New technologies for water harvesting

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1

Basic Concepts of Water Harvesting

1.1 Introduction

For sub-Saharan Africa and Southern Asia alone there is an estimated *hiddenannual food gap of almost 400 million tons by the year 2020.*

According to a global IFPRI (International Food Policy Research Institute) study report, this is the food required above the total sum of projected domestic production and imports, to meet the energy needs of the population.

Hunger and poverty are thus predicted to remain a major problem especially in these two regions, both subject to “under nutrition climatology”. In these regions, a large proportion of the arable land is located in water scarce areas subject to recurrent dry spells.

Water stress caused by such short and recurrent periods of drought during crop growth is a major cause of yield reduction. In the past, misleading "blue water" analyses (focusing only on perennial river flow and accessible ground water) and drought assessments (focusing only on annual cumulative rainfall) have been used as arguments to rule out semi-arid tropical savannah agro ecosystems as potential bread baskets.

There are several problems with such conventional analyses. The majority of the land users in these areas depend on rainfall for their livelihoods (i.e. green water), not on irrigation based on blue water. In drought prone drylands there are problems both due to rainfall deficiencies (primarily due to poor temporal distribution of rainfall and high evaporation losses), soil problems as well as plant problems, the latter originating from dry spell damages and nutrient deficiency.

The green revolution clearly showed that well regulated crop water access is crucial for stable long-term yield increase. Not only because yield growth is directly related to plant water uptake, but also because secured crop water supply reduces risks for crop failure, thereby increasing farmers´ incentives to invest in farm inputs, such as fertilizers, hybrid seed and pest management. Even though irrigation plays a very important role in supplying foods, the potential for increasing water withdrawals for irrigation is considered quite limited.

Despite the higher risks of crop yield fluctuations in rainfed agriculture in drought prone areas, it is a safe assumption that the bulk of world food will also in a foreseeable future originate from rainfed agriculture. A significant gain in crop production in rainfed agriculture will therefore have to come from small scale harvesting of water in combination with protective irrigation.

Remarkable successes have in fact been witnessed in poverty stricken and drought prone areas in India. Research suggests that there is a *large window of opportunity* in terms of potential gains in crop yields that needs to be analyzed. This report provides an analysis of the problems and an identification of fundamental research needs.

1.2 Water Harvesting Systems

Water harvesting is applied in arid and semi-arid regions where rainfall is either not sufficient to sustain a good crop and pasture growth or where, due to the erratic nature of precipitation, the risk of crop failure is very high.

Water harvesting can significantly increase plant production in drought prone areas by concentrating the rainfall/runoff in parts of the total area. The intermittent character of rainfall and runoff and the ephemerality of floodwater flow requires some kind of storage.

There might be some kind of interim storage in tanks, cisterns or reservoirs or soil itself serves as a reservoir for a certain period of time.

Water harvesting is based on the utilization of surface runoff; therefore it requires runoff producing and runoff receiving areas. In most cases, with the exception of floodwater harvesting from far away catchments, water harvesting utilizes the rainfall from the same location or region.

It does not include its conveyance over long distances or its use after enriching the groundwater reservoir.

Rainfall is highly erratic, and most rain falls as intensive, often convective storms, with very high rainfall intensity and extreme spatial and temporal rainfall variability. The result is a very high risk for annual droughts and intra-seasonal dry spells.

The annual (seasonal) variation of rainfall can typically range from a low of 1/3 of the long term average to a high of approximately double the average; meaning that a high rain fally ear can have sometimes 6 higher.

This is why it is important to distinguish between droughts and dry spells. Anagricultural drought occurs when the cumulative plant available soil water is significantly lower than cumulative crop water requirements, i.e. there is absolute water scarcity.

While a meteorological drought is caused only due to climatic fluctuations, poor rain fall partitioning resulting in soil water scarcity in the root zone causes an agricultural drought.

Agricultural droughts can be man-made, due for example to poor land management resulting in low infiltration, low water holding capacity and poor plant water up take capacity. A dry spell occurs as short periods of water stress, often only a couple of weeks long, during crop growth.

Such short periods of water stress can have a serious effect on crop yields if occurring during water sensitive development stages like, e.g. during flowering.

