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**Proposal**

# *Improving the value of maize as livestock feed to enhance the livelihoods of maize-livestock farmers in East Africa*

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## German Federal Ministry for Economic Cooperation and Development (BMZ)

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FUTURE HARVEST CIMMYT and ILRI are Future Harvest Centers (www.futureharvest.org)

**Research proposal submitted to The German Federal Ministry for Economic Cooperation and Development (BMZ) Program for targeted funding of International Agricultural Research Centers**

## *1. Project Summary*

*1.1. The IARC applicants:* International Livestock Research Institute (ILRI) and Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT)

1.2. Project title: Improving the value of maize as livestock feed to enhance the livelihoods of maize-livestock farmers in East Africa

*1. 3. Budget total and project duration:* Euros 1 436 287 for three years

### *1.4. Project description*

This ILRI and CIMMYT collaboration proposes a new multidimensional approach to maize improvement to provide maize cultivars that better match the needs of resource poor mixed-crop livestock farmers for food **and** fodder. It aims at improving our understanding of where food-feed maize cultivars have potential from both a farmer and agro-ecological perspective, alongside research to develop dual purpose cultivars for diverse and often marginal environments in Ethiopia, Kenya and Tanzania that produce higher grain yield under conditions of biotic (gray leaf spot, stem borer) and abiotic (drought, low fertility) stress than currently used cultivars while providing good stover quantity and quality for livestock fodder. *The goal* of this project is to investigate the potential of dual-purpose maize to enhance the livelihoods of resource poor crop-livestock farmers of East Africa where the concentration of mixed smallholders is highest and agricultural systems are undergoing further intensification. *The purpose* is to contribute to smallholder food security and benefits from livestock through superior dual-purpose maize cultivars providing both food and feed.

*The outputs* of the project will be:

1. *Influence of livestock related factors on farmers choice of maize cultivars assessed in Ethiopia, Kenya and Tanzania*
2. *Superior dual-purpose maize cultivars identified from existing maize germplasm for diverse agro-ecological zones in Ethiopia, Kenya and Tanzania*
3. *Opportunities and strategies for further genetic enhancement towards dual-purpose maize for diverse agro-ecological zones in East Africa defined*
4. *New tools for quick and economical on-field assessments of stover fodder value in crop improvement work*
5. *Additional selection criteria for variety releasing agents and public and private seed industry*

### *1. 5. Project justification*

In Ethiopia, Kenya and Tanzania maize is grown on about 5 million hectares and the grain provides on average for one third of the daily calories in the diets (de Groote *et al*., 2002). Furthermore, maize is often grown in crop-livestock farming systems where maize stover can contribute to livestock feeding (Thorne *et al*., 2002). Livestock rearing can provide a pathway out of poverty through improvements to household nutrition, cash income, asset building and employment (de Haan, 2004) and is, therefore, essential for the region where one third of the population lives under the poverty line of 1 US $ per day (de Groote *et al*., 2002). It is highly probable that by exploiting the opportunities represented by the increasing demand for livestock products in developing countries (Delgado *et al*., 1999), that even higher benefits can accrue for poverty reduction from livestock in the years to come. In Ethiopia, Kenya and Tanzania livestock productivity is closely linked to the quantity and quality of available fodder, of which a significant proportion may be sourced from maize stover (Desta *et al*., 2000, Romney *et al*., 2003). Increasing demand for fodder, shortage of arable land and water together with shrinking and deteriorating common property resources is likely to put further pressure on feed resources. The demand for food-feed maize cultivars that provide good stover fodder quantity and quality besides grain yield was strongly voiced by the stakeholders attending a recent CIMMYT-coordinated workshop on the direction of maize improvement in East Africa and agrees with and confirms the observation of ILRI and others in the region (Desta *et al*., 2000; GebreMedhin, personal communication). Stover quality and quantity in cereals is highly genotype dependent which in the past sometimes resulted in rejections of new cultivars that were only improved for grain yield, while neglecting the demand for fodder value from the stover (Capper, 1988, Kelly *et al*., 1996). As recently shown for several cereals significant differences in stover quantity and quality with direct impact on livestock productivity exist in currently available cultivars. It is promising that in these works grain yield and stover yielnsoeld2(rgv)7.2 (Go participatory research and geospatial information related to livestock production as well as economic assessment complement the biophysical conclusions.

*1. 9. Stakeholders*

Stakeholders include farmers, NGO's, development agencies, private sector, research organizations (crop breeders, agronomists, natural resource managers and animal scientists) of Ethiopia, Kenya, Tanzania CGIAR and donors. The key stakeholders in identifying priorities for selection of cultivars and for using maize stover or parts of the maize plant) will be farmers, with contributions from other stakeholders. Farmers, executing agencies and partners will be involved in project implementation. CIMMYT, ILRI and partners will be responsible for coordination, monitoring and reporting. Development agencies with support of research organizations will be involved in dissemination of outputs.

*1. 10. Leading scientists:* Z. Mduruma (CIMMYT ECAMAW Coordinator, email z.mduruma@cgiar.org) S. Twumasi-Afriye (CIMMYT, Maize Breeder, email: s.twumasi@cgiar.org; H. de Groote (CIMMYT, socio economist, email h.degroote@cgiar.org), D. Romney (ILRI, livestock scientist (email: d.romney@cgiar.org and M. Blümmel (ILRI, ruminant nutritionist, email: m.blummel@cgiar.org)

*1. 11. Collaborating institutions and staff*

Collaborating institutions under ECAMAW and ASARECA umbrella:

Ato. Dagne Wegary, maize breeder, Bako Research Center Box. 3. Addis Ababa, Ethiopia. Email: CIMMYT-Ethiopia@cgiar.org; Dr. Jane Ininda, Maize Breeder KARI-Muguga Regional Research Center Box Kenya. Email: jininda@todays.co.ke; Mr. Kheri Kitenge, maize breeder, Ministry of Agriculture and Food Security, Selian Agricultural Research Institute Box 6024 Arusha Tanzania email: kkitenge@yahoo.com

Farm enterprise

Dr Jürgen Greiling, HARMONY FARM ENTERPRISE, P.O. Box 700, Addis Ababa, Ethiopia. Email: ados@telecom.net.et

*1. 12. German participation*

Prof. Dr. Albrecht E. Melchinger, University of Hohenheim, Institute for Plant Breeding, Seed Science and Population Genetics, e-mail: melchinger@uni-hohenheim.de. Prof. Melchinger and his team will develop portable "on-farm" NIRS technology that is more economical than currently used technology. The proposed NIRS technology will significantly shorten the time in which data about stover fodder quality will become available to crop breeders for cultivar choice and decisions on breeding and selection. It is highly probable that the new technology can also be applied to multidimensional crop improvement in other crops than maize.

*1. 13. Position of the project on the German thematic funding priorities*

Working in partnerships with national and international institutions on crops important for feed security and natural resource management with poor farmers in crop-livestock systems, the project will address the following German thematic funding priorities: **a)** Sustainable increase in productivity, **b)** Conservation and efficient use of natural resources and biodiversity, **c)** Development of sustainable production systems, **d)** Post-harvest systems on-farm and **e)** Strengthening institutions and improving policy development

*1. 14. Positioning of the project on the research-development continuum*

The project will potentially bring a livestock dimension to maize improvement in crop-livestock systems. The IARCs will apply these principles and genomics science to develop improved food-feed maize. NARS will test the innovations together with farmers and civil society organizations. Private and public sectors will be targeted to become involved in dissemination of project outputs.

