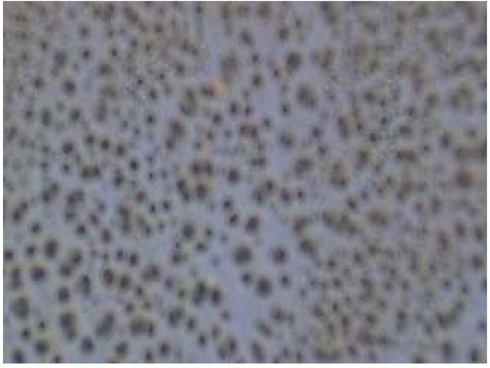
iX3 75:25 (triticale x tef)



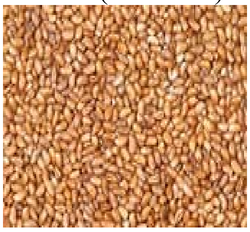
iX0 (100% triticale)



iX0 (100% tef) **- control**



iX2 50: 50 (triticale x tef)



Tef ~ (0.2-1 μ)

Triticale ~0.7mm)

Photos: Author

### 6.3.2 Evaluating the bread quality

The overall quality mean score between the various mixture proportions for bread was rated similarly to that for injera and is partially consistent to previous studies by Pena and Amaya (1992) who indicated that triticale flour blends of up to 50% with wheat flours produce breads with quality similar to breads made from wheat flours only. In our experiment the 25% triticale blend with wheat was better preferred to the 50:50 mixture in terms of appearance, texture and in the overall quality mean next to the bread without triticale. However, in terms of the single quality attribute for taste, the 25% triticale mixture was surprisingly, rated similar to that with the 0:75 mixture ratio, which reflected the vice-versa situation of our assumptions (see also Table 6.2).

Table 6.2. Quality evaluation test of bread prepared from wheat, triticale and their mixtures

| Bread | | | | | |
|---|---|---|---|---|---|
| | Ratio of triticale flour in the triticale – wheat mixture | | | | |
| Food quality attributes | bX0 (0:100) | bX1 (25:75) | bX2 (50:50) | bX3 (75:25) | bX4 (100:0) |
| Appearance | 1,40 | 1,50 | 1,90 | 2,20 | 2,50 |
| Texture | 1,40 | 1,60 | 1,80 | 2,30 | 2,70 |
| Flavour | 1,50 | 1,70 | 2,20 | 2,60 | 2,40 |
| Taste | 1,70 | 1,90 | 1,70 | 1,90 | 2,30 |
| Overall quality mean (OQM) | 1,50 | 1,76 | 1,90 | 2,25 | 2,56 |

| Score ranges | Legend definition |
|---|---|
| 1) 1.0-1.5 = excellent 3) 2.2-2.7 = good<br>2) 1.6-2.1 = very good 4) 2.8-3.3 = not so good<br>5) 3.4-3.9 = only moderately acceptable<br>6) 4.0 ≥ unacceptable | bX0 = 100% wheat flour only<br>bX1 = 25% triticale with 75% wheat flour<br>bX2 = 50% triticale with 50% wheat flour<br>bX3= 75% triticale with 25% wheat flour<br>bX4 = 100% triticale flour only |

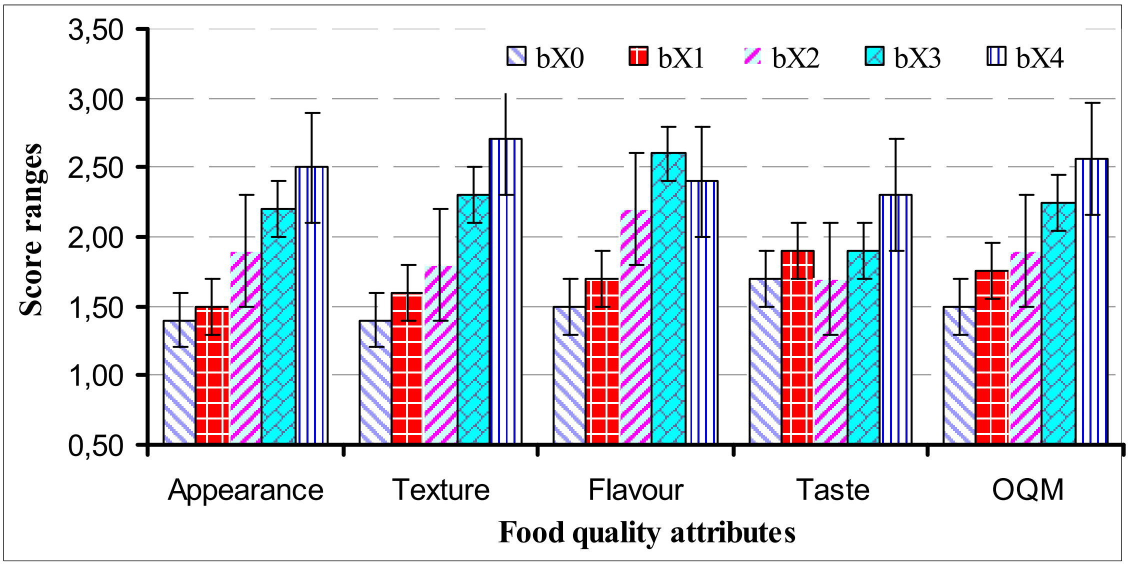
Source: own survey

The scoring for flavour in bread was also similar to that for injera. However, the 100% triticale (bX4) had outperformed the 75% (bX3) mixture ratio in terms of flavour. The 100% wheat has outperformed the mixture ratios in terms of appearance, texture and flavour. The taste was rated similar to the 50% wheat blend. The panellists rated the 0% triticale (wheat flour only) as "best" (most preferred) in terms of appearance, texture and flavour which is also reflected in the overall quality mean. This is followed by the 25:75 mixture ratios except in terms of flavour and taste. As the overall bake quality mean indicates, the most preferred bread could be obtained by blending wheat flour with 25% triticale flour.

