Combining soil conservation and fodder production for an adaptation to climate change

Southern region – Ethiopia

Main contributors: Lolita Guyon, Getamesay Demeke, Philippe Redon, Francois Bourgois, Damien du Portal, Tadesse Mega, Abebe Tilahun, Mesfin Desalegn, Inter Aide and RCBDIA teams

July 2016

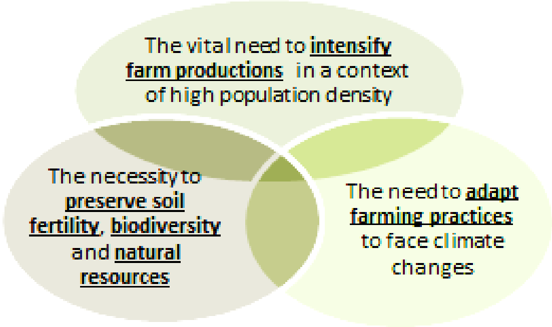
Table of content

A. The idea: integrating fodder on anti-erosive structures

Presentation of the innovation

As many small-holder farmers in Africa, the farming families of southern Ethiopia face 3 major challenges:

- The **vital need to <u>intensify and diversify their farm productions</u>**, on very small surfaces, in a context of high population growth. In these rural areas, given today's fertility rate, the population will double in 35 years;
- The agricultural practices must **preserve the environment to <u>maintain its productive capacity</u>,** for current and future generations;
- The necessity to rapidly adapt farming practices to **<u>cope with climate change.</u>**



Regarding these 3 challenges, Inter Aide has developed an innovative approach that consists in combining fodder production and soil and water conservation. The basic idea is simple: **to plant fodder on anti-erosive structures and in unproductive places of the farm**. This single practice allows farmers to address several problems: erosion, moisture, loss of fertility and fodder scarcity, and contributes to generate new sources of income (as well as food and wood), to reduce the burden on women of collecting fodder, and to stop open grazing.

If the innovation seems quite simple and relatively obvious, it is however the result of a long process, as several factors may influence the success and the range of adoption and diffusion of a new practice[1]. In this case, 3 elements have been decisive:

- The multiplication of vegetative material by the families themselves in **farm based micro-nurseries;**
- The **association of grass and legumes** forages integrated on anti-erosive structure, as well as on unproductive or underused spaces, to address the crucial livestock feeding problems but without competing with traditional crops;
- The involvement of traditional organizations called "Iddirs" to stimulate community ownership, to ensure consistent implementation at the scale of micro watersheds, and to address the critical issue of **animal open-grazing control**.

As a result, combining fodder production and soil conservation has shown many advantages:

- **The land loss due to erosion control structures** (estimated at 6-8% of the plot) is offset by the intensive use of embankments as biomass production support (grasses, legumes, banana trees, shrubs).
- **The vegetated structures help reduce the effects of soil erosion, avoiding further loss of fertility** (through better nutrient and water retention and due to the presence of leguminous plants on the structures, such as Cajanus cajan).
- **Fodder production benefits for all categories of families**. Intensive fodder cultivation on anti-erosive embankments (where the fertility is maximal) proved extremely profitable for the poorest families, as the most important source of cash in an environment where such opportunities are extremely rare, as well as for the better-off farmers, who can increase their livestock, milk production and animal fattening.
- **Fodder production especially benefits women and young girls** by reducing the burden and the time spent on collecting natural grass.
- **The decrease of pressure on Ensete venticosum plantation,** usually overexploited for cattle breeding in the dry season, brings a positive effect on human food security. Ensete is a key crop for those smallholder farmers in terms of food reserves, shade generation or protection against wind and drying of soils. Ensete plantation is an objective marker of poverty in southern Ethiopia: the poorer the family, the smaller the number of Ensete.

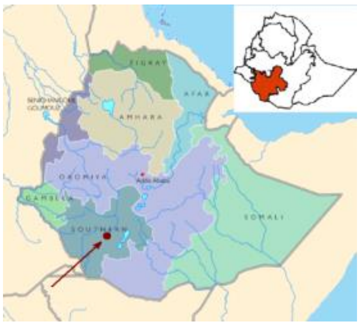
Photo: overview of the vegetated anti-erosive structures with fodder production – Doyo Gena District

---

[1] Everett Rogers, http://www.spreadingscience.com/our-approach/diffusion-of-innovations-in-a-community/

B. The context: understanding the main causes of poverty in Wolayta and Kembatta Zones (South Ethiopia)

The presented experience takes place in the southern region of Ethiopia, the "SNNPR" which is inhabited by about 17 million people. The targeted districts are located in the Kembatta and Wolayta administrative zones (total population of 2.3 million) where over 85% of the population lives off farming. Family farming is based on the culture of Ensete (Ensete ventricosum), cereals, pulses and tubers, and a fairly small home garden. While Ensete and garden byproducts are largely self-consumed[2], cereals are the primary sources of cash crop. The rainfall pattern is bimodal with a main rainy season ("Meher") from June to September; a small rainy season ("Belg") from February to May, and a relatively long dry season from October to February. It usually allows 2 consecutive cropping seasons in the year, but any delay in the arrival of the small rains may lead to serious consequences for the food security of the rural families (April-May-June). Three main causes must be emphasized to understand this fragile situation:



- **The role of demographic density** in this part of southern Ethiopia is absolutely central: the division of the family land between the male heirs has led to a splitting up process. As a clear indication: the surface of arable land per family has been divided by 2 to 3 within only one generation. Today, a farm in Wolayta or Kembatta has an average surface of 0.53 ha[3], which makes food security an objective difficult to achieve. These areas are among the highest densely populated rural areas in the world, with 300 to 600 inhab/km^2 in some areas, which is comparable to Rwanda. Rural exodus is still in its early stage in Ethiopia, as shown by the fraction of population still living in rural areas (the highest in Africa) and is therefore not mitigating demographic growth. The progressive reduction in the size of cultivable plots induces an intensive exploitation of available land.

- **Soil erosion and the gradual loss of fertility are aggravating the situation**. From a physical point of view, the concerned areas have a mountainous profile that split the environment in different altitudinal and agro-ecological zones from 1300 to 2500m and above. In a highly densely populated rural area, the combination of a steep topography and high rainfall results, in the absence of adapted measures, in intensive erosion of the open fields. This evolution negatively affects the traditional mixed cropping and breeding farming system, reduces soil fertility and compels more and more families to give up land lots as they become gradually unfit for cultivation and even pasture.