**1.15. Short budget summary (EURO)**

| | EXPENDITURES | | | |
|---|---|---|---|---|
| **Partner** | **Year 1** | **Year 2** | **Year 3** | **Total** |
| **ILRI** | 196 737 | 248 914 | 163 546 | 609 197 |
| **CIMMYT** | 154 000 | 190 000 | 218 000 | 562 000 |
| **NARS** | 108 000 | 58 000 | 58 000 | 224 000 |
| **German Institution** | 121 000 | 69 000 | 70 000 | 260 000 |
| **BMZ** | 506 767 | 492 944 | 436 576 | 1 436 287 |
| **Total** | 579 737 | 565 914 | 509 546 | 1 655 197 |

## 2. Background

### 2.1 Analysis of the development problem (political, economic and cultural framework)

East Africa is one of the regions of the world with the highest concentrations of people and where poverty is of greatest concern (Thornton *et al*., 2001). Between 1993 and 1996, 76.4, 62.3 and 59.7% of the population of Ethiopia, Kenya and Tanzania survived on less than 2 US dollars a day (2000/2001 World Development Report). The region has also one of the highest rates of child malnutrition. Forty-eight percent of Ethiopian children under 5 years of age suffer malnutrition (2000/2001 World Development Report). Agriculture is the engine for economic growth of East African countries. Because of the synergies that result from the joint production of crops and livestock, crop-livestock integration has become an important path for agricultural intensification in these countries. Livestock constitutes a source income through the sale of animals and animal products, and also provides opportunities for employment, farm traction and manure for use as organic fertilizer. Livestock contributes with 40, 38 and 23% of the agricultural GDP of Ethiopia, Kenya and Tanzania, respectively (Winrock International, 1992).

The importance of livestock in agricultural development is likely to increase, as the demand for livestock products is projected to double by the year 2020 (Delgado *et al*., 1999). The increasing demand for milk and meat puts an enormous pressure on the farm natural resources, but it also offers opportunities to reduce rural poverty. More than 50% of the poor in the region are livestock keepers who count as their main assets cattle, sheep and goats (Thornton *et al*., 2001). With access to markets these poor smallholder livestock keepers are already pulling themselves out of poverty. This process can be facilitated and accelerated with adequate services, institutional and policy support and provision of proper technologies. A key factor limiting competitive access to markets, income and enhanced nutrition of smallholder livestock producers is low livestock productivity. Feed scarcity is the common constraint to increasing livestock productivity as the pressure on land for food crops may limit the specialized production of fodder in systems where farmers prefer to spread risk across multiple enterprises and reduces the availability of grazing lands. This means than a significant proportion of the feed produced on farm needs to come from the crops that produce food for human consumption. Romney *et al.* (2003) noted maize fodder contributions of up to 34% of total offered feed even in intensive smallholder dairy systems in the Kenya highlands.

In East Africa, maize is planted on more than 15 million ha and is the food staple of 24 million poor families, the majority of whom also rear livestock (Thorne *et al*., 2002; Byerlee and Eicher, 1997; CIMMYT, 1999). In Ethiopia, Kenya and Tanzania alone, 4.9 million ha were planted with maize in 2002 (FAO, http://www.fao.org). In surveys conducted in Ethiopia's maize belt in 2003 it was found that maize contributes with about 60% of the feed produced on farm (GebreMedhin *et al.,* 2004, personal communication). The current programs for developing improved maize varieties for the region are mainly based on traits related to food grain production. Improving the yield and fodder nutritive quality of maize offers potential for reduce the feed constraints for crop-livestock famers in maize systems. This project proposes an innovative approach to improve the potential contribution of maize fodder to livelihoods of crop-livestock producers in East Africa. The factors that determine farmers' choice of cultivar and feeding strategies, together with the existing variation in grain and fodder yield and quality will be used as basis for identifying superior cultivars that meet the needs for food and fodder and to assess opportunities for further improvement. This project seeks to combine a range of parameters that will improve our understanding of the potential contribution of maize fodder to livestock production at farm level whilst at the same time implementing biophysical studies to determine likely options for improving the feed quantity and quality of maize cultivars. Bringing these two aspects together, and evaluating the value of pursuing such an approach for maize will also contribute to the whole issue of evaluating the potential of food-feed crops in mixed systems.

### 2.2 Beneficiary problem focus in formulating the research

Population increase in East Africa will result in intensification of crop-livestock systems (Thornton *et al*., 2002; Thorne *et al*., 2002) with livestock a key to value addition and economic growth (Delgado *et al*., 1999). Lack of feed was identified in farmer surveys in all regions as a major obstacle to increased economic and socio-economic benefits from livestock. Scarcity of arable land and water under smallholder conditions limit allocation of these resources for the exclusive purpose of fodder production, and increasingly food and feed need to be concomitantly produced from the same area. In this situation, there is a potential for maize to contribute to the feed resources and the present project seeks to understand how improved maize fodder could contribute to farmers' strategies to address these challenges whilst at the same time developing cultivars that could better address such needs than existing ones.

### *2.3. Analysis of current research and review of the pertinent literature*

The present project seeks to draw together a number of aspects related to the use of maize as a food feed crop in East Africa. These include the current maize use and breeding strategies, research on multidimensional crop improvement for other cereal crops and the integration of fodder value (biophysical and farmer perceptions) aspects into crop breeding and selection programs.

### *Maize in Ethiopia, Kenya and Tanzania*

Maize is cultivated in all the major agro-ecological zones in the region up to altitudes of 2400 masl. Maize production areas in East Africa may be classified into five broad environments: l) Lowland tropics, comprising the coastal belt of Tanzania, and Kenya, 2) mid-altitude dry ecologies, found in Ethiopia, Kenya and Tanzania, 3) mid-altitude wet ecologies found located in central and western Kenya and Tanzania, 4) transitional-highlands, the most productive maize growing areas in Ethiopia and Kenya and 5) highland ecologies in Ethiopia, Kenya and Tanzania. Maize breeding programs for East Africa have developed germplasm with increasing tolerance to major biotic (stem borer, gray leaf spot) and abiotic (drought, low fertility) stresses of regional importance. Such genetic improvement programs were already successful in that new cultivars out-yielded local and old cultivars (Hassan *et al.,* 2001) and were responsible for the African maize revolution (Byerlee and Eicher, 1997). Seed of these improved varieties is a strategic input, essential for national food security. Seed is consistently recognized as the most important and least expensive agricultural input. Seed of improved varieties is the factor that sets the upper limits on crop productivity and stability where inputs are readily available and seed-embedded technologies can be easy for farmers to adopt where there is a well developed market system and where cash flow and other household factors are not a constraint. Use of improved maize varieties in the region averages around 20%, although reliable figures are lacking (CIMMYT, 1999). Use depends on the relative price of seed and grain, on the cost of other inputs, such as fertilizers that are needed to obtain the benefits of the improved genotypes, cash flow when inputs need to be purchased and access to input and output markets (Doss *et al*. 2003, Rohrback and Alumira, 2002). This results in tremendous national and regional variation. For example, adoption rates exceed 90% in the productive highland regions of Kenya. In contrast, throughout Tanzania, the area planted to improved maize as a percentage of the total maize area is as of yet still less than 5%.

Until now maize improvement for Eastern Africa was focussed on grain yield neglecting yield and quality of the stover (Tolera *et al.,* 1999; Songa *et al.,* 2002). However, the use of maize residues as source of feed for livestock may be influencing farmer choices in systems where intensification and feed scarcity result in farmer placing greater importance on the crops as a source of fodder. In fact, a recent stakeholder workshop eliciting stakeholder opinion for the direction of further maize improvement have documented the need for food-feed crop type of maize (ECAMAW minutes, 2003), although these priorities need further corroboration in the field in terms of the potential role of maize fodder in addressing feed constraints. Participatory rural appraisal studies have shown increasing demand for use of maize as livestock feed (Thorne *et al*., 2002). It has been observed that farmers rejected short-stemmed maize varieties in the past because it did not provide fodder for the livestock. Such observations suggest that consideration of stover quality and quantity as well as investigating farmers' perceptions and use of maize stover would be relevant. Experiences of this kind were also made by sister institutions of CIMMYT working on improvement of barley, pearl millet and sorghum for mixed crop-livestock systems, giving rise to new approaches to crop improvement by targeting improvement of the whole plant instead of only the grain.