The predominant view of the panellists was that 100% wheat-bread (bX0) performed excellent in all of the bake quality attributes, followed by the 25:75 mixtures except for taste, which showed a better result in the 50:50 mixture ratios. This was unsurprising due to the fact that as was the case in injera, bread from triticale flour was also prepared in the same and usual way as the households normally prepare it from wheat alone, which suggests that triticale bread might have appeared differently if it had been treated otherwise. As our bakers explained, better tasting and hollowly textured bread from triticale flour might be gained if the dough is left for a higher fermentation and dough proofing period than the dough from wheat flour. The amount of water and kneading intensity also affect the strength and dough elasticity which is a prerequisite for light texture and hollow loaf. If the dough is underwatered, the dough can lack elasticity and forms sticky, gummy, crumb dough, which in turn, results in a non porous sticky structure on the bread. But the experienced woman who baked the bread told that too extensive or over-mixed dough may also lack the appropriate dough elasticity to obtain the hollowed quality of bread. Furthermore, the elasticity of gluten affects the rise and texture of the bread crust. Also food science experts like Corell (2002) report that in addition to flour quality, a number of factors such as the amount of water, extent of mixing, length of fermentation and presence of protease enzymes in flour affect the gluten strength or elasticity and thus the baking quality.

The food quality assessment result for bread is illustrated in Figure 6.3, whereby all of the food quality attributes of each mixture ratios are compared with each other. The Figure also shows the mean scores of the four attributes.

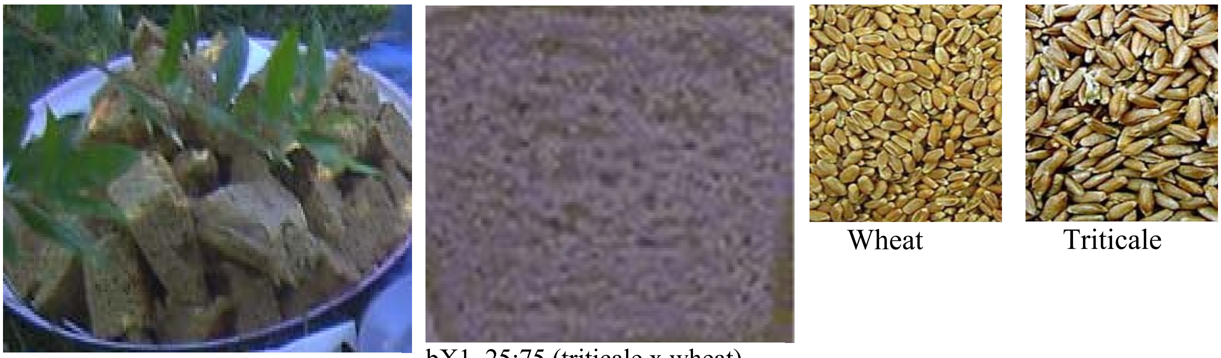
Figure 6.3. Quality evaluation test of bread prepared from triticale, wheat and their mixtures



Source: Source: Based on data from the survey

Photo 6.2. Types of bread prepared from wheat, triticale and their mixture

bX0 (100% wheat) - **control** bX4 (100% triticale) bX2 50:50 (triticale x triticale)



Wheat Triticale

bX3 75:25 (triticale x wheat) bX1 25:75 (triticale x wheat)

Photos: Author

# 7 CONCLUSION

The chapter provides the empirical results. It synthesizes the theoretical notions of the study with the empirical results gathered through the fieldwork and own observations during the survey period.

Based on the results analysed from the household questionnaire, expert interviews and own observations, conclusions are drawn for the chapters four to six.

About 73 and 75.5% of growers and non-growers respectively, were male headed households, but the mean difference was not significant statistically. The mean age of household heads for triticale growers was 42.7 years and 43.4 (approx. 43 years) respectively. 74.5 and 70% of growers and non-growers respectively, were married and the number of widowed households were about 4% higher by triticale growers.

### "The adoption or growing of triticale in the Amhara Region and determinants influencing adoption"

*It was hypothesized that if triticale yield is higher than other crops, such as* tef*, wheat and barley, the adoption of the crop increases the supply with staple food significantly.*

**The hypothesis in this study is supported.**

As the main objective of this hypothesis was to assess if triticale provides a higher grain yield per unit area as compared to tef, wheat and barley, it will improve food availability and access to it by the poor households and contribute to food security at household level. The hypothesis in this study is affirmed. However, not all of the independent variables selected to represent the determining components of agricultural productivity, particularly for yield increase in triticale adoption were significantly relevant for this hypothesis.