- **Southern midlands and highlands agriculture depends to a very large extent on animal traction**. However, as less than 25% of rural households own a yoke of oxen, they are forced to find arrangements, sharing animals under multiple types of contracts. Furthermore, maintaining cattle becomes more and more difficult in a context of acute land and fodder shortage. An agro-economic study (*Aurélie Cheveau & Camille Hoornaert, Doyo Gena - May 2011*) analyzed that the historical reduction of the cultivable plots was much quicker than the decrease in the number of livestock per family, resulting in a decline of fodder units per cattle head. The intensification of farming practices has also led to the gradual replacement of pasture by stabling. So far, farmers have overcome the increasing shortage of fodder resource through the adoption of a feeding system based on a "cut-and-carry" practice, but at the cost of more labor and/or expenses. The expenditures to get fodder nowadays represents a substantial proportion of the tight family budget.

The repeated droughts due to the extension of dry periods, linked with the recurrent food and fodder shortages, the difficulties of the extension programs in addressing the root causes of food insecurity, and the continuous land fragmentation have led to a progressive weakening of the farming system and family resilience: decrease in the number of species and varieties grown (loss in biodiversity), decrease of biomass level in the ecosystem, reduction of livestock, depletion of Ensete grove, decline of the soil fertility. If it still appears difficult today to forecast the effects of climate changes on these local areas[4], all these elements contribute to exacerbate an already fragile situation and affect small-holder families' resilience and capacity to cope with climate change and hazards in general.

[2] Alice Bortzmeyer: study of the home garden systems, Damot Sore Woreda, Wolayta (SNNPR), 2014

[3] Data measured in 10 851 farms in midlands and highlands (Inter Aide project database, Damot Gale, Kacha Bira and Hadero Woreda 2006-2011)

[4] "L'impact des changements climatiques en Ethiopie et dans les sociétés du sud", Hubert Cochet, Professor Paris Institute of Technology for Life, Food and Environmental Sciences (AgroParisTech), 2009

C. Origin and development of an innovation process

Since its first intervention on agriculture in Ethiopia (1996), Inter Aide has focused on supporting farmers and local actors in meeting environmental challenges, including in the field of **erosion control**. The first objective was to respond effectively to the soil leaching issue by installing physical structures to regulate the water flow, in order to curb nutrient losses and to improve soil moisture and fertility. Soil bunds (embankment-and-ditch structures) were progressively adopted as the main technical option, on the basis of farmers' acceptability more than technical standards. Those structures presented limitations: they are labor intensive (6 to 8 hours of work needed to build 10m), they occupy up to 6 to 8% of the cultivated land and they need regular maintenance to avoid the leaching effect.

To fix the top soil of the structure and consolidate the soil bund with vegetation, the Inter Aide team initially promoted the plantation of Vetiver (*Vetiveria zizanioides*) on the embankments. This grass species is usually recommended against erosion, as its deep vertical root system enables a strong anchoring effect and helps water infiltration. Ironically, Vetiver was also selected for its thick unpalatable leaves that animals do not eat, as the main purpose was to protect the vegetative material against open grazing.

A key limiting factor quickly appeared to be the quantitative availability of the vegetative material and its relatively low survival rate. The project mainly multiplied Vetiver plantlets in a central nursery maintained by the project, but the onerous logistic and the related substantial expenses allowed to reach only a restricted number of farmers, with relatively low survival rates for the plantlets. The promotion of **farm based micro-nurseries** to multiply and grow grass species, was an appropriate logistic and methodological response. It gave the opportunity for farmers to independently multiply and transplant seedlings at the right moment, resulting in a higher survival rate.

In 2005, an agrarian study commissioned by Inter Aide emphasized the vital role played by fodder in the local farming system. This was an methodological cornerstone and an eye opener in the understanding of the milieu: a mixed cropping and breeding farming system in a context of accelerated depletion of fodder. In fact, **integrating fodder on the soil bunds** became a decisive component as access to fodder influences family vulnerability. Ten years ago, no family grew fodder and women, in charge of feeding animals, spent up to 1 hour per day to collect crop residues and weeds in order to feed livestock. In the dry season, many households would resort to Ensete (*Ensete ventricosum*) leaves to feed animals, to the detriment of family food.

The **introduction of fodder production and its integration on anti-erosive structures** has been the triggering effect that encouraged farmers to setup vegetated soil bunds to control erosion and rapidly obtain alternative sources of fodder and/or income. Based on the above observations, Inter Aide identified species with an appropriate rooting system, highly productive in biomass, easy to multiply and with a good feeding value for animals (as opposed to Vetiver zizanioides). *Pennisetum riparium*, an endemic grass, little known and poorly disseminated, met the required criteria: (i) deep rooting, (ii) good quality forage, (iii) rapid growth allowing several cuts in the year and (iv) easy to multiply in family backyard nurseries.

Progressively, with the support of Ilri (International Livestock Research Institute) and the Ministry of Agriculture, **Inter Aide started to diversify the species grown on the embankments** to preserve fertility and increase biomass production, leading to the concept of "productive hedges". The promotion of biomass production, **combining fodder grasses and leguminous species** on anti-erosive embankments, provides a direct response to animal fodder scarcity[5], while contributing to preserving soil and fertility in the long run.

Finally, a decisive factor was the mobilization of traditional organizations, the "Iddirs", as the coordinating body to manage anti-erosive master plans at micro-watershed level and setup appropriate rules to control open-grazing. Iddirs are traditional systems of mutual aid based on a contribution of the members in exchange for material support at the time of funerals or other hard blows. Benefitting from a strong collective recognition[6], these vernacular organizations have a tremendous economic importance, including for the poorest, but had never really been integrated in the institutional frame, although they were identified as potential interlocutors for participative planning by the Ministry of Agriculture[7].

[5] And to some extent also to food shortages with the production of peas (from Cajanus cajan) and bananas.
[6] "Ethiopian Iddir mechanisms: A case study in pastoral communities of Wolayta and Kembatta-Tembaro", Thomas Léonard, 2014
[7] "Managing land, a practical guidebook for development agents in Ethiopia (Icraf and Ministry of Agriculture, 2005) http://www.worldagroforestry.org/downloads/Publications/PDFS/MN13598.pdf page 39

D. Three decisive factors: farm-based nurseries; planting fodder on anti-erosive structures; and the role of traditional systems "Iddir"

a. Farm-based micro nurseries: a rapid access to large quantities of fodder

A farm-based nursery is a small plot (around 10m²) allocated by the farmer inside his/her farm to multiply vegetative material before transplanting it on anti-erosive structures and other places in the farm. It is an effective way to provide fast access to large quantities of fodder grasses and other vegetative material. This part explains the context in which this practice was introduced and its advantages and limitations.