The result is that productive green water flow as transpiration in general is reported to account for merely 15-30% of rainfall. The rest, between 70 – 85 %of rainfall, is “lost” from the cropping system as non-productive green water flow (assoil evaporation) and as blue water flow (deep percolation and surface runoff). Moreover, this scarcity is often human induced as a result of long-term land degradation.

In the commonly practiced subsistence farming systems, where traditional shifting cultivation practices have been abandoned in favour of continuous cultivation without any external inputs of fertilization, the productive green water flow component can be even lower.

The "lost" water would be sufficient to produce 4-5 reasonable crop yields (assuming roughly 100 mm of transpiration flow for a grain yield of 700-1000 kg ha), if the totality was allocated as plant transpiration.

The above indicates that major biophysical problems encountered in semi-arid farming systems are:

1. a poor distribution of the rainfall resulting in short periods of crop water stress, and
2. soil structural constraints (crusting and compaction) and poor so il fertility.

So il fertility and water constraints are closely related. Plant nutrient deficits result in a very sparse canopy cover and a weak root system, which in turn means that the crop is unable to take advantage of the available soil water during the periods of sufficient rain fall.

Statistically in a semi-arid region, severe crop reductions caused by a dry spell occur 1-2 t i m e s , out of 5 years, and total crop failure caused by annual droughts once every 10 years. Short dry spells resulting in crop water stress over periods of 2-4 weeks, occur almost every rainy season, negatively affecting crop growth. This means that the poor distribution of rain fall over time often constitutes amore common cause for crop failure than absolute water scarcity due to low cumulative annual rain fall.

Hydro-climatic deficiencies set the boundary conditions of potential yields, and are manifested as low cumulative rain, meteorological droughts and dry spells. Soil deficiencies are manifested by low soil infiltrability and poor water holding capacity of the soil. Plant deficiencies are manifested by poor plant water uptake capacity, due to weakly developed roots and canopies, in turn related to, e.g. soil nutrient deficiencies.

The potential lyield for a given crop and hydro-climate (assuming no deficiencies) is largely determined by climatic factors like radiation and temperature. The maximum yield is achieved when the deficiencies above are reduced to a minimum for a given crop and agro-ecological setting.

But, farmers generally do not harvest maximum yields, but are submitted to the reality of biophysical deficiencies (determining what can be produced) and they are constrained by socio-economic opportunities (determining what will be produced).

"Runoff farming" is identical with "Water Harvesting, but for Irrigation Purposes".

When the harvested runoff water from un-cropped areas is directed to a cropped area, this technique is called *runoff farming*.

Soil profile acts as a water storage container, but storage in ponds or cistern sisal so feasible. Factors affecting the capacity of soil storage are: depth of the soil profile, depth of plant roots, texture, structure, infiltration rate and the water holding capacity of the soil. The catchment to field ratio can range from 1:1 and from 1: many square kilometers. The higher the aridity of an area, the largeris there quired catchment area in relation to the cropping area for the same water yield.

There are two major forms:

-in situ *rainwater harvesting*, collecting the rainfall on the surface where it falls, and

-*external water harvesting*, collecting runoff originating from rain fall over a surface elsewhere.

In order to enable supply of harvested surface runoff flow according to human needs over time, storage is inevitable, which can be done in various types of surface and sub-surface storage systems.

1.3 Classification of runoff farming water harvesting techniques

Two run off farming water harvesting groups are generally recognized:

1. rain water harvesting;
2. flood water harvesting.

Rainwater harvesting can be further divided into:

I. micro-catchments, and
II. macro-catchments run off farming types.

Flood water harvesting can also be divided into two

I. with in streambed and
II. through diversion run off farming types.

Micro-catchments run off farming is a method of collecting surface run off from a small catchments area and storing it in the root zone of anadjacent infiltration area.

Macro-catchments run off farming (catchment area being 1,000m^2-200ha) the system is referred to "run off farming water harvesting from long slopes", as "medium-sized catchment water harvesting" or as "harvesting from external catchment systems".

Run off farming with flood water harvesting comprises a systems with catchments being many square kilometers in size, from which run off water flows through a major *wadi* (bed of anephemeral stream or river); the water is forced to infiltrate and the wetted area can be used for agriculture or pasture improvement.

Run off farming requires relatively large labor inputs and land. Low- cost efficient use of run off farming in arid zones for food and fuel production could help to restore self sufficiency in food production for local populations in many dry regions.

Run off farming has proved to be