Family size has strongly correlated with triticale yield as it was assumed that a higher number of people in the family would contribute to a higher labour supply whose share in farm activities, such as weeding, harvesting and looking after animals will contribute to enhance farm productivity.

Household labour was positively associated to farm productivity and yield increment which apparently leads to improved food security as well as increased opportunity to generate income for households' expenditure.

Access to farm related information to households was limited to farm extension availability for dissemination of information through extension agents (locally known as development agents - DAs). The impact of this determinant to yield increment was significantly correlated with farm productivity whereby higher number of extensionists per household or farm visits by the DAs will minimize risk of crop failure that occurs due to unfavourable weather conditions, plant diseases and pests or unfavourable field management. The mean difference in access to extension service (t = 3.45) was significant at the 5% level, which is in consistent with the hypothesis on the importance of agricultural extension service to grow triticale. However, the frequency of contacts between the farmers and the extensionists varies significantly among the growers and non-growing farmers.

As of the impact of market distance on yield increment, the regression result shows a negative association with yield at 1% significant level, which was in consistent with the assumption that long market distance will have a negative impact on crop yield, and thus insufficient food availability for the household.

Another important factor presumed to positively affect crop yield as well as food availability is the education level of the household heads, hence households with education may acquire and interpret information more efficiently than those without any basic skill in education. In addition to this, increased production may influence the decision making by farmers to apply improved techniques as well as improved varieties of crops or new species with grain yield harvest. However, the findings obtained from this determinant and grain yield increment of triticale was not associated in a significant manner. This is in consistent with another study, for example, that cited by WU (1977) which could not establish a significant correlation between farm education and crop yield performance. On the other side, the farming system in the United States verifies education as an important element of crop production.

As agriculture is the mainstay of the sample households who eke out a living on ever decreasing plots of farmland with continuous declination of fertility, increasing size in cultivable land was assumed to increase yield and availability as well as accessibility to it in order to enhance food security. However, the results of the Probit estimate regression show only weak association of farm size with grain yield, implying that crop productivity cannot necessarily be obtained by just increasing farm size but other factors, such as utilisation of improved seeds, fertilizer and spraying chemicals, and quality of land are more likelihood determinants for higher yield increment and contribute to bolster food security.

**“Impact of social network on triticale adoption decision by farmers”**

*It was hypothesized that among other things, social capital at household level has an impact on the decision by farmers to grow triticale*

**The hypothesis in this context is rejected.**

This is in contrary to the assumption that socialisation increases the probability of the farmers’ decision positively to grow triticale and to allocate resources obtained from additional activities (for example, participation in development aid projects and being a member of traditional associations - representing social capital) for purchasing seed and farm inputs. Nevertheless, participation in the traditional associations and development projects as a proxy for social capital was found the second important information source for the farmers after the extension services provided by local agricultural and rural development offices. As discussed in section 5.4, […triticale and its introduction in the study areas…], 94% of the sample households know about the triticale crop through formal and informal sources. Informal sources of being church festivities, funeral gatherings, farm or work festivities in which on going farming related operations in the villages could be discussed and ideas exchanged. This suggest that based on the empirical study, social capital despite insignificant positive association with the adoption decision, it fills the gap between the extension services and the farming community and serve as an additional source of farm information with triticale growers, non-growers and consumers providing mutual support and sharing benefits and risks of triticale (if there exists any) production to achieve sustainable food self-sufficiency and reduce poverty.

Two indicators namely, participation in development projects and being a member of community based associations, such as *idir* (funeral association), *mahber* (church festive group on saint days) and *wobera* (work festive group) were used as a proxy for social capital at household level, which did not show a significant relationship between households’ decision to grow triticale or not. This is mainly due to the fact that not only triticale growers were members of these associations and employees of rural development related nongovernmental organisations (NGOs), but also non-triticale growers were members of such associations and had a relationship with NGO projects by some other means. Therefore, since the conformity of the dichotomous variable (being affiliated = 1 and 0 otherwise) was not fulfilled, the Probit regression for this variable could not suggest any significant implication on the adoption decision by farmers and on the perceived food production rise for the achievement of food self-sufficiency, the hypothesis shall be rejected.

**“Impact of family size, farm size, physical capital, extension service, market distance from households’ residence, agricultural input, education …on triticale adoption decision”**

*It was hypothesized that the above determinants have a significant impact on farmers’ decision to grow triticale*

**The hypothesis in this context is supported.**

Each of the explanatory variables hypothesized to potentially influence farmers to grow triticale was filled into the Probit model. Out of the predicted 16 variables 9 are found to have an influence in the decision by farmers to grow triticale positively and significantly. Family size, being a good source of household labour, it influences the adoption along with the education, market distance, livestock ownership, extension service, number of oxen available for ploughing and grain aid, have contributed to the growing of triticale positively and significantly. Other determinants, such as gender, marital status and off-farm monetary income are found not to have influenced farmers’ decision to grow triticale in a significance manner.