The issue of distributing (new) vegetative material for a large number of families often represents a major issue for organizations and institutions (Ministry of Agriculture, Research Centers, NGOs…). At the beginning, the project team of Inter Aide relied on large central nurseries to multiply and supply planting material to farmers to consolidate anti-erosive soil bunds, but the cost of maintaining those project nurseries, producing and transporting the vegetative materials to farmers' field was substantial. Paradoxically, this onerous logistic and the related expenses only allowed to reach a restricted number of farmers, residing at accessible places close to roadsides. Furthermore, the survival rates of the seedlings after transplantation on the farms were low, sometimes below 50%.

Growing fodder is also not a widespread practice in Southern Ethiopia. Farmers mainly rely on natural grasses and crop residues to feed their cattle, but they have never considered growing fodder "as a crop" in their field. Many reasons can explain the limited development of fodder production, among which Duncan A. and al (2011) emphasize the very low availability of forage seeds, as the Ethiopian seed system is mainly dedicated to cereal production. In addition to this, according to researchers from the International Livestock Research Institute (ILRI) and the International Food Policy Research Institute (IFPRI), organized markets for quality forage almost do not exist, both at a local level and on a larger scale.

In 2006, Inter Aide tried a direct self-multiplication by the farmers themselves in small plots in their backyard before being transplanted in the farm. Like many Pennisetum, the multiplication of Pennisetum riparium can easily be done by cutting. **With 5 clumps given as starting material for one family, and multiplied in a backyard nursery of 15m², 2000 seedlings can be obtained in less than 1 year, allowing to cover 150 to 200 meters of anti-erosive soil-bunds**. Backyard nurseries therefore give autonomy to farmers who can rapidly increase available biomass. As they directly control the multiplication process, they can also decide on the most appropriate time to move the seedlings. It has largely improved the average survival rates, reaching more than 90%.

From seedlings taken from backyard nursery to fodder production on anti-erosive structure

a) Clump removed from the nursery with several seedlings;
b - c) Division of a seedling from the clump

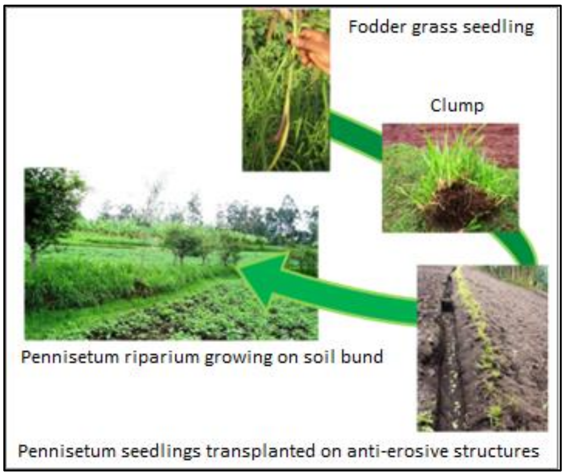


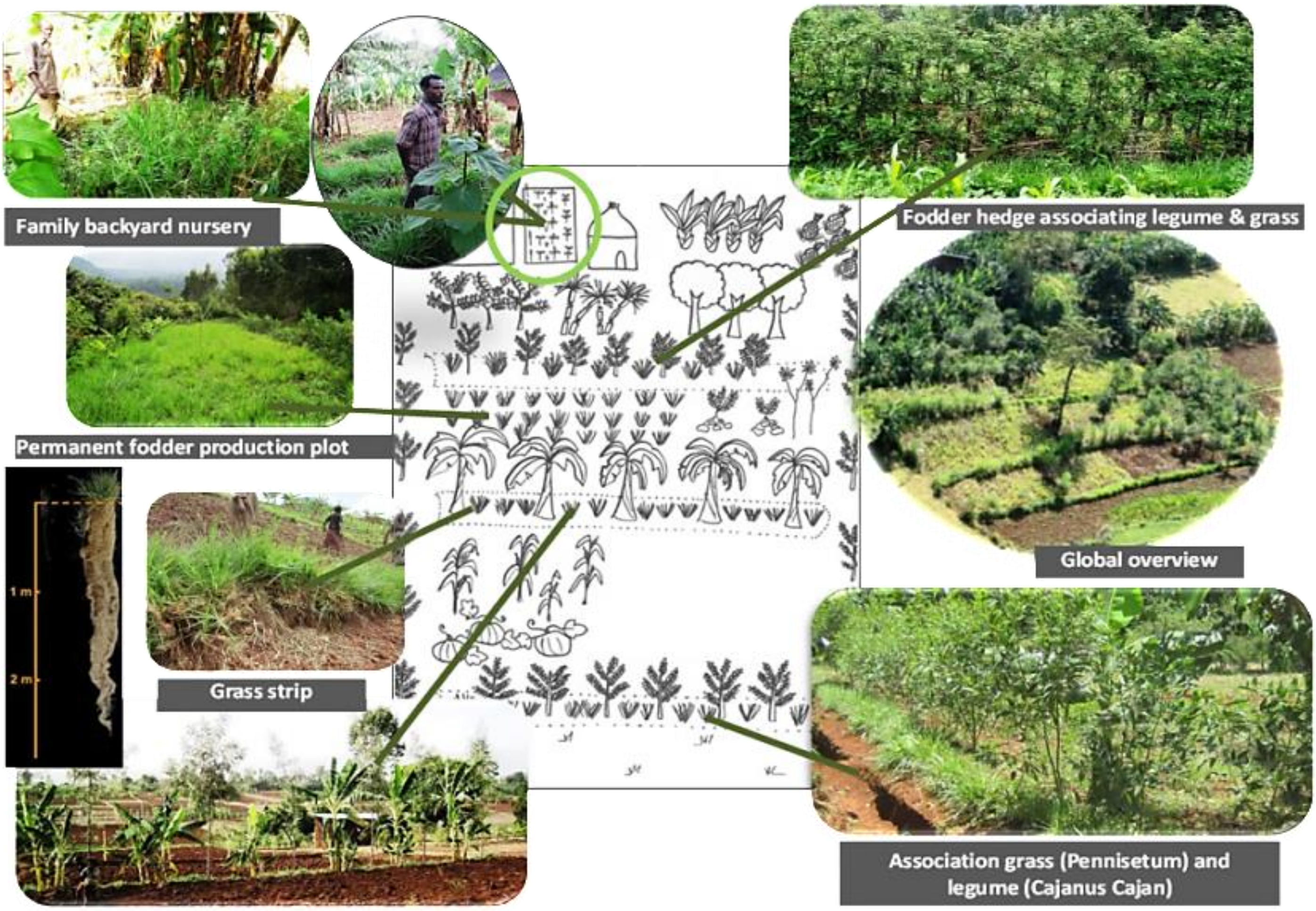
Table 1: main advantages and the limitations of farm-based nurseries:

Advantages	Limitations
• Farmers are autonomous in producing their own vegetative material	• It requires access to an initial small quantity of planting material
• Some grass species (like Pennisetum) are easy to propagate by cuttings	• The technique requires some practice to get confidence, especially during the 1st year
• It enables a rapid multiplication of a large number of plantlets (or seeds for some legumes) on a very reduced area	• Areas formerly used for home garden products may become dedicated to fodder production, leading to a slight reduction in vegetables for self-consumption
• It allows for direct control of the transplanting time, at the most suitable moment for the farmer	• The nursery must absolutely be protected from open-grazing, to avoid the risk of losing all plantlets at once
• Survival rates for the plantlets are very high after transplantation	• Slips require wet soil for seedling establishment or germination, at least during the first 2 months

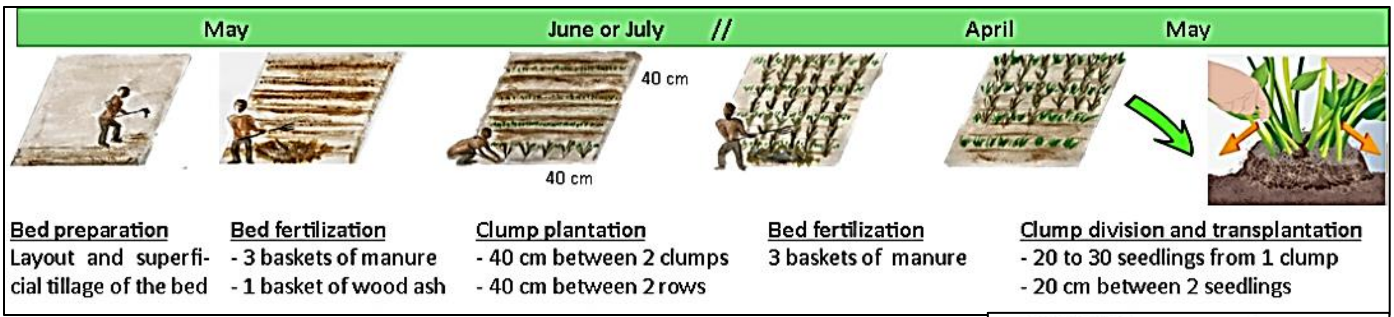
From the backyard nursery to the field: illustrations

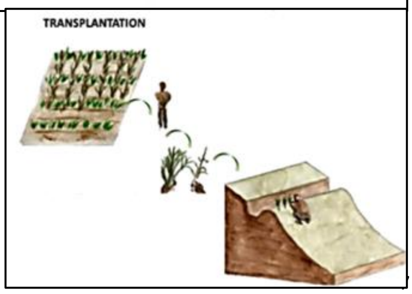
The combination of farm based micro-nurseries and fodder integration on anti-erosive structures appeared as a key innovative solution for the families. Farmers generally start to practice the multiplication and the cultivation of fodder grasses on very small plots, essentially to transplant the seedlings on anti-erosive structures, but, rapidly realizing the benefits of integrating fodder within the farm, and the given possibility to autonomously control the multiplication of the grass, most farmers have extended fodder production to new areas: along hedges, on farms' contours, and even on dedicated small areas within their farm to develop permanent fodder plots.

The following pictures illustrate different possibilities of fodder integration inside the farm, contributing to increased fodder resources while preserving soil and fertility. The farm-based nursery is usually set up close to the "tukul" (house). It is represented in the green circle. (source: Inter Aide)



Below, a representation of the farming calendar for the multiplication of planting material in backyard nurseries, before transplantation on the field, 6 to 12 months after (source: Inter Aide)





b. Building and vegetating erosion control structures with grass and legumes

The proposed solutions to physically control erosion are mainly vegetated soil bunds or fanya juu and/or fodder grass strips, whereas cut-off drains (upstream of the land), and simple check dams (on gullies) are rarer. Using "on-site material", those structures slow down the process of erosion while increasing water retention and progressively inducing a terracing of the land.

For the layout of the structures, Inter Aide relies on local referent farmers, who provide support to their peers in measuring and estimating the slope range, evaluating the number of rows needed and leveling out the structures. They also advise farmers for the construction work process, and are responsible for tools' distribution. Referent-farmers are trained and equipped by the project with some tools (level, rope, shovel…).

Technically, 3 people are required to measure the slope using the line level method, to determine the location of the rows, and to level out each row. More technical details can be found on Inter Aide's website: http://interaide.org/pratiques/Agriculture?language=en.

The time spent to build 10 m of anti-erosive structure varies from 5 to 10 hours, according to the number of people working and the type of soil. On average, **14 days are required for 1 farmer to construct 100 m of anti-erosive structures** and solve the problem of surface loss. Furthermore, most of the structures require maintenance several times during the first year after construction, especially during the rainy season. Maintenance work mainly consists in scraping the trenches out and shoveling the soil up on the bunds to reinforce them. **On average, 3 hours are needed to maintain 10 m during the first year** (5 days for 100m).

Then, to vegetate the soil bund with fodder species, farmers usually transplant their self-multiplied seedlings between April and June, depending on moisture availability. This is the optimal period for grasses to grow quickly and play their key role as soon as possible (i) to avoid too much maintenance of the bunds after heavy rains, and (ii) to get rapidly available feed for livestock. Once fodder seedlings are separated, they are planted on the top of the bund every 20cm. **The necessary time to plant 100m of soil bund is between 1 and 2 days**.

Diversifying fodder resources by associating grass and legumes

With the increasing pressure on land and on natural resources, providing a balanced feeding to livestock all year long remains a critical challenge for the majority of the small-scale farmers of Wolayta and Kembatta. Traditionally, during the dry season, farmers mainly rely on straw and Ensete ventricosum leaves. However, because of their low digestibility, crop residues remain in the rumen for a long time, limiting intake. Their other major limitation comes from the fact that they do not contain enough crude protein to support adequate microbial activity in the rumen. **Integrating diversified fodder production within the farming system presents various advantages and is well adapted to the cut-and-carry system**.

Inter Aide promotes the multiplication and diversification of 3 main types of fodder grasses (Pennisetum riparium, Elephant grass, and Bana grass), as well as 7 species of legumes (Cajanus Cajun, Pigeon pea, Sesbania sesban, Alfalfa, Desmodium, Vesce, Lupin, and Tree Lucerne). The association of high biomass productive grasses with nitrogen-fixing plants as high-protein forages can help supply balanced animal feeding.

Associated with different Pennisetum varieties, the project strongly promotes Pigeon Pea (Cajanus cajan) on the embankments as nitrogen-fixing, additional forage and a source of human food: 100 linear meters of structure bearing pigeon pea can produce annually more than 35 kg of peas.

Illustrations

By cropping fodder on soil bunds (here Pennisetum riparium and Cajanu cajan), with drought resistant varieties, farmers have some reserves to feed their livestock during the dry season or/and an alternative source of income. They can decide on the most appropriate time to harvest the fodder, and then use it or sell it directly.