*Multi-dimensional cereal improvement targeting grain yields as well as fodder quantity and quality in straws*

Multidimensional crop improvement programs targeting both grain yield and fodder quality in the crop residue was implemented at ICARDA's barley breeding program after farmers rejected new cultivars , that had been improved with only grain yield in mind, on grounds of too poor straw fodder quantity and quality (Capper*,* 1988). Similar experiences were made by ICRISAT, which found little adoption of new pearl millet (Kelly *et al.,* 1996) and sorghum (Rattunde *et al.,* 2001) cultivars when stover quantity and quality was poor. Considerable work has been, and continuous to be, conducted on food-feed opportunities in barley, sorghum and pearl millet (Goodchild *et al*., 1997, Hall *et al*. 2004). With some generalization, the results from these multidimensional crop improvement programs can briefly be summarized as follows: 1) nutritionally important and exploitable genotypic variations in fodder quality of crop residue exists in available genotypes and 2) fodder value of crop residues and primary traits such as grain yield exhibit a large degree of independence. Thus, live weight changes in sheep fed un-supplemented barley straws varied from slight gains (*c*. 10g/d) to substantial losses of up to 160 g/d on high and low quality straws, respectively (Capper *et al*., 1989). Similar important genotypic differences have recently been observed in the fodder quality of sorghum and pearl millet stover (Blümmel *et al*., 2003a, Blümmel and Rai, 2003; Ravi *et al*., 2003; Hall *et al*., 2004).

Straw/stover quality and grain yield exhibited an encouraging degree of independency. For example in 32 cultivars of barley (Goodchild *et al*., 1997) grain yields ranged from 2 to 4 t/ha and were completely unrelated to straw intakes in sheep which varied by almost twofold (34.6 to 61.2 $g/kg^{0.75}$). In other words, high grain yield and high barley straw quality were compatible traits. In 83 cultivars of sorghum, high grain yields (*c*. 4 t/ha) could be associated with digestible stover yields (product of stover digestibility times stover yield) of 1.5 to 4.7 t/ha (Ravi *et al*., 2003). Blümmel *et al*. (2003b) investigated 30 cultivars of pearl millet at three locations in India and found stover quality as reflected by digestible organic matter intake in sheep unrelated to either grain or stover yield. Interestingly, across the three locations and 30 cultivars the heritability for digestible organic matter intake was 0.62 (Blümmel *et al*.; 2003b) suggesting good opportunities for further targeted improvement in stover quality through breeding and selection.

While maize selection for livestock feeding has been implemented successfully with silage-type maize in developed countries (for example Barriere *et al.,* 1995; Schwarz and Kirchgässner, 1996) no concerted work was conducted with either regards to stover quantity or quality. Nevertheless findings from preliminary work strongly suggest the opportunity for exploiting genetic variation also for maize stover quantity and quality. Mkhabela *et al*. (1992) examined grain – stover yield relationships in 23 local and improved cultivars in different seasons and across diverse environments and observed significant and exploitable cultivar differences not only for grain yield but also for stover yield and stover leafiness. Tolera *et al*. (1999) investigated 8 genotypes of maize released in Ethiopia and found genotypic differences in 48 h digestibility measurements that ranged from 42.8 to 50.6 % and that were unrelated to either grain or stover yield. Digestible stover yield ranged from 2.0 to 4.1 t/ha and was unrelated to grain yield (Tolera *et al*., 1999).

*Integrating fodder value assessments of crop residue into crop selection and breeding*

Tests for prediction of fodder value in crop improvement programs need to be accurate yet practical enough for application to large plant populations. Fodder quality is ultimately defined by the productivity of the livestock consuming it, but livestock productivity trials are unsuitable for routine fodder quality assessments in crop improvement programs. While numerous laboratory techniques, mostly of the *in vitro* and chemical kind, have been proposed for assessing crop residue quality few of those have been actually validated through livestock productivity measurements in target crops in this instance cereal stover. As recently shown some complex *in vitro* estimates believed to be highly related to livestock productivity like measurements of rate and extent of ruminal fermentation performed poorly with sorghum and pearl millet stover (Blümmel *et al*., 2003c) In contrast, rather unconventional measurements relating to morphology and structure like residual green leaf area and stem diameter were highly related to digestible organic matter intake and nitrogen balances in sheep. From extensive work with sorghum and pearl millet stover (Hall *et al*., 2004) it was concluded that laboratory techniques require validations in the target crop before being employed for large-scale screening. With regards to sorghum and pearl millet stover it was observed that, using stepwise multiple regression procedures, combinations of morphological/structural, *in vitro* and chemical measurements were required to account for adequate variation ($R^2 > 0.8$) of digestible organic matter intake, nitrogen balances and changes in live weight. Near Infrared Spectroscopy (NIRS) can then be used to predict these pertinent laboratory measurements in large number of plant entries (Prasad *et al*., 2002).

While stationary NIRS technology is well-established (Melchinger *et al*., 1986) new technological development in NIRS technology (NIR diode array spectrometer) promise further simplifications in that fodder quality predictions may directly be obtained at crop harvest, at lower costs and quicker availability of results than with currently used stationary NIRS technology (Paul and Rode, 1999). After NIRS calibration with pertinent laboratory traits, simulation models can be used to predict livestock performance in large numbers of germplasm from crop improvement work (breeding but also management/input trials).

### *2.4. Positioning of the project on the research continuum*

By addressing the improvement of maize to meet the needs of crop-livestock producers, the project will be positioned in the interface of crop and animal science. Through participatory approaches the needs of farmers for dual-purpose maize will be assessed. By researching the traits in maize fodder that influence livestock production and the genetic basis of these traits, aspects of farmers' perception and utilization strategies with respect to the potential of maize fodder will be considered in relation to maize breeding programs. Tools for crop breeders in the region will be provided to enhance the value of crops as livestock feeds. Information on new cultivars will be disseminated to private and public organizations as well as NGOs involved in the dissemination of seed and other productivity enhancing technologies.

### *2.5. Conclusions from completed activities*

Conclusions from a number of activities are being drawn together to provide the underlying hypotheses for the present proposal. The interactions and relationships between these different activities especially in relation to farm level needs have not been unequivocally established, and the present project aims to investigate these linkages and evaluate the potential of continuing the approach involving improved dual purpose maize genotypes. Poverty mapping has shown high numbers of poor crop livestock farmers in East Africa (Thornton *et al*., 2001), which was also identified as a region where maize contributes decisively to food security (Hassan *et al*., 2001) and where stress resistant maize genotypes can have substantial impact on livelihoods (Friesen *et al.,* 2001; Songa *et al*., 2003). The demand for livestock products is expected to grow in the region (Delgado *et al*., 1999) but benefits from livestock are constrained by fodder shortage (Thorne *et al*., 2002, Romney *et al*. 2003); reduced land area under common grazing will result in diminishing fodder supply from this source, increasing the demand for alternatives such as food-feed crops. Extensive work with barley (Goodchild *et al.,* 1997), cowpea (Singh *et al*., 2003) sorghum (Ravi *et al*., 2003) and pearl millet (Blümmel *et al*., 2003b; Hall *et al*., 2004) has shown that differences in fodder value of crop residues can be exploited to increase livestock productivity without necessary detriment to grain yield.