The mean landholding size per household including rented or sharecropped land was 4.33 *timad* or *eqa*, but did not show a significant relationship wit the decision by farmers to grow or not to grow triticale. Also total farm size comprising of renting in land, sharecropping and tenant farming, did not show to have a significant contribution towards the tendency of the farmers decision to grow triticale; whereas, renting in land as a single attribute was important in the decision of farmers to grow triticale. The number of households who shared or rented in land is significantly larger for non-growers than growers at 1% (t=1.83) level of significance. The number of households who shared or rented in land is significantly larger for non-growers than growers at (t=1.83; $p<0.1$) level. The total farm size for growers was slightly higher than for non-growers, which was not statistically significant (t= 0.16). About 30% and 29.1% of triticale growers and non-growers respectively, had rented or shared in crop land area of about 0.54 ha. This implies that most probably, growers were willing or had a higher opportunity to hire or rent in land due to their possession of higher number of draught power (oxen, horses and mules) and higher number of family members (compared to non-growers) as a potential household working force.

The number of oxen (NOXEN) owned by the sample households in our study was considered as an indicator to influence farmers’ decision to grow triticale. Limited draught power, such as oxen coupled with diminishing acreage availability for cultivation per household was hypothesized to negatively affect crop production resulting low food availability and food security. As oxen in the study areas are the dominant traction power, most of the respondents owned one or two oxen in that they combine with their neighbour to be able to cultivate. Thus having an ox or pair of oxen enhances the households to have access to farmlands for food production, while having no ox may result otherwise. The mean difference in oxen ownership between the two household groups was significant at (t=2.13) the 5% level of significance.

Level of education (EDULEVL), availability of farm credits and the road distance (RODSTNC) of the WOARD from farmers' residence, have shown a negative and significant correlation with the growing or adoption decision by farmers as it was hypothesized in the study. Remarkably, these households were engaged in beekeeping non farm business. The chi-square test suggests a highly significant difference in the education level of the household heads, implying that there is indeed a significant association between education and the growing of triticale as a new technology.

### "Suitability of triticale, particularly for *injera* and bread-baking, and its subsequent impact on household food security"

*It was hypothesized that bread and injera baking quality influences the growing of triticale and contribute to achieve food security at household level.*

**The hypothesis in this context is supported.**

Daily meal intake per day in kilocalories as an indicator of food security, which is applied at national and international levels, was difficult to apply in this study as the energy values of the types of food (for example, *injera*, bread, boiled and/or roasted grain) with the accompanied sauces from various types of pulse crops and meat, the amount of food consumed by each person per day calculated for all the sample households, would produce an enormous amount of work and could consume a lot of time and resources. Therefore, this indicator was avoided as a proxy for food security in our study. Instead, basic household food security indicators including availability of food frequency of daily meal consumption during the 'worst dry' and 'normal season', consumption frequency before and after the adoption of triticale, clean drinking water and utilisation of alternative household energy to firewood as household energy source, are used as a proxy for household food security and level of poverty in the study areas.

**“The production of triticale improves daily meal intake frequency and thus food household food security”**

*It was hypothesized that daily meal consumption increases with the adoption of triticale*

**The hypothesis is accepted**

Out of the listed indicators as a proxy for household food security, frequency of daily meal intake before and after the growing of triticale was selected as the most viable indicator of household food security, i.e. being better off after triticale adoption and otherwise without adoption at the household level. The result whether daily meal consumption has improved after triticale adoption or not was calculated based on the opinion of triticale growing households which was then compared with the response of those households who have not adopted triticale.

As the Probit regression model reveals, five out of the eleven independent variables selected to affect the dependent variable or the frequency of daily meal consumption were identified.

Larger family size (FAMSIZE) was negatively correlated with daily meal intake frequency as it was predicted. This implies that apart from the fact that larger family size can ensure household labour supply, it affects the frequency and amount of food consumed by the family members negatively; hence the food available for the household should be rationed among all family members and leads to a reduced per capita calorie intake per day.

The regression model provided no significance association between the market distance from farmers’ residence and daily meal intake frequency, despite prior predictions that larger market distance will have a negative impact on food consumption and security as with increasing distance transaction costs and time needed to travel rises.

The purchase of agricultural inputs (PURINPUT), which has a direct linkage with markets along with grain aid showed a positive impact on the frequency of daily food consumption. This was statistically significant at $p>0.01$ level.

The study has found that about 10% additional income was generated from triticale adoption by the sample households, which the study sees as a good beginning in the attempt towards achieving food security and reducing poverty in a foreseeable future in the study areas and beyond.

Income other than rearing of animals and crop farming denoted as OFRINCOM, showed a highest level of significance in food consumption frequency in the Probit regression model. Off-farm activities, such as beekeeping, retailing of firewood, trading of eucalyptus wood (locally known as *atana*) for house construction, selling of *tella* and participating in CfW/ FfW operations (specifically, in the GTZ-run projects), are used as sources of additional income other than farming with this being the ultimate source of living for both, triticale growing and non growing sample households in the study areas.

With regard to farm size (FARMSIZE), the study finds a significant association between the landholding size per household and frequency in daily meal intake. Apart from the fact that larger farm size alone does not guaranty excess production and food self-sufficiency, it was found to be one of the most crucial factors affecting food security in the study areas. This is because, in addition to the extremely small farm size, the crop lands are over-utilised and exposed to water erosion which makes the perceived intensive agriculture quite difficult. Therefore, in order to cop with the ever growing population growth and thus a high demand in food supply, a large farm size was assumed to have a positive effect on crop production and food self-sufficiency.