The integration of fodder grass production helps increase food quantity and quality, especially during the dry season; however, legumes fodder plantation is still at an early stage of diffusion. The pictures below illustrate practical applications done by some farming families.

1: Desmodium associated with bana grass at a permanent forage cultivation plot; 2: Desmodium under a coffee tree; 3 and 4: integration of alfalfa in association with P. Riparium on soil bunds; 5: rehabilitation of degraded land with C. cajan; 6: vesce seeds production on anti-erosive structure for 7: green manure; 8: hedge of sesbania sesban with P. riparium

Cultivating fodder inside the farm, on arable lands, is a new practice in south-Ethiopia. Gradually, farmers have extended their fodder production besides the physical support of anti-erosive structures. Below, an illustration of a farmer who established a perennial fodder production plot associating Pennisetum riparium with Desmodium.

February 2014: preparation of the land and establishment of the fodder production plot

September 2015 (19 months after): the fodder has been collected 15 days before taking the picture

October 2015: the picture shows the fodder regrowth (1 month after the previous picture), at the end of the rainy season

On the left, this farmer in Boloso Sore district took some plants of Bana grass in his friend's farm located in a neighboring village, and then multiplied them himself. On the right, a large row of Elephant grass in Damot Sore district.

c. The key role of a traditional system "Iddir" to organize conservation measures and control open grazing

Controlling erosion in mountainous landscapes usually requires considering the entire watershed or at least part of it. The originality of the approach developed by Inter Aide in the southern Ethiopian context was to rely more on **coherent socio-geographical units**, according to *Iddirs'* locations, rather than purely focusing on geographic criteria.

Iddirs represent a traditional system of mutual aid, based on a regular membership fee in exchange for support at the time of funerals or hard blows. They are one of the only forms of authentic collective organization that can be found in rural Ethiopia, used to managing collective goods, fees and memberships, and having their own bylaws. They also benefit from a strong recognition and legitimacy: every farming family from every social class is member of an Iddir, and the management committee of the Iddir is directly selected by the members[8].

For more than 10 years, Iddirs have proven able to play a crucial role in implementing a collective management system of land protection against erosion at the scale of micro-watershed. Involved on a voluntary base (with no incentive), they have successfully handled fundamental activities:

- Mobilizing their members on the issue of soil erosion, fodder scarcity and climate change;
- Facilitating initial participative diagnosis with the farmers.
- Designing consistent protection work adapted to their specific geographical unit and monitoring its correct implementation;
- Supervising "referent farmers" who are trained and equipped to provide technical support to their neighbor peers;
- Identifying families facing workforce shortage (widow-headed houses with no assisting family members, sick and old people, young couples) and organizing assistance from the community to implement protection work in their farms;
- Managing common tools provided by the project for the construction and maintenance of the structures (distribution, check, inventories, replacement);
- Representing farmers and facilitating links with other stakeholders involved in land management: agents from the MoA, local authorities, neighbored Iddirs…;
- Negotiating and adopting specific rules in their bylaws to control open-grazing

Two elements deserve to be emphasized in the approach developed with the Iddirs:

- First, **the role of exchange visits to favor adoption**. It is an excellent opportunity for farmers to exchange knowledge with others, to better understand the processes and conditions of success, and overall to observe concrete results in similar farming situations (farm-based nurseries, vegetated structures and fodder integration in the farm, grass/legume associations, open-grazing control, ways to support vulnerable families…)

- Secondly, **the critical importance of rules, and their application, to control open-grazing.** Many grasses, such as most of the Pennisetum or legumes, do not survive if they are over-grazed. Open grazing is a common uncontrolled practice, conflicting with erosion control and fodder cropping. Animals impede grass regrowth, compete with cultivated fodder, prevent tree seedling development., and can severely damage the physical and biological anti-erosive structures. To help restrict open-grazing in their communities, Iddirs have defined, negotiated, and integrated adapted regulation in their own bylaws. This goes along with the Southern-Regional (SNNPR) Land Administration and Utilization Proclamation that stipulates that "in any type of rural land where soil and water conservation works have been undertaken, a system of free grazing shall be prohibited and a system of cut and carry feeding shall be gradually introduced".

  Beyond ensuring the durability of the vegetated structures, controlling open-grazing also gradually allowed the **introduction of new measures that contribute to restoring soil fertility**: the reintegration of straw (wheat are cut higher and straws are reincorporated in the fields, which is not possible with common grazing), the development of fodder hedges or alleys, the promising intercropping of green manure as "improved fallow" with species like Vesce, Lupin, Cow-pea...

[8] "Ethiopian Iddir mechanisms: A case study in pastoral communities of Wolayta and Kembatta-Tembaro", Thomas Léonard, 2014

E. Adoption and durability of the changes

a. Cumulated number of farmers having adopted soil conservation structures with fodder grasses

If a number of projects have focused on soil and water conservation, in parallel to improving crop and fodder production, few have considered the combination of conservation and biomass production as one of the opportunities offered by such a constrained and "anthropized" environment.

The first interventions combining soil conservation and fodder production started in 2005 in 2 districts of the southern region of Ethiopia. In 2012, the activities have been extended to 2 new districts, and the Ethiopian organization RCBDIA replicated a similar approach in 2 other new districts respectively in 2012 and 2013.

In 10 years, 13960 farmers have adopted the practice. They have constructed and vegetated a total of 2 067 km of anti-erosive structures (source: project database)**.** More soil bunds and fanya juu structures have been built but only those that have been vegetated with fodder production (grass and legume) have been taken into account.

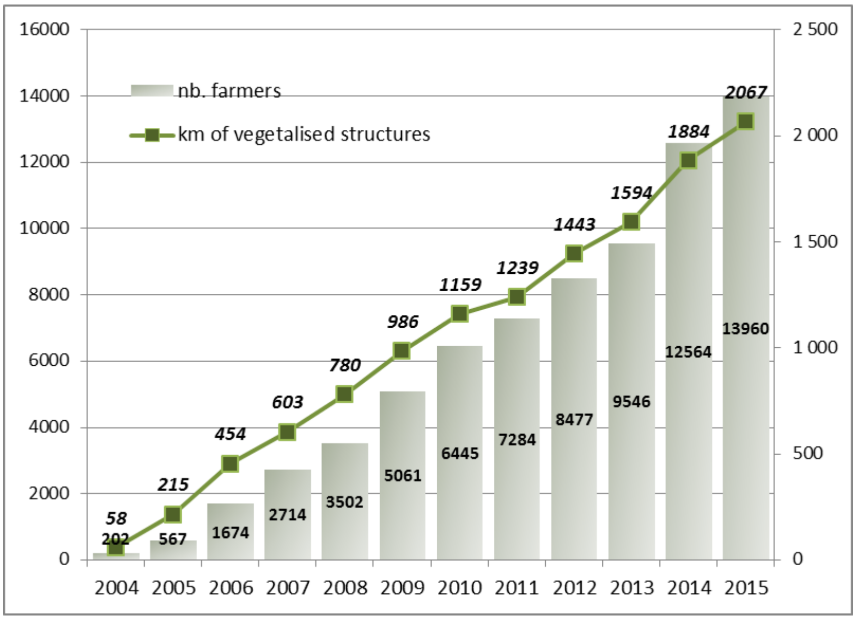


Chart 1: Cumulated number of farmers having adopted soil conservation structures with fodder grasses