### *2.6. Positioning of this project within ILRI and CIMMYT core projects and programs*

Mitigation of fodder shortages through collaborative research with crop improvement for breeding and selection of crops that provide fodder value in the residues besides grain yields is one of ILRIs' operating projects. Extensive work was, and is, conducted with IITA on food-feed-crop cowpea cultivars and with ICRISAT on pearl millet, sorghum and groundnut. CIMMYT and collaborating NARS have significant experience and ongoing work in maize improvement in East Africa, including knowledge of maize germplasm, experience in seed production, and numerous contacts with all the collaborating organizations. The project will directly link with an ILRI initiative in their targeting theme to develop a framework to evaluate the potential of feed resources to address farm level constraints in a range of mixed crop-livestock systems. Substantial skills in combining spatial and econometric data, impact assessment and system analysis will contribute to the project. At the same time participatory approaches to assess farmer perceptions and to try to understand the decision making process will complement the analysis of quantitative data. Delivery systems will be recognized as an important factor in the likelihood of farm level adoption. Ongoing projects of ILRI and CIMMYT which relate to the proposed work and which will contribute to synergism in the proposed collaboration on maize improvement are listed below:

- *Improving the quality of pearl millet residues for livestock* (ILRI in collaboration with ICRISAT, ACIAR-funded, 1.1. 2004 to 31.12. 2008).

- *Enhancing livelihoods of poor livestock keeper through increasing use of fodder* (ILRI in collaboration with ICRISAT, ICARDA, IITA, CIAT, DFID-funded, 1.10. 2002 to 30.9 2005).

- *Community-level assessments of food-feed crop traits: targeting options to promote sustainable livelihoods for poor livestock keepers* (ILRI, USAID-funded, 1.1 2004 to 31.12. 2004)
- *Strengthening Maize Seed Supply Systems for Small Scale Farmers in Western Kenya and Uganda* (collaborative work led by CIMMYT, Phase II extension recently approved by the Rockefeller Foundation)
- *Quality Protein Maize Development for the Horn and East Africa* (collaborative work led by CIMMYT, funded until 2008 by CIDA).
- *Developing and Disseminating Stress Tolerant Maize for Sustainable Food Security in West, Central and East Africa.* (CIMMYT in collaboration with IITA, the WECACMN, CORAF, ECAMAW and ASARECA; donors UNDP, IFAD and SIDA).
- *Southern African Drought and Low Soil Fertility Project* (collaboration between CIMMYT and SADC; donor SAD and Rockefeller).
- *Seed sector appraisal in Ethiopia, (*collaborative project led by CIMMYT)
- *A framework for* ex ante *impact assessment of feed resource options to promote sustainable livelihoods of resource-poor smallholders* (collaborative project led by ILRI with input from ICRISAT and CIAT funded to 2005 by Systemwide Livestock Program linked to a USAID seed grant)

## *2.7. Expected use and users of research results*

Information about livestock-related aspects in farmers' choice of maize cultivars together with information about areas with high demand for food-feed maize will help national and international maize improvement institutions in breeding cultivars that better match farmers' needs. Crop improvement institutions will use information about variations in stover fodder value, relationships between stover fodder value and primary traits as well as heritability and heterosis estimates for stover traits to implement well-supported multidimensional crop improvement. Public and private variety releasing agents will be informed about exploitable genotypic variations in stover fodder quantity and quality and will be provided with indicators for stover fodder value to include stover fodder aspects as releasing criteria. Private and public seed producers, which are already multiplying and delivering conventional maize cultivars are expected to preferentially multiply and promote superior food-feed type cultivars for resource-poor crop-livestock farmers in East Africa. Results will also be used by scientists leading overall assessment and development of a framework for the ex ante impact assessment of feed resource options (see 2.6).

## *2.8. Mode of dissemination of research results*

The project will be executed under the umbrella of East and Central African Maize and Wheat (ECAMAW) network and of the Association of Agricultural Research for East and Central Africa (ASARECA). This umbrella will assure flow of information across multiple agriculture-related institutions within countries and across the regions The work will be conducted in close co-operation with farmers notably through the medium of mother/baby trials which are well-established by CIMMYT in East Africa. Established linkages with the private sector will be used already at an early stage to ensure that the potential key-partners in the deliver pathway are immediately aware of the research outcome. The project will contribute to the development of advertising material for any new cultivars that are successfully identified but ultimate responsibility for delivering new seed material will rely on existing systems employed by public and private sector. Information material which the project will contribute to will include crop improvement reports, newsletters, brochures and leaflets on cultivars and management. Further dissemination pathways for researchers and a broader range of stakeholders will be a) annual reports presented to the ECAMAW meetings and b) publications in peer reviewed crop and animal science journals and scientific congresses.

## *2.9. Expected benefits of the project for NARS*

This project will strengthen the capacity of participating NARS in conventional and multidimensional crop improvement and will further multidisciplinary crop-animal science interactions between NARS and between NARS and IARC's. The budget includes direct funding for national program collaborators for training, conferences and small grants to support evaluations on station and on farmers' fields in the target areas. It is also planned to transfer the NIRS technology to be developed with our German partners to the NARS.

## *3. Project Description and Workplan (Logical framework in Annex A)*

### *3.1 Goal, purpose, outputs and measurable assessment indicators*

The *goal* of this project is to investigate the potential of dual-purpose maize to enhance the livelihoods of resource poor crop-livestock farmers of East Africa where the concentration of mixed smallholders is highest and agricultural systems are undergoing further intensification. The *purpose* is to contribute to smallholder food security and benefits from livestock through superior dual-purpose maize cultivars providing both food and feed.

*The outputs* of the project will be:

- *Influence of livestock related factors on farmers choice of maize genotypes assessed in Ethiopia, Kenya and Tanzania*
- *Superior dual-purpose maize cultivars identified from existing maize germplasm for diverse agro-ecological zones:*
- *Opportunities and strategies for further genetic enhancement towards dual-purpose maize assessed for diverse agro-ecological zones in East Africa defined:*
- *New tools for quick and economical on-field assessments of stover fodder value in crop improvement work*
- *Additional selection criteria for variety releasing agents and public and private seed industry*

### 3.2. Cost-benefit of the research at micro and macro level

Impact assessments on annual returns from investments in maize technologies targeting the grain have predicted returns of 29% in Ethiopia (Zegeye 2001). Similar estimates for returns of crop improvement targeting grain as well as stover improvement have predicted benefit: cost ratios of 15: 1 for sorghum and pearl millet (Kristjanson and Zerbini, 1999) and of 32 to 127 for cowpea, depending on the assumptions used (Kristjanson *et al.,* 2002). Given the investment in infrastructure for maize improvement and the mechanisms for seed delivery by governments and private sectors, considerable potential for rapid adoption and economic impact exists. The present research, combining farmer level information, geospatial assessments with strategic livestock nutrition and maize breeding issues, will offer the opportunity to understand the potential cost benefit implications in the context of developing dual purpose maize varieties. It will also contribute to the broader agenda of the development of a framework for ex ante evaluation of feed resource options.

### 3.3. Identification of target groups

CIMMYTs existing network of on-station and field sites will be used to carry out the basic testing of cultivars. However, these sites do not necessarily reflect a cross-section of the areas with high potential for food-feed cultivars. Sites for field surveys will be selected where:

a) Farmers keep livestock and source a significant amount of their fodder needs from maize
b) Farmers are already using improved cultivars (hybrids and OPVs). It is hypothesised that farmers may change their choice of improved cultivar to obtain preferred fodder characteristics.
c) There is an existing delivery pathway whereby farmers can access new varieties. This means identifying a private or public sector partner to work with the team who are committed to delivering any desired genotype.

**3. 4. Activities and work plan: activities to achieve outputs**

Activities to achieve output 1*: Influence of livestock related factors on farmers' choice of maize genotypes assessed in Ethiopia, Kenya and Tanzania*

Activity 1.1: Use of existing data to explore factors that influence farmers' choices of cultivars (year 1)

CIMMYT georeferenced databases exist, for Kenya at least where household characteristics are combined with farmers choices of planting material and genotype. CIMMYT databases do not provide information on livestock ownership or use of maize biomass as a source of feed. Therefore the possibility of combining with ILRI geo-referenced household data covering household characteristics, resource endowment, land and livestock management and productivity will be explored. Spatial data will be included describing population density and market access (defined as the total time to drive to the nearest market centre, taking account of different road types. These data may be used to start to explore the factors that can be used as predictors of areas where selection of hybrids or OPVs over local landraces coincides with large populations of livestock farmers using maize fodder. The information will also be used to select sites where there appears to be potential for planting materials with improved fodder characteristics. As far as possible these sites will be existing CIMMYT sites where genotype evaluations are carried out and where the criteria listed in **3.3** hold true. Information on local farmers and farming systems from all existing CIMMYT sites will be reviewed to allow selection of a smaller number of sites.