Although, the quick spreading of triticale as a grain crop in the Amhara Region has faced some amounts of resistance from a few farmers and some agricultural experts with the argument that the expansion of the crop at the present (2005/06) pace of expansion would chuck out other crops and might generally propagate mono-cropping, the notion of the researcher towards the acceptance of the crop by the sample households and the community at large, is that it has been well received not only in the research districts but also in the other eight districts of South and North Gondar Administrative Zones, which were visited for comparison purposes during the survey period.

Questions have been raised as to the possibility of exploitation of soil nutrients by triticale plant, with a consequent drop of nutrition for the succeeding crops. But, this is not a valid concern since triticale takes up soil nutrients just like other crops and therefore, the removed nutrients need to be replaced by yield enhancers (for example, organic and/ or chemical fertilizers). Triticale absorbs soil nutrients at deeper levels of the soil profile more efficiently than other cereals. This is very important, particularly in areas with low levels of soil nutrients.

While the prime objective of the growing of triticale is to increase food production and ensure its availability for all involved households, it is awaited that household income generated through the adoption of the crop not only ensures livelihood security but also improve quality of life and reduce rural poverty.

As to the food quality of triticale crop, the inter-dimensional approach applied in this study made it also possible to capture the various features of triticale grain for food and the preparation of traditional drinks, such as *tella* and *areke*. In this context, the suitability of triticale grain for the preparation of variety of foods, such as the main staple food injera and bread, and local beverages was testified by the sample households and proved positive by own experiment, which was presented at a workshop in Debretabor town in January 2006. The workshop was organised in order to discuss the field survey, including the experiment on the baking quality and applicability of triticale flour for the Ethiopian traditional foods, such as *injera* and bread, and to evaluate the suitability of the grain for *tella* and *areke*.

# 8 FUTURE PERSPECTIVES

This section provides a brief appraisal in respect to the future performance of triticale and its impact on food security on the basis of the research findings. It also presents the thoughts of the interviewed agricultural researchers and workers on triticale and its impact on food security.

## 8.1 Perspectives for production and consumption of triticale in Ethiopia and beyond

Intensive experiments on triticale developments worldwide has resulted in the emergence of various crop varieties that are exposed and adapted to various environments, pests and diseases, climatic and soil conditions that differ from one place to another. As the soil characteristics under which these triticale varieties are grown are important for a good harvest, triticale seems to be highly adapted to various growing conditions. The overall agronomic performance, combined with the superiority in protein and lysine content for example over tef rice, sorghum and maize, suggests the high potential of the crop not only for the Amhara Region, but also for other areas with low soil and agronomic conditions, where cereals form a major part of the human diet. The nutritional quality and ability of triticale to be used as a forage crop is also being explored by many countries, which can also be considered by dairy farms in Ethiopia as a good source of fodder.

From the analysis it appears that farmers with more favourable economic conditions and those with higher family members in the household are likely to benefit more from triticale adoption.

As reported by the farmers and researchers involved in the region, there exists a high demand for triticale crop due to its relative advantage over tef, wheat and barley in terms of high grain yield even under adverse growing conditions, such as acidic or alkaline soils and heavy competition from weeds. An important example of this is triticale's well performance on the poor soils in East Gojam Administrative Zone. The soils of East Gojam are said to be marginal, mainly acidic and highly degraded where farmers usually could manage to grow oats with very low yield out put.

It was demonstrated that growing of triticale provides a suitable option of crop diversification and can still be expanded further. Although to identify the increase in income generated from the sale of triticale was at an early stage and could not be significantly verified at this stage, the survey sees future perspectives of production in a larger scale for commercialisation to enhance household income and thus reduce poverty in Ethiopia and beyond.

As the study findings indicate, triticale may indeed positively affect the life of the sample households to improve the family food security; reflecting the bright future prospects of triticale for food security at district level and beyond. Commercialisation of triticale production by smallholders may result to improve not only the level of food consumption (in terms of calorie intake) but also enhances household income and thus higher flexibility in expenditure for higher quality and diversity of food.

The low calorie intake level in the Amhara Region and Ethiopia at large reflects the dramatic magnitude of malnutrition existing in the country, particularly among the vulnerable household groups in the study districts, whereby triticale can maximise the choice to improve calorie intake and food self-sufficiency.

Based on the empirical evidence and opinions of key informants in Farta and Este districts, increased calorie intake and marketing possibilities of triticale grain was observed due to the higher yield performance of triticale compared to tef and other small cereals. Some of the ominous signs for future expansion and prospects of triticale, amidst concerns that continued threats of soil depletion, water scarcity, increasing desertification of agricultural lands and fast population growth pose a grave threat to the food security situation in the region.

In some areas, there were some problems encountered during the field visit with regard to the integration of the triticale crop. The inaccessibility of triticale seed during sowing on the one side, and the high demand of labour during threshing on the other side were some of the complaints raised by the farmers. The researcher sees the latter not as a serious problem since the harvest can be left on the field for further drying to make the threshing easier.