b. Durability of the changes

In order to evaluate the durability of the adoption, an exhaustive assessment has been conducted within the frame of this study in 4 old "sub-watersheds" of intervention. In these communities, the objective was to compare the number of structures recorded at the end of the project presence and the current situation in order to evaluate if the farmers have maintained the practices or not. The obtained results were encouraging. For instance, in the village of Ajacho, where Inter Aide intervened between 2005 and 2008, 93% of the villagers have conserved their structures.

District / Kebele / village	Start year / end year	Total nb of families	% farmers with vegetated struct. at project end	% farmers with vegetated struct. in 2015
Kacha Bira / Burchana / Ajacho	2005 / 2008	72	99%	93%
Kacha Bira / Hobi Chaka / Yayama	2007 / 2008	80	93%	93%
Hadero / Hachacho / Geshame	2011 / 2012	102	75%	90%
Boloso Sore / Gununo / Dagecho	2012 / 2014	127	72%	80%

Table 2: durability of the changes, results of the evaluation conducted in 4 old project catchments

Village of Ajacho in Kacha Bira (April 2015), at the peak of the dry season. Ten years after the construction of the first structures with fodder (here Pennisetum riparium), the effect of the soil bunds counter-planted with grass (the ditches have now been refilled) on the terracing is visible.

F. Impact

a. Planting grass on anti-erosive structures increases the economic value of the field

Without considering the possible effects on soil fertility, **a field equipped with vegetated anti-erosive structures provides more income than without, despite the loss of surface caused by the structures**. This simple calculation was certainly the triggering effect for many farmers to invest time and energy into building the structure. The production of biomass on anti-erosive structures allows to significantly increase the gross value of the field:

- 1/4 of a hectare (50m x 50m) planted with wheat generates a gross income equivalent to 1600 to 2000 ETB for one season (corresponding to about 70 to 80 euros in 2015 with 1 euro = 22 ETB)[9].
- 2 rows of erosion control structures of 50m long by 2m wide (1m width for the ditch and 1m for the earthen bund) represent a loss of 8% of the cultivated plot, or an economic loss in production equivalent to 128 to 160 ETB.
- The production of fodder on these 2 earthen bund lines generates an average annual income of 1100 ETB, when sold directly on foot or on the market (3 cuttings per year, 2 in rainy season and 1 during dry season – data from field measurements and prices from the local market in 2015[10]).
- Bringing this yearly production to 6 months, the increase in the plot gross value can therefore be estimated at 20% per season.
- However, during the first year, the initial investment in terms of labour is important and require around 20 days of work (14 days to establish 100m of soil bund + 5 days for the maintenance during the first year + 1 to 2 days to plant the grass). As from the second year, the production is perennial and little labour, except for harvesting, is needed.

b. Measures of fodder production in 120 farms and estimation of its market value.

To evaluate average grass fodder productions per farmer, field measurements have been conducted in 120 farms in 3 villages in 2015 (randomly selected villages within the list of the villages targeted at least 3 years after the withdrawal of Inter Aide's intervention). All the surfaces dedicated to fodder grass production inside the farm have been measured and recorded. For each farmer, a classification into 3 categories was done based on objective indicators defined within the frame of agrarian studies[11]. It mainly relies on the number of animals (owned and shared) and the surface of the farm. From these field measurements, the results are as follows:

- Among the 120 farmers, 3 families were not producing grass fodder on their farm (2,5%)
- On average, farmers have built **171m² of structures with vegetative production.**
- The total **average grass fodder production is 303m²**, meaning that farmers have gradually increased their own production beyond the physical support of anti-erosive structures. 44% of the production in total comes from plots of the farmers' land other than vegetated anti-erosive structures: on dedicated perennial fodder production plots (18%), around the field (14%), at the foot of hedges (8%), under trees (3%).
- The last column in the table below indicates the financial return expected from grass sale per social category (yearly average fodder market value for 1m² of grass was 22ETB in 2015, corresponding to 1 euro). Not all farmers sell fodder (essentially vulnerable families). It represents the market value of the production if it would have been fully sold on the market. **On average, the grass fodder production value of a farm is 303 euros per year**. For vulnerable families, it represents 232 euros which is the equivalent of more than 100 days of daily work (1 day of seasonal work is paid locally between 1 and 2 euros).
- This data has been measured at least 3 years after planting the grass. All plants were thus well established and productive.

Type	Sample	Antierosive structures (m²)	Other: hedge, plots, around field… (m²)	Total (m²) (%)	Estimated value
Better-off	34	231	176	406	8937ETB (406€)
Intermediate	44	166	121	287	6313ETB (287€)
Vulnerable	39	124	107	232	5096ETB (232€)
Total	**117**	**171**	**133**	**303**	**6670 ETB (303€)**

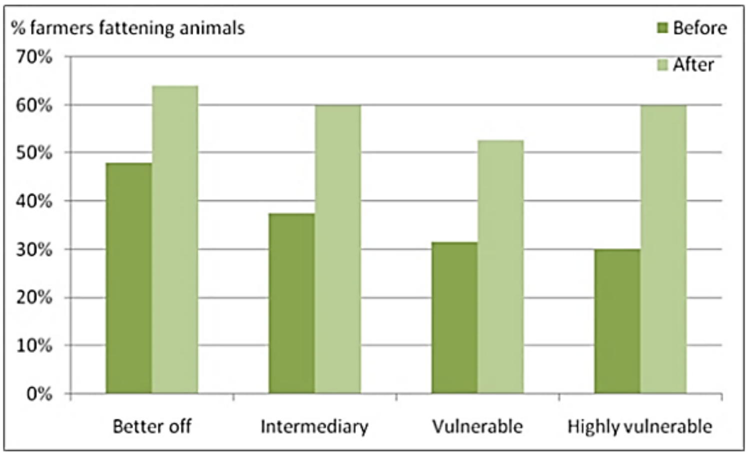
Table 3: Measure of the fodder production in 117 farms and estimation of the production's market value

[9] Updated data from the agrarian study conducted in 2011 in Doyo Gena Woreda (Aurélie Cheveau and Camille Hoornaert, AgroParisTech)
[10] The reference for the economical yearly value of fodder production is therefore set at 22 ETB per m² (1 €) or 11 ETB per linear meter (0.5 €).
[11] Aurélie Cheveau & Camille Hoornaert, Doyo Gena - May 2011

In addition to the quantitative field measurements, surveys have been exhaustively conducted in July and August 2015 among 381 farmers of 4 villages involved in the project at different stages (from 2005 until 2012). They underlined the following effects:

c. Effect on animal health and by-products

Chart 2: evolution of the percentages for animal fattening per social category



With fodder availability, animal fattening (mainly oxen) is becoming much more common: 39% of the farmers were involved in animal fattening before producing fodder, and 57% did so afterwards[12]. Cows and oxen are kept around 4 months; the average gross added value per animal was 2135 ETB and 2810 ETB respectively in 2015 (97 and 127 €).

67% of the interviewed farmers state that their animals are getting fatter and 65% also highlight an increase in milk quantity. However, the introduction of fodder cropping does not seem to have an impact on the number of animals owned. Fodder cropping has influenced the percentage of improved breed animals owned: on average, 21 % of the families have purchased one (or more) improved cow(s). In villages where cultivated fodder has been introduced 10 years ago, this percentage is higher with half of the families having invested in improved animal breeds. Milk production from Jersey or Holstein cows is on average 3 times higher than from traditional breeds (850 to 1460l/year for local breed and 2850 up to 4015l/year for Jersey and Holstein), but these animals require a higher quantity and quality feeding management than traditional breeds.

d. Reducing the burden for women and children to collect fodder

Women and children are traditionally mainly responsible for animal feeding and fodder harvest in targeted areas. Harvesting natural grass is a physically demanding and time-consuming task: the average time spent during the rainy season reach 4 hours per week, with a maximum of 12 hours per week. With the introduction of fodder within farmland, the average time spent on harvesting fodder comes close to 3 hours per week, with a maximum of 7 hours per week.

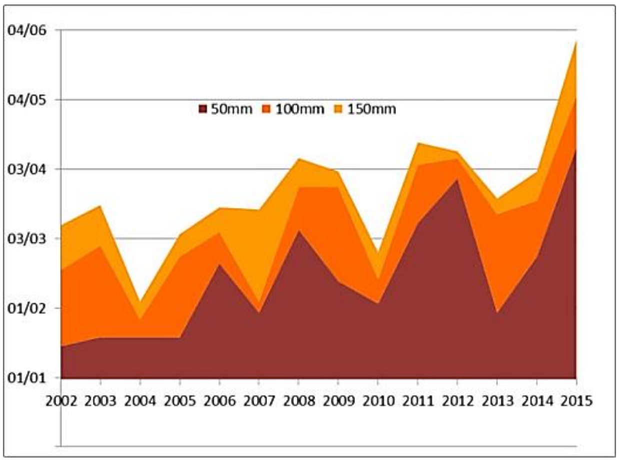
e. Attenuation of the climate change effects

To figure out possible effects of the climate change on the precipitations during the dry and the rainy season, an analysis of the last 14 years' daily rainfall data collected by Gununo research center (Wolayta Zone) has been performed within the frame of this study. Statistic tests (Kendal) did not confirm a significant trend on cumulated seasonal precipitations, or in the number of rainy days, or in the number of annual intense rainfall events (more than 20mm of precipitation per day) over the last 14 years. Those time series of data cover too short a period to reach significant variations. With available information, it is only possible to consider a progressively late arrival of the small rains in the region, without significant difference in terms of number of days or global amount of rains. This factor could nevertheless confirm that farmers are affected by climate changes mainly during the first cropping season (Belg), which is essential for their food security. Traditionally, the early harvests at the end of the small rainy season (Belg) mark the termination of the hunger and fodder gap after the dry season.

A later arrival of the small rains?

The mark of 50mm of cumulated rain seems to gradually occur at a later period in the year, as indicated by the following chart, which shows, for each year, the dates corresponding to the attainments of 3 cumulative thresholds of precipitation (50, 100 and 150mm).

Chart 3: attainments of 3 cumulative thresholds of precipitation (50, 100 and 150mm) for 14 consecutive years (data: daily rainfall record – Gununo Research Center (Wolayta Zone)



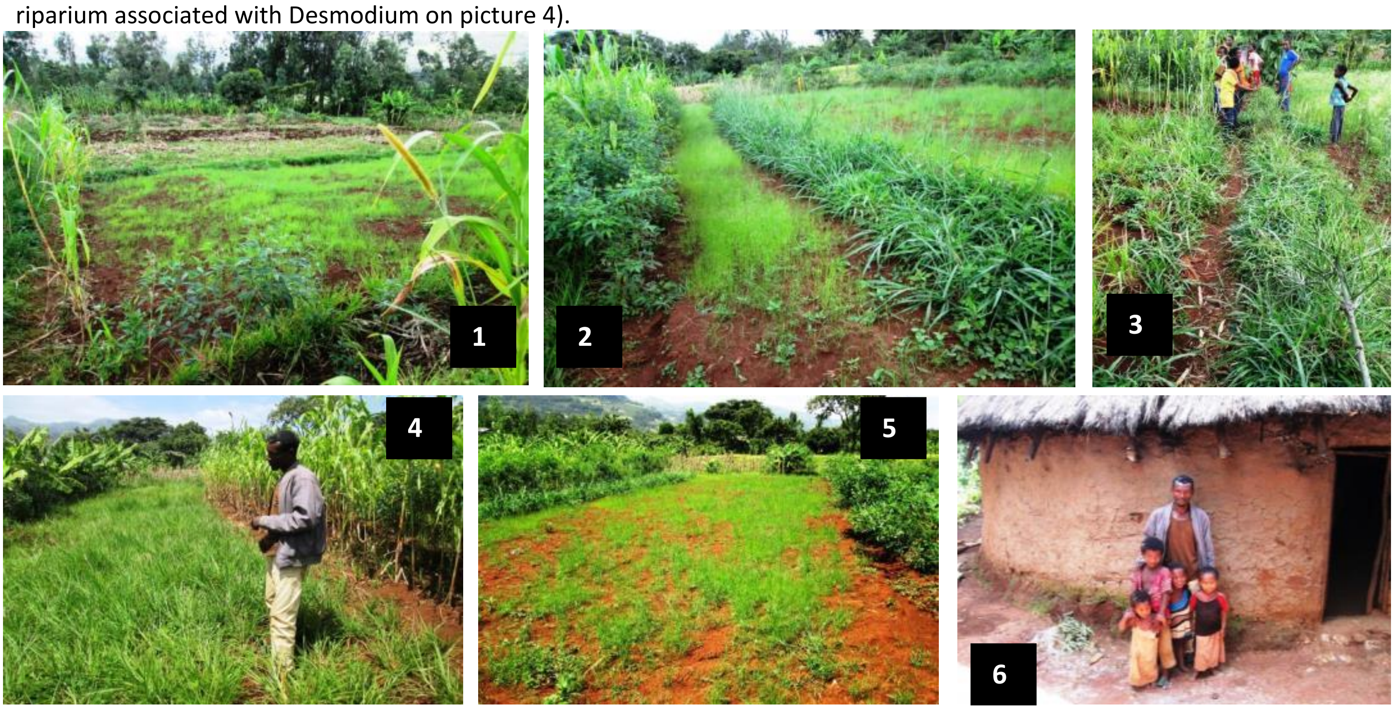
[12] Difference between the two percentages highly significant, with $p<0.001$