Activity 1.2:Participatory evaluation of influence of fodder traits on cultivar choices (year 1, 2 and 3)

The findings from activity 1.1. will be complemented with field level surveys in the sites identified using participatory appraisal methods to elucidate: a) the desirable traits in maize that determine the choice of genotype for farmers in different systems and agro-ecological environments; b) the extent to which the different uses of the stover (mulching, feeding to livestock in the same farm, selling for feed in case of non-livestock keepers, etc.) influence the choice of genotype of maize; c) the existing ways in which farmers obtain seed; and d) farmers constraints in accessing seed that meet their needs in a timely manner (existence of seed providers, seed availability, seed price, etc.) d) the trade-offs that farmers make in selecting materials (eg with other uses for maize stover). This work will link with mother/baby trials already planned by CIMMYT and NARS partners for 2005 under other on-going projects. This will allow farmer perceptions and the relevant importance of fodder characteristics and farmer feeding strategies in some sites to be determined, with the work continuing into year 2 when dual-purpose genotypes will be tested in the mother-baby trials (see activity 2.3).

Activities to achieve output 2: *Superior dual-purpose maize cultivars identified from existing maize germplasm for diverse agro-ecological zones in Ethiopia, Kenya and Tanzania*

Activity 2.1: Stover fodder quality assessments to predict stover quality in large number of genotypes (year 1 and 2)

In Ethiopia stover from at least 10 diverse cultivars grown under low (farmers input) and high (recommended crop input rates) will be investigated in livestock productivity trials with sheep. The choice of these genotypes will be based on agronomic importance, crop physiology, morphological/structural (botanical composition, stem diameter, stem diameter, grinding energy requirements, residual green leaf area), chemical (nitrogen, fiber, lignin, sugar) measurements and *in vitro* fermentation (*in vitro* digestibility, rate and extent of digestion, efficiency of carbon conversion) characteristics. The latter three measurements are collectively referred to as laboratory traits. Farmers' perception of the stover quality of the 10 genotypes and their visual, sensory and quantitative criteria (hardness of stem, leafiness, color, plant height and stover yield as well as potential for fodder) will be documented. Feeding trials using maize stover will be designed to relate to farmer feeding strategies, and will include maize stover fed restricted and *ad libitum* as sole feed as well as part of a diet. Data recorded will be intake, digestibility, digestible organic matter intake, change in live weight and in nitrogen balance**.** Laboratory traits will be related to livestock productivity data using multiple regression procedures to determine relative importance of laboratory traits in predicting livestock productivity measurements. Stationary Near Infrared Spectroscopy will be calibrated with laboratory traits having strong partial $R^2$ with livestock productivity measurements. After calibration-validation procedures, NIRS equations will be applied to screening the comprehensive germplasm from the maize improvement activities.

Activity 2.2: Variability in stover quality and relationship between stover quality and primary traits (year 1, 2 and 3)

Genotypes from least 200 parental lines, 50 advanced lines, 10 released varieties and 3 local checks grown at three locations each under low (farmers level) and high (recommended crop input rates) at low, mid and high altitudes at CIMMYT-NARS testing sites in Ethiopia (Ambo, Bako and Awassa), Kenya (Kitale, Embu and Kakamega) and Tanzania (Hai, Arumeru and Himo Makuyumi) will be investigated. The selection of genotypes will be based on the large number of germplasm planted in 2004 in each country and agro-ecological zones and evaluated for the morphological traits measured. Data to be collected will be: a) tasselling and silking dates, plant and ear heights, number of leaves, leaf blights, rust and grey leaf spot, b) stay green characteristics and c) biomass, stover and grain yield, harvest index and moisture content. Stovers will be dried, ground and send to ILRI Ethiopia laboratory for NIRS predictions of important laboratory traits. Predicted laboratory traits and regression coefficients from laboratory traits and livestock productivity trials will be used to predict pertinent stover quality traits such as digestibility, digestible organic matter intake, changes in live weight and nitrogen balances. Stover quality traits will be related to primary traits such as grain yield and stress resistance to determine presence and degree of competition between traits and possible trade-offs.

Activity 2.3: On-farm testing of promising food-feed cultivars (year 2 and 3)

Extensive on-farm testing will be conducted with the assistance of NARS extension and NGO' staff and private farmer entrepreneurs (such as HARMONY Farming Enterprise in Ethiopia) using mother/baby trial design. Each mother trial will contain 6 to 12 baby trials within walking or bicycling distance and 12 to 16 such mother trials will be evaluated at each site in each country selected in activity 1.1. Sites will be selected carefully so that farmers involved are those expected to benefit from the varieties being evaluated. The mother trial will evaluate a promising set of maize cultivars under both optimal and farmer representative management conditions. The trials will be located at the center of a farming community and be managed by a local counterpart such as a teacher of agriculture, an extension officer or a member of an NGO. Baby trials will contain up to four of the cultivars in the mother trial and will be sown and managed exclusively by the farmers that host them. Maize genotypes included in the mother/baby trials will be ranked using farmers' perceptions as well as quantitatively in terms of grain and fodder yield, fodder nutritional quality and other agronomical traits. In the baby trials observation will include days to maturity, grain yield, biomass yield and farmers perception with regard to a range of potential food-feed characteristics using pair wise and matrix rankings for breeders-farmers comparisons. The relative importance of these traits in the ranking of the varieties included will be assessed through participatory evaluation with farmers.

## Activities to achieve output 3: *Opportunities and strategies for further genetic enhancement towards dual-purpose maize assessed for diverse agro-ecological zones in zones in Ethiopia, Kenya and Tanzania*

Activity 3.1: Heritability, heterosis and combining ability of stover fodder traits (year 3)

Heritability of stover fodder quality traits will be investigated for altitudes within and across countries and including comparisons of input systems (low and recommended crop input level). The proportion of genetic and additive variation in the phenotypic variation will be determined for the germplasm in the three agro-ecological zones. After the evaluation of the germplasm used in improvement program materials will be selected and crossed for a line x tester analysis involving at least 12 parents (9 female and 3 male testers). Parents and the 27 crosses will be evaluated at 3 locations in the third year of the project. Combining ability analysis will identify the best combiners for these traits and will enhance future selection of crosses for direct use and/or further breeding program.

Activity 3.2: Uptake of improved cultivars and prospects for further genetic enhancement (year 3)

Crop simulation model components from Decision Support System for Agro-Technology Transfer (DSSAT) will be used to predict grain yield and biomass benefits and tradeoffs from further improvements in crop management practices. Taking into account the farmer preferences and information about strategies of stover utilization identified from on-farm testing (activities 1.1, 1.2 and 2.3), the economic net benefits to farmers from uptake of the best food-feed maize cultivars evaluated on farmers' fields will be estimated. The simulation results from DSSAT will be used to assess the potential economic gains and tradeoffs from improvements in agronomic and crop management practices and to identify agro-climatic zones where the new cultivars could be adopted. This will be compared with the net benefits and tradeoffs that farmers obtain from currently grown maize genotypes. This ex-ante impact evaluation will be crucial to inform decision makers and seed enterprises about the potential for dissemination of these cultivars to farmers and to the breeders on any additional progress that needs to be made in terms of genetic enhancement of dual-purpose maize cultivars. The value of investing in additional progress in genetic enhancement will be predicted based on results from activity 3.1.