## 8.2 Recommendations for further research

The demographic, socio-economic, infrastructural and institutional factors were identified to be some of the determinants of triticale adoption, which are complex to verify through a single set of household questionnaire. To further strengthen the adoption of triticale and thus enhance food production, an in-depth approach perhaps at zonal and regional levels is necessary, which was beyond the scope and capacity of this study. Therefore, it would be useful to research further in order to conduct contrasting studies at varying socio-economic and agro-climatic conditions, and different cropping patterns.

In spite of the fact that several factors could be identified to grow triticale, not all of the identified variables were significant in the Probit regression model. The same holds true in terms of the determinants associated with triticale yield even though all of the selected determinants might influence triticale yield over tef, wheat and barley, only some of the predicted determinants were found to have a significant relationship to triticale yield. Apart from the demographic, the socio-economic, infrastructural and institutional matters, there could be other determinants that can influence triticale grain yield and therefore, further research is required.

Most importantly, further research is needed on triticale plant towards its contribution to food security and poverty reduction in a sustainable manner. Daily meal intake frequency was one of the indicators used as a proxy for food security in this study. As a result, several determining factors were identified that affect the frequency of daily meal consumption at household level. As the probability model indicates, family- and farm size, off-farm income, and some other factors were some of the determinants that have an impact on daily meal consumption, before and after the adoption of triticale in the study areas. Nevertheless, as the study was limited to only one growing season, the sustainability in increase of household food security and reduction of poverty needs to be further investigated. We also believe that the variable daily meal intake frequency as a proxy for food security should not be the only determinant to show the impact of the triticale crop on food security adequately. Therefore, we also recommend a further research in this regard, and beyond the study areas.

As a shorter market distance (DMARKT) from the farmers' residence was expected to encourage the farmers in exchanging goods, such as triticale seed, fertilizer, pest- and insecticides, which in turn, contribute to improve yield and food availability positively. A vice-versa situation, however, may impact grain yield and food security negatively, since with increasing distance, transaction costs and time to travel rises. Nevertheless, the regression model did not show any statistically significant impact on daily meal intake frequency as it was estimated. Thus, further research on the sustainability of the daily meal intake improvement through the growing of triticale on the one hand, and the impact of the market distance on the daily meal intake frequency and food security on the other hand, needs to be carried out.

A differentiated pattern of factors affecting the growing of triticale in the study areas were estimated through the Probit regression model. As a result, several determinants are identified which could influence farmers' decision to grow triticale or not. Particularly withstanding to disease and pest infestation is one of the unique properties that can lead to a high interest by farmers to cultivate triticale. Triticale with its rye component is reported to be able to tolerate disease and environmental stresses (e.g. drought, frost, hail) that wheat and barley cannot. However, as neither pests nor diseases have occurred so far in the study areas, the ability of triticale to resist diseases and pests could not be verified during the survey. In addition to that, as disease and pests can occur any time (as can be the case by other cereals) after many years of adaptation, the best features of triticale including the disease and pests resistance needs to be further observed using this data as a baseline.

Socialisation of farmers is also an important determinant predicted to increase the probability of farmers' decision to grow triticale through the allocation of resources obtained from additional activities for example, being employed by nongovernmental organisations and /or being a member of traditional associations, such as *idir, wobera* and other festive groups. But due to the fact that the association of social capital and the adoption of triticale could not be regressed, the hypothesis is rejected and thus would be noteworthy to investigate it further.

As of income, according to the empirical results, an 8% additional income generated through triticale adoption by the sample households was registered which was seen as a significant contribution to increase household income and reduce poverty. This requires further follow ups and exploration to which extent this is sustainable, and how well it is grounded to expect further income growth and food self-sufficiency as a result of the growing of triticale.

# 9 POLICY RECOMMENDATIONS

The main objective of introducing and implementation of the new crop is to increase production to ensure household food security in a sustainable manner.

In order for the farmers to accept triticale as a new technology in the study areas, there is a need to consider the environmental conditions which vary from area to area, the socio-economic situation of the farmers, the institutional conditions, such as availability of agricultural information or extension services and farm credits for purchasing of agricultural input, such as seed, fertilizer and spray chemicals. Since the use of chemical fertilizer in the study areas is quite limited due to high import prices, which in turn, become unaffordable for the adopting farmers the search for alternative measures (for e.g., preparation and use of compost, use of organic fertilizer supplemented by the application of nitrogen fixing leguminous plants in crop rotation) may give a higher return to investment.

Post harvest loss, particularly due to weed infestation in Ethiopia including the study areas, is reported to be one of the highest in Africa. Thus a diversified pest and weed management practice, such as yield loss pre-harvest assessment and a link between the researchers and farmers for better information dissemination may reduce further yield losses and enable farmers to better control weed and pests infestation.

Animal production is part of the agricultural system in the study areas and plays an important role in household food security. Since farm oxen, which are less productive than solid-hoofed animals are the most important draught power in the region, the study recommends that adopting solid-hoofed animals as draught power source, and oxen for beef and leather production could be a more successful and wise strategy, so as to improve the income potential from livestock activities to reduce poverty, support widely shared economic growth, and increase household food security.