Measuring the impact of the vegetated structures on the soil and the moisture is beyond the scope of this study. The effects on mitigating the consequences of intense rainfall events on soil erosion or on better maintaining moisture are however well documented in the literature[13]. Beyond these probable effects, the integration of drought resistant grass and leguminous species on anti-erosive structures (like Pennisetum riparium, P. purperium, P. americanum, Cajanus cajan…) introduces new fodder and food resources that are particularly interesting during the critical time of the bridging period at the end of the dry season. For instance, the yearly production of 100 meter of Pennisetum riparium corresponds to 5700 kg of green fodder per year on average. This is the equivalent of 2 months of fodder to feed 2 animals of 250 kg. Letting the grass grow after the rainy season allows constituting a fodder reserve to address the dry period. Also, associating this grass with Cajanus cajan on the soil bunds provides an additional yearly production of peas of 35 kg on average, essentially harvested during the dry season. Cajanus cajan is produced after 6 months and can then be pruned and maintained as a perennial crop for 3 to 4 years.

Overall, in the particular context of southern Ethiopia, the availability of fodder during the dry season is to be related with the reduction of the use of the Ensete ventricosum leaves for animals, which is a crucial element for families' food security in the region. As mentioned above, Ensete ventricosum is a fundamental crop used by the farmers to overcome the bridging period in the region[14]. As for the families, Ensete is one of the rare farm resources remaining in the farm during the dry season. For animal diet, the fresh leaves are cut and mixed with the remaining straw, usually between October and May. The use of Ensete to feed animals directly competes with available food for family consumption, and Ensete depletion is a strong poverty marker[15]. With the introduction of cultivated fodder, 48% of interviewed farmers highlight the improvement of their Ensete plot, as the use for leaves and corms for animal feeding has decreased.

f. Vulnerable families:

Finally, the role of fodder as a cash crop seems particularly interesting for vulnerable families, who are much more likely than others to sell fodder. With the introduction of anti-erosive structure coupled with fodder production, those families get a new income source through the sale of fodder. The example of M. Feleke Dalecho in Hadero district (6), a farmer in a precarious situation due to an illness of 5 years, is quite indicative. Several structures to control erosion have been built by the farmer. Different fodder species (Bana grass, Pennisetum riparium, Cajanus cajan, Desmodium) have been integrated in the farm: 1 on the antierosive structures; 2 directly as pure fodder hedges; 3: along the paths surrounding the fields; 4 as permanent fodder production plot. Usually, due to the lack of animals and biomass, the soil fertility of these types of farms is relatively poor. Looking at the picture 4 and 5 taken in adjacent plots, it illustrates quite well the additional benefit fodder integration can represent as compared to cereals on degraded soils (here Teff on picture 5 and P riparium associated with Desmodium on picture 4).



[13] "Ways of Water: run-off, irrigation, drainage", Dupriez H., De Leener P.; "Participatory Evaluation of Different Multipurpose Grass Species for Graded Soil Bund Stabilization in Gimbo District, South West Ethiopia", Getahun Yakob1, Abiy Gebremicheal, Andualem Aklilu, Ermias Melaku
[14] The
"The tree Against Hunger, Enset-Based Agricultural Systems in Ethiopia", Steven A. Brand, Anita Spring, Clifton Hiebsch, J. Terrence McCabe, Endale Tabogie, Mulugeta Diro, Gizachew Wolde-Michael, Gebre Yntiso, Masayoshi Shigeta, and Shiferaw Tesfaye
[15] Alice Bortzmeyer: study of the home garden systems, Damot Sore Woreda, Wolayta (SNNPR), 2014

G. Conclusion

Identifying practices and innovations combining risk mitigation (soil and water conservation) and increased resilience strategies (management and storage of biomass), is what ultimately counts. The promising innovations are those that improve resilience. Today, the model is primarily based on the diffusion of a combination of practices, the promotion of biomass production, combining fodder grasses and leguminous species on anti-erosive embankments. It provides a direct response to animal fodder scarcity while contributing to maintaining soil and fertility in the long run. Moreover, today, fodder production represents one of the most important sources of short term cash for farming families. Poverty alleviation is therefore the main impact of this new practice in the southern Ethiopian context, as forage production generates a quick alternative income, facilitating access to livestock and organic manure. Rare enough to be stressed: this model allows income generation and economic improvement for all categories of farmers, including the most vulnerable.

Furthermore, improving resilience is also a strong effect of the innovation through different angles: i) fodder plant multiplication is managed by the farmers themselves in micro farm-based nurseries ii) 57% of the adopting farmers are involved in animal fattening as opposed to 39% before producing fodder iii) there is an integrated approach of the micro-watershed, not only as a geographical unit, but also as a socio-economic and bio-physical unit, aiming at a complete protection of the catchment and iv) the role of the traditional organisations "Iddirs" in enforcing anti-erosive measures, prohibiting open-grazing and coordinating the work at micro watershed level is fundamental for social acceptance and allows an important lever effect.

Improved resilience in turn facilitates adaptation to climatic change. Erratic rain patterns and late arrival of the rains in the Belg season (corresponding to the dry season) may affect food security through alternation of droughts and heavy rains. The introduction of cultivated fodder on embankments creates hedgerows which protects soil from drying. This phenomenon is also reinforced by the extension of the Ensete ventricosum plots, caused by the decrease in pressure on animal feeding, which in turn acts as a windbreak. Vegetated soil bunds slow down water speed and increase infiltration, reducing the leaching effect and retaining moisture longer.

Finally, the relevance of the innovation is testified by the 13 960 farmers who have adopted the practice and constructed and vegetated a total of 2 067 km of anti-erosive structures. The durability of the adoption has been measured in former operational sites, where 93% of the farmers had conserved their structures established 10 years ago.

Picture: overview of the conservation work carried out by the farmers of the sub-watershed of Lechecho, Hadero District, 2015