### Activities to achieve output 4: *New tools for quick and economical on-field assessments of stover fodder value in crop improvement work*

Activity 4.1: Development of NIR diode array spectrometer instrumentation fit to garden chopper at Hohenheim University (year 1 and 2)

In crop improvement in developed countries a new technology based on NIR diode array spectrometer mounted on combine harvesters and termed NIRS-online has recently been proposed for quick and economical quality assessment of grains and silages. NIRS-online instruments will be modified at Hohenheim University, which has already gained experience with this new technology, and fit to garden-type plant choppers. NIRS-online will be calibrated and validated with maize stover at Hohenheim University during the first two years of the project using laboratory traits analogous to the traits described in activity 2.1 that is morphological/structural, chemical and *in vitro* measurements.

Activity 4.2: Transfer of NIR diode array spectrometer instrumentation adapted for fitting onto a garden-type chopper to East Africa (year 3)

One prototype of NIR diode array spectrometer instrumentation modified to fit onto garden choppers will be transferred to Ethiopia for on-field testing and further calibration and validation with maize stover at two sites in Ethiopia. Predictions of stover laboratory traits and livestock productivity measurements by stationary NIRS and NIRS-field technique will be statistically compared.

### Activities to achieve output 5: *Additional selection criteria for variety releasing agents and public and private seed industry*

Activity 5.1: Introduce releasing agents to stover fodder value as additional releasing criteria

Releasing agents, seed industry representatives and other partners will be invited to participate in the activities relating to evaluation of stover fodder characteristics that are part of activities 1.2, 2.1, 2.2 and 2.3 to familiarize them with farmers perception of maize fodder value, strategies for use and demand for stover value for livestock fodder. Information about exploitable variation in stover fodder value and relationships between stover fodder value and primary traits will be shared with them.

Activity 5.2: Provide simple indicators for estimating stover fodder quality for variety releasing agents

A synthesis of indicators for stover fodder value will be made available to releasing agents and other on the ground partners. The choice of indicators will take into account infrastructural facilities of releasing agents. Indicators developed and validated in this proposal will range from farmers perception and criteria to laboratory traits and NIRS applications and equations. The NIRS field technique will be demonstrated to NARS partners and releasing agents in Ethiopia and in Kenya and Tanzania partners will be introduced to it using appropriate media.

*Calendar of activities*

| **Activity** | **YEAR 1** | | | | **YEAR 2** | | | | **YEAR 3** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Q1** | **Q2** | **Q3** | **Q4** | **Q1** | **Q2** | **Q3** | **Q4** | **Q1** | **Q2** | **Q3** | **Q4** |
| Project initiation &. planning activities | **X** | | | | | | | | | | | |
| | | | | | | | | | | | | |
| 1.1 Analysis of existing datasets | | **X** | **X** | **X** | **X** | | | | | | | |
| 1.2 Participatory evaluations | | | | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** |
| | | | | | | | | | | | | |
| 2.1 Stover fodder quality assessments | | **X** | **X** | **X** | | **X** | **X** | **X** | | **X** | **X** | |
| 2.2 Stover quality and primary traits | | | **X** | **X** | | | **X** | **X** | | | **X** | **X** |
| 2.3 On-farm testing | | | | | | **X** | **X** | **X** | | **X** | **X** | **X** |
| | | | | | | | | | | | | |
| 3.1 Heritability/heterosis of stover quality | | | | | | | | | **X** | **X** | **X** | **X** |
| 3.2 Modeling of benefits | | | | | | **X** | **X** | **X** | **X** | **X** | **X** | **X** |
| | | | | | | | | | | | | |
| 4.1 Development of NIRS field technique | | **X** | **X** | **X** | **X** | **X** | **X** | | | **X** | **X** | **X** |
| 4.2 Transfer of NIRS field technique | | | | | | | | | | **X** | **X** | **X** |
| | | | | | | | | | | | | |
| 5.1 Introduce agents to stover aspects | | | | **X** | | | | **X** | | | | |
| 5.2 Additional selection criteria/indicator | | | | | | | | | **X** | **X** | **X** | **X** |
| | | | | | | | | | | | | |
| Workshop on dual purpose maize | | | | | | | | | | | | **X** |

## 4. Probability of Success

The experience from on-going work and existing partnerships will form the basis for a successful project with a high expectation of reaching the milestones and potential for success. The increasing demand for livestock products and need to increase production of food and feed on limited land holdings suggest that food-feed maize has the potential to contribute in the context of the on going intensification of crop-livestock systems. CIMMYT's expertise with maize in the region with its well–established partnerships under the umbrella of ECAMAW and ASARECA and ILRI's experience in addressing fodder shortages through multidimensional crop improvement assures a high probability of success. Inclusion of information on farmers' preferences, their feeding strategies and existing familiarity with the crop will enhance the likelihood of adoption of improved genotypes that better meet their needs. The success of the project in terms of the direct effects and uptake of dual purpose maize is based on the following major assumptions:

- Demand for livestock products will increase
- Presence of fodder traits influences farmers choices of maize cultivar
- Superior genotypes of food-feed maize with heritable nutritional traits will be identified
- Improved maize genotypes will be adopted by small-holder farmers

Project success could also be evaluated in terms of the improved understanding of the potential of dual purpose maize varieties to provide farmers with options for livestock feeding in the context of intensifying farming systems in East Africa in particular, and the strategies for developing and promoting food-feed crops in general.

## 5. Training and Scientific Interaction

- The project will provide for 1 Post Doc who will develop the NIRS field technique at Hohenheim and transfers the technique to East Africa. In addition 2 PhD students will work on participatory evaluation of farmers choices of maize cultivars (based in Kenya) and on food-feed traits (based in Ethiopia).
- Scientists, public and private seed producers, certifying agencies will participate in the Mini-workshops, an annual event for all ECAMAW projects conducted during February.
- Collaborating scientists will participate in conferences to present project results (regional and

international livestock and crop conferences/workshops)

- One workshop on dual-purpose maize varieties will be held in year 3.
- Based on funding allocated through this project and the small grants program in ECAMAW, participating-NARS will have the opportunity to attend appropriate regional training courses and conferences.

## *6. Intellectual Property Rights*

The products of this research, advanced technologies and techniques, which include biological material, genetically modified through traditional breeding techniques, will be made available for use in improving food-feed crops in developing countries. In line with the policies of the CGIAR, the results of the research will be available in the public domain and techniques and markers developed through the project will be international public goods. The selected cultivars of food-feed maize will be made freely available from the gene banks and breeding programs of the IARCs involved in the project. Centers will place no intellectual property restrictions on the use of germplasm but reserve the right to protect their innovations to ensure continued availability of improved genotypes, inventions, publications and databases to prevent their misappropriation by others for profit making.