Based on the empirical evidence of the sample households, the pressure for repayment of fertilizer-credits taken from government agencies was that farmers were often forced to repay their loan, also if crop had failed due to drought, pests and diseases or at very low prices during the first harvest months. Thus, policy makers require intervening on possibilities to temporarily write-off farm credits at times when the farmers can not come up with their obligation to pay back these credits – for instance due to crop failure – which the farmers could see as an incentive and felt encouraged to invest and accept new technologies.

According to the results of the empirical study, the long market distance from farmers' residence, scarcity of all weather roads, absence of storage facilities, the squeezed market for perishable crops and post harvest losses are among the fundamental market related constraints which hinder the adoption of triticale in some of the peasant associations where the field survey was carried out. Thus, there is a need to take coercive actions to overcome these problems which can help to alleviate rural food insecurity and boost farmers' incomes sustainably.

As is the nature elsewhere in the country, private wholesalers are the main marketing intermediaries linking, producers and consumers. As a result, farmers are usually obliged to bring out their produce to the market for low prices during harvest months. Obviously, brokers and wholesalers are the ones who make high profits which can be a result of high dependency of the farmers on such brokers and wholesalers who may determine market prices only to their own advantages. The study therefore, insists that market-related information centres need to be established at least at zonal level from which, producers can acquire information on actual food prices in order for them to respond accordingly.

It is crucial that the role of water in securing food supply is understood and the potential for improving overall agricultural productivity with respect to water is fully realized in the Amhara Region. As the key informants in the study areas indicated, the population growth may drive the expansion of urbanization, which will in turn, increase the demand in water including domestic and livestock use, and therefore, attention needs to be paid in this regard as well. This indicator in the present study reveals that there is a need for policy makers to intervene in this sector as strongly as through other food security related measures at household and community levels.

As the findings of the study suggest, if the region integrates the triticale plant into the existing agricultural systems throughout the region, more than 3.4 million (18% of its total population of about 19 million) people could be fed twice a day, which would mean that food self-sufficiency can be achieved in the region within a foreseeable future. This is nearly 33% higher than the estimated emergency food assistance requiring people of 2.3 million in 2007. The study recommends that the developments of triticale in terms of its contribution to food security, particularly at district, zonal and country levels, needs to be further investigated. Furthermore, further consumer preference and acceptance experiments needs to be made frequently in order to find the best baking formula that will meet the needs of households and consumers across the study areas and beyond.

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# List of appendices

Appendix 1. Estimates of fertilizer applied area, use by type and amount of fertilizer for *meher* crops and private holdings in Ethiopia* (2003/2004, in hectare)

| **Crops** | **Total area (ha)** | **Organic** | **DAP** | **Kg ha$^{-1}$ yr $^{-1}$** | **UREA** | **Kg ha$^{-1}$ yr$^{-1}$** | **DAP & UREA** | **Kg ha$^{-1}$ yr$^{-1}$** |
|---|---|---|---|---|---|---|---|---|
| **Cereals** | 3140948 | 804716 | 1034760 | 69.2 | 171429 | 78.4 | 1130042 | 129.3 |
| Tef | 996852 | 84389 | 355625 | 64.3 | 97917 | 67.8 | 458921 | 102.2 |
| Barley | 376461 | 130626 | 164488 | 74.1 | 7992 | 68.0 | 73354 | 113.9 |
| Wheat | 663668 | 74276 | 267361 | 73.8 | 32819 | 72.2 | 289212 | 143.0 |
| Maize | 737327 | 320504 | 139946 | 76.2 | 16507 | 139.1 | 260370 | 170.8 |
| Sorghum | 216090 | 173773 | 10257 | 75.1 | 10985 | 124.2 | 21074 | 148.0 |
| F.millet | 141523 | 18859 | 91454 | 54.3 | 4980 | 42.8 | 26231 | 70.2 |
| Pulses | 203172 | 121186 | 54663 | 76.3 | 5905 | 78.6 | 21416 | 169.7 |
| Oil seeds | 55663 | 29695 | 17330 | 83.4 | 1462 | 157.4 | 7175 | 421.6 |
| Permanent crops | | | | | | | | |
| All crops | 3882506 | 1371945 | 1125712 | 72.0 | 186141 | 90.6 | 1178340 | 136.0 |

Note: * Does not include nomadic areas

Source: Calculated based on data from CSA (2004)

Appendix 2. Estimates of fertilizer applied area, use by type and amount of fertilizer for *meher* crops and private holdings in Ethiopia* (2004/2005, in hectare)

| **Crops** | **Total area (ha)** | **Organic** | **DAP** | **Kg ha$^{-1}$ yr $^{-1}$** | **UREA** | **Kg ha$^{-1}$ yr$^{-1}$** | **DAP & UREA** | **Kg ha$^{-1}$ yr$^{-1}$** |
|---|---|---|---|---|---|---|---|---|
| **Cereals** | 3686605 | 937401 | 1353140 | 68.8 | 137767 | 70.5 | 1258297 | 125.7 |
| Tef | 1138047 | 97892 | 437313 | 55.0 | 66074 | 49.9 | 536767 | 98.2 |
| Wheat | 923730 | 105230 | 428021 | 71.3 | 32577 | 66.7 | 357902 | 144.2 |
| Maize | 784867 | 375824 | 141916 | 73.4 | 20088 | 121.6 | 247040 | 164.5 |
| Barley | 473278 | 167848 | 222981 | 64.8 | 6652 | 73.9 | 75798 | 112.3 |
| Sorghum | 205047 | 166891 | 12200 | 68.0 | 9365 | 125.4 | 16591 | 163.8 |
| F. millet | 144998 | 21879 | 96806 | 51.9 | 2675 | 38.5 | 23637 | 78.0 |
| Pulses | 254509 | 147994 | 73582 | 74.6 | 7721 | 99.5 | 25213 | 177.8 |
| Oil seeds | 84764 | 40056 | 31786 | 79.8 | 2318 | 131.6 | 10604 | 466.2 |
| Permanent crops | 346165 | 323492 | 7388 | 258.0 | 6161 | 308.3 | 9123 | 470.4 |
| All crops | 4549663 | 1566857 | 1493227 | 66.4 | 162157 | 85.8 | 1327421 | 144.4 |

Note: * Does not include nomadic areas

Source: Calculated based on data from the CSA (2005/2006 - 1998 E.C) Ethiopia

Appendix 3. Tropical Livestock Unit (TLU) equivalents for Sub-Saharan Africa

| | **Species** | **Average biomass (kg)** |
|---|---|---|
| Camels | 250 | 1.0 |
| Cattle | 175 | 0.7 |
| Sheep/ goats | 25 | 0.1 |
| Horse/ mules | 200 | 0.8 |
| Donkeys | 125 | 0.5 |

Source: ILCA (1990)

Appendix 4.Value per 100 grams whole grain (Nutrient values and weights are for edible portion)

| **Nutrient** | **wheat** | **barley** | **triticale** | **maize** | **sorghum** | **tef** [a] | **Advised** [b] | **Units** |
|---|---|---|---|---|---|---|---|---|
| **Proximate** | | | | | | | Daily amount for 75 kg person | |
| Water | 10.27 | 10.09 | 10.01 | 10.37 | 9.20 | 10.0 | - | g |
| Energy | 339 | 352 | 338 | 365 | 339 | 351 [c] | - | kcal |
| Energy | 1418 | 1473 | 1414 | 1527 | 1418 | 1468 | - | kj |
| Protein | 13.70 | 9.91 | 13.18 | 9.42 | 11.30 | 12.3 | 75 | g |
| Total lipid (fat) | 1.87 | 1.16 | 1.81 | 4.74 | 3.30 | 2.1 | - | g |
| Ash | 1.60 | 1.11 | 1.85 | 1.20 | 1.57 | - | - | g |
| Carbohydrate, by difference | 72.57 | 77.72 | 73.14 | 74.26 | 74.63 | 59.8 | - | g |
| Fiber, total dietary | 12.2 | 15.6 | 14.6 | - | 6.3 | 7.9 | 30 | g |
| Sugars, total | 0.41 | 0.80 | - | - | - | - | - | g |
| **Minerals** | | | | | | | | |
| Calcium, Ca | 34 | 29 | 35 | 7 | 28 | 167 | 900 | mg |
| Iron, Fe | 3.88 | 2.50 | 2.59 | 2.71 | 4.40 | 5.7 | 12 | mg |
| Magnesium, Mg | 138 | 79 | 153 | 127 | - | 194 | 420 | mg |
| Phosphorus, P | 346 | 221 | 321 | 210 | 287 | - | - | mg |
| Potassium, K | 405 | 280 | 466 | 287 | 350 | 477 | 3500 | mg |
| Sodium, Na | 5 | 9 | 2 | 35 | 6 | - | - | mg |
| Zinc, Zn | 2.93 | 2.13 | 2.66 | 2.21 | - | 4.6 | 15 | mg |
| Copper, Cu | 0.382 | 0.420 | 0.559 | 0.314 | - | 0.8 | 1.1 | mg |
| Manganese, Mn | 3.799 | 1.322 | 4.185 | 0.485 | - | - | - | mg |
| Selenium, Se | 70.7 | 37.7 | | 15.5 | - | - | - | mcg |
| **Vitamins** | | | | | | | | |
| Vitamin C, (Ascorbic acid) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.25 | 70 | mg |
| Thiamin (B1) | 0.447 | 0.191 | 0.378 | 0.385 | 0.237 | 0.51 | 1.0 | mg |
| Riboflavin (B2) | 0.215 | 0.114 | 0.132 | 0.201 | 0.142 | <0.1 | 1.5 | mg |
| Niacin (B3) | 6.365 | 4.604 | 2.860 | 3.627 | 2.927 | 0.8 | 16 | mg |
| Pantothenic acid | 1.008 | 0.282 | 2.167 | 0.424 | - | - | - | mg |
| Vitamin (B6) | 0.341 | 0.260 | 0.403 | 0.622 | <0.1 | <0.1 | 3 | mg |
| Folate, total | 44 | 23 | 74 | - | - | - | - | mcg |
| Folic acid | 0 | 0 | 0 | - | - | <0.02 | 0.4 | mcg |
| Folate, food | 44 | 23 | 74 | - | - | - | - | mcg |
| Folate, DFE | 44 | 23 | 74 | - | - | - | - | mcg_ DFE |

a) Soil and Crop Improvement BV (2006): Eragrain Teff. b) WHO (1991).

c) Converted by dividing to the conversion factor of 4.187 = (1468/4.187)

Source: USDA (2006)