## ANNEXES:

ANNEX A: LOGFRAME
ANNEX B: Detailed budget
ANNEX C: References

**Annex A**

Logical Framework: **Improving the value of maize as livestock feed to enhance the livelihoods of maize-livestock farmers in East Africa**

| NARRATIVE SUMMARY | MEASURABLE INDICATORS | MEANS OF VERIFICATION | IMPORTANT ASSUMPTIONS |
|---|---|---|---|
| *GOAL* | | | |
| To investigate the potential of dual-purpose maize to enhance the livelihoods of resource poor crop livestock farmers of East Africa where the concentration of mixed smallholders is highest and agricultural systems are undergoing further intensification. | • Development indicators for income, nutrition, education, and health improved in response to increased farm productivity and marketing grain and livestock products. | • International agencies and country reports<br>• Surveys in targeted countries | • Appropriate pro-poor policies and institutions promote rural development, equity and economic growth in target countries |
| *PURPOSE* | | | |
| To contribute to smallholder food security and benefits from livestock through superior dual-purpose maize cultivars providing both food and feed. | • Adoption rates of improved food-feed maize will increase by 5 % by year 6 (2 genotype releasing cycles) after end of project in three pilot sites in each of three agro-ecological zones of Ethiopia (E), Kenya (K) and Tanzania (T).<br>• Adoption of superior food-feed maize will increase productivity of grain by 5% and that milk and meat by 15% project in three pilot sites in each of three agro-ecological zones of Ethiopia (E), Kenya (K) and Tanzania (T) by year 6 after end of project. | • Records on sales of seed<br>• Impact assessment reports<br>• Surveys | • Maize will remain an important source of staple food and the demand for it will increase further<br>• The demand for livestock products will continue to increase and smallholders will participate in meeting this demand<br>• Appropriate services (seed availability, other inputs) will meet the needs of smallholders |

| *OUTPUTS* | | | |
|---|---|---|---|
| 1. Influence of livestock related factors on farmers choice of maize genotypes determined in Ethiopia, Kenya and Tanzania | • Areas where selection of improved cultivars coincides with the use of maize fodder determined by year 1<br>• Relative importance of fodder traits in farmers selection of cultivars determined in E, K and T by year 1<br>• Farmers' characteristics and perceptions expected to affect importance of fodder traits in farmers choice of cultivars determined in E, K and T by year 2<br>• Multiple feed related criteria used by farmers to choose maize genotypes determined in three pilot sites in each of three agro-ecological zones of Ethiopia (E), Kenya (K) and Tanzania (T) by year 3 | • Project reports<br>• Surveys | • Project partners including farmers collaborate effectively<br>• Project is well funded and staffed |

| | | | |
|---|---|---|---|
| 2. Superior dual-purpose maize cultivars identified from existing maize germplasm for three agro-ecological zones in Ethiopia, Kenya and Tanzania | • At least one superior food-feed maize genotype identified from already released materials for each of three agro-ecological zones of E, K and T by end of year 2.<br>• At least one superior food-feed maize genotype identified from materials in the releasing process for each of three agro-ecological zones of E, K and T by end of year 3.<br>• At least 50 maize genotypes in advanced stages of improvement assessed for food-feed traits and the best 10% identified for each of three agro-ecological zones of E, K and T by end of year 2.<br>• At least 200 maize parental lines used in breeding programs assessed for food-feed traits and the best 10% identified for each of three agro-ecological zones of E, K and T by end of year 2. | • Project reports<br>• Variety registering records<br>• Reports by variety releasing agencies | • Project partners including farmers and seed releasing agencies collaborate effectively<br>• Project is well funded and staffed<br>• Project activities are not affected by natural disasters such as drought, flood, etc. |

| | | | |
|---|---|---|---|
| 3. Opportunities and strategies for further genetic enhancement towards dual-purpose maize assessed for diverse agro-ecological zones in East Africa defined | • Estimates for heritabilty and heterosis of maize stover as feed available by end of year 3<br>• Estimates of potential trade-offs between food and feed traits determined by year 3<br>• Prospects for further genetic enhancement on the basis of farmers preferences, genetic parameters and potential trade-offs defined by year 3 for the three target agro-ecological zones | • Peer reviewed journals<br>• Project reports | • Project partners including farmers collaborate effectively<br>• Project is well funded and staffed<br>• Project activities are not affected by natural disasters such as drought, flood, etc. |
| 4. New tools for quick and economical on-field assessments of stover fodder value in crop improvement work | • NIRS-online yields comparable estimates of stover quality to stationary NIRS technology by end of year 3 | • Product reports<br>• Peer reviewed journals | • Project is well funded and staffed |
| 5. Additional selection criteria for variety releasing agents and public and private seed industry | • Releasing agents in Ethiopia, Kenya and Tanzania integrate stover value as additional criteria for releasing new varieties by year 3.<br>• At least one seed producer in each country includes fodder value of the stover as information in the labeling of seeds by end year 3 | • Protocols and reports from releasing agents<br>• Seed labeling information<br>• Advertisements from seed industry | • Crop improvement and releasing agents accept and implement criteria |

| ACTIVITIES | MILESTONES | MEANS OF VERIFICATION | IMPORTANT ASSUMPTIONS |
|---|---|---|---|
| **1. Influence of livestock related factors on farmers choice of maize genotypes assessed in Ethiopia, Kenya and Tanzania** | | | |
| Activity 1.1: CIMMYT and ILRI household data will be combined to determine potential areas for impact of improved food-feed-maize in agro-ecological zones and countries | Promising areas for impact of food-feed-maize determined by end of year 1 | • Progress reports with area mapping | • Project partners including farmers collaborate effectively<br>• Project is well funded and staffed |
| Activity 1.2: Participatory evaluation of influence of fodder traits on cultivar choice. Field activities to elucidate the effects of livestock related issues on cultivar choice. | Livestock related factors affecting farmers' choice of cultivar identified by end of year 3. | PhD thesis describing farmers decision making in its socio-economic and environmental context | |
| **2. Superior dual-purpose maize cultivars identified from existing maize germplasm for diverse agro-ecological zones in Ethiopia, Kenya and Tanzania** | | | |
| 2.1:Stover quality assessments and predictions of stover quality in large number of genotypes | Combinations of laboratory stover quality traits account for at least 80% of the variation in one or more livestock productivity measurements by end of year 1<br>Stationary NIRS analysis predicts pertinent laboratory traits with an accuracy of at least 85% by end of year 1 | • Progress reports<br>• Peer reviewed journals<br>• PhD thesis on food-feed type maize | • Project is well funded and staffed<br>• Project activities are not affected by natural disasters such as drought, flood, etc.<br>• Project partners including farmers collaborate effectively |
| 2.2:Determine the variability in stover quality and relationships between stover quality and primary traits | Relationships between these traits calculated for the 3 zones, 3 countries, 2 cropping seasons and 2 input levels by beginning of year 3 | • Progress reports<br>• Peer reviewed journals<br>• PhD thesis on food-feed type maize | |
| 2.3: On-farm testing of promising food-feed genotypes | First of promising food-feed type cultivars planted on-farms in the cropping seasons of year 2 | • Progress reports<br>• Field days<br>• PhD thesis on food-feed type maize | |
| **3. Opportunities and strategies for further genetic enhancement towards dual-purpose maize assessed for diverse agro-ecological zones in East Africa defined** | | | |

| | | | |
|---|---|---|---|
| Activity 3.1: Heritability, heterosis and combining ability of stover fodder traits | Heritability/heterosis effects over 2 seasons and for 3 agro-ecological zones, 3 countries and 2 input levels available | • Progress reports<br>• Peer reviewed journals | • Project partners including farmers collaborate effectively<br>• Project is well funded and staffed<br>• Project activities are not affected by natural disasters such as drought, flood, etc. |
| Activity 3.2: Assess prospects for further genetic enhancement towards food-feed crop maize | Simulated maize improvement scenarios available | • Impact assessment report | |
| **4. New tools for quick and economical on-field assessments of stover fodder value in crop improvement work** | | | |
| Activity 4.1: Develop garden-chopper mounted NIRS-online, calibrate and validate it at Hohenheim University | Device functioning by end of year 2 at Hohenheim University | • Product report<br>• Project report | • Project is well funded and staffed |
| Activity 4.2: Calibrate and validate NIRS-online with stovers from Ethiopian maize in Ethiopia and compare it with the stationary NIRS instrumentation | Device transferred to Ethiopia and compared with stationary NIRS by end of year 3. | • Product report<br>• Project report<br>• Peer reviewed journal | |
| **5. Additional selection criteria for variety releasing agents and public and private seed industry** | | | |
| Activity 5.1:Introduce releasing agents to stover fodder value as additional releasing criteria | Releasing agents have participated in at least on participatory evaluation and in at least one selection cycles in at least 1 agro-ecological zones in each country | • Project report<br>• Crop improvement report | • Crop improvement and releasing agents accept and implement criteria |
| Activity 5.2: Provide simple indicators for estimating stover fodder quality for variety releasing and trading | Releasing agents find at least one pertinent stover fodder characteristic appropriate for use in varietal release | • Project report<br>• Crop improvement report | |

## Annex B: Detailed budget (EURO)

| Expenditure (Euro) | Unit Months per year | | | Rate per month | Year 1 | | | | | Year 2 | | | | | Year 3 | | | | | TOTAL FROM BMZ | From IARCs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | ILRI | CIMMYT | UoH | NARS | Yr 1 from BMZ | ILRI | CIMMYT | UoH | NARS | Yr 2 from BMZ | ILRI | CIMMYT | UoH | NARS | Yr 3 from BMZ | | |
| *Personnel* | Y1 | Y2 | Y3 | | | | | | | | | | | | | | | | | | |
| Scientist maize breeder/agronomist | 3 | 3 | 3 | 12 000 | | 48 000 | | | **36 000** | | 48 000 | | | **36 000** | | 48 000 | | | **36 000** | **108 000** | 36 000 |
| Scientist socio-economy | 1 | 1 | 1 | 12 000 | | 24 000 | | | **12 000** | | 24 000 | | | **12 000** | | 24 000 | | | **12 000** | **36 000** | 36 000 |
| Scientist economy | 2 | 1.5 | 1.5 | 7 906 | 15 812 | | | | **7 906** | 11 859 | | | | **3 953** | 11 859 | | | | **3 953** | **15 812** | 23 718 |
| Scientist livestock system | 3 | 3 | 2.5 | 9 322 | 27 966 | | | | **18 644** | 27 966 | | | | **18 644** | 23 305 | | | | **13 983** | **51 271** | 27 966 |
| Scientist system modeler | 1.75 | 2 | 2 | 9 322 | 16 314 | | | | **6 992** | 18 644 | | | | **9 322** | 18 644 | | | | **9 322** | **25 636** | 27 966 |
| Scientist GIS | 1.5 | 1.5 | 1 | 11 210 | 16 815 | | | | **5 605** | 16 815 | | | | **5 605** | 11 210 | | | | | **11 210** | 33 630 |
| Scientists ruminant nutrition | 3 | 3 | 2.75 | 11 210 | 33 630 | | | | **22 420** | 33 630 | | | | **22 420** | 30 828 | | | | **19 618** | **64 458** | 33 630 |
| Scientists livestock production | | | | | | | | 6 500 | **6 500** | | | | 6 500 | **6 500** | | | | 6 500 | **6 5000** | **19 500** | |
| Scientists crop production | | | | | | | | 6 500 | **6 500** | | | | 6 500 | **6 500** | | | | 6 500 | **6 5000** | **19 500** | |
| Research assistant | 5 | 10 | 10 | 1 200 | 6 000 | | | | **6 000** | 12 000 | | | | **12 000** | 12 000 | | | | **12 000** | **30 000** | |
| Technicians animals/fieldwork | 12 | 12 | 0 | 600 | 7 200 | | | | **7 200** | 7 200 | | | | **7 200** | | | | | | **14 400** | |
| Technicians laboratory work | 12 | 12 | 12 | 600 | 7 200 | | | | **7 200** | 7 200 | | | | **7 200** | 7 200 | | | | **7 2000** | **21 600** | |
| Post doctoral fellow | | | | | | | 62 000 | | **62 000** | | | 63 000 | | **63 000** | | | 64 000 | | **64 000** | **189 000** | |
| PhD socio economy | | | | | | | | 15 000 | **15 000** | | | | 15 000 | **15 000** | | | | 15 000 | **15 000** | **45 000** | |
| PhD Ethiopia | | | | | | | | 15 000 | **15 000** | | | | 15 000 | **15 000** | | | | 15 000 | **15 000** | **45 000** | |
| Supplies & Operations | | | | | | | | | | | | | | | | | | | | | |
| Output 1 | | | | | 12 200 | 10 000 | | | **22 200** | 45 200 | | | | **45 200** | 15 000 | | | | **15 000** | **82 400** | |
| Outputs 2, 3,5 | | | | | 20 000 | 24 000 | | | **44 000** | 23 000 | 50 000 | | | **73 000** | 4 000 | 68 000 | | | **72 000** | **189 000** | |
| Output 4 | | | | | | | 5 000 | | **5 000** | | | 2 000 | | **2 000** | 4 000 | | 2 000 | | **6 000** | **13 000** | |
| **Equipment** | | | | | | | | | | | | | | | | | | | | | |
| Laboratory | | | | | | 5 000 | | | **5 000** | | 5 000 | | | **5 000** | | 5 000 | | | **5 000** | **15 000** | |
| NIRS instrumentation | | | | | | | 50 000 | | **50 000** | | | | | | | | | | | **50 000** | |
| Vehicle (2) | | | | | | | | 50 000 | **50 000** | | | | | | | | | | | **50 000** | |
| Computers | | | | | 5 000 | | | | **5 000** | | | | | | | | | | | **5 000** | |

(Cont.)

**Annex B (continued): Detailed budget (EURO)**

| Expenditure (Euro) | Unit | Year 1 | | | | | Year 2 | | | | | Year 3 | | | | | TOTAL FROM BMZ | From IARCs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ILRI | CIMMYT | UoH | NARS | Yr 1 from BMZ | ILRI | CIMMYT | UoH | NARS | Yr 2 from BMZ | ILRI | CIMMYT | UoH | NARS | Yr 3 from BMZ | | |
| **Training / Workshops** | | | | | | | | | | | | | | | | | | |
| - Workshop | | | 10 000 | 1 000 | | **11 000** | | 10 000 | 1 000 | | **11 000** | | 20 000 | 1 000 | | **21 000** | **43 000** | |
| - Training | | 2 000 | 5 000 | | 15 000 | **22 000** | 9 000 | 15 000 | | 15 000 | **39 000** | | 15 000 | | 15 000 | **30 000** | **91 000** | |
| **International Travel** | | | | | | | | | | | | | | | | | | |
| - Project coordination | | 5 000 | 5 000 | | | **10 000** | 5 000 | 5 000 | | | **10 000** | 5 000 | 5 000 | | | **10 000** | **30 000** | |
| - Regional activities | | 11 100 | 5 000 | | | **16 100** | 15 900 | 5 000 | | | **20 900** | | 5 000 | | | **5 000** | **42 000** | |
| - UoH | | | | 2 000 | | **2 000** | | | 2 000 | | **2 000** | | | 2 000 | | **2 000** | **6 000** | |
| **Publication** | | | | | | | | | | | | | | | | | | |
| - Reports and articles | | | | | | | 5 000 | 10 000 | | | **15 000** | 10 000 | 10 000 | | | **20 000** | **35 000** | |
| **Other Expenses** | | | | | | | | | | | | | | | | | | |
| - Operational costs Hohenheim | | | | 1 000 | | **1 000** | | | 1 000 | | **1 000** | | | 1 000 | | **1 000** | **3 000** | |
| - Operational costs Ethiopia | | 3 500 | 6 000 | | | **9 500** | 3 500 | 6 000 | | | **9 500** | 3 500 | 6 000 | | | **9 500** | **28 5000** | |
| - Operational costs Kenya | | 3 500 | 6 000 | | | **9 500** | 3 500 | 6 000 | | | **9 500** | 3 500 | 6 000 | | | **9 500** | **28 500** | |
| - Operational costs Tanzania | | 3 500 | 6 000 | | | **9 500** | 3 500 | 6 000 | | | **9 500** | 3 500 | 6 000 | | | **9 500** | **28 500** | |
| TOTAL | | **196 737** | **154 000** | **121 000** | **108 000** | **506 767** | **248 914** | **190 000** | **69 000** | **58 000** | **492 944** | **163 546** | **218 000** | **70 000** | **58 000** | **436 576** | **1 436 287** | **218 910** |

## ANNEX C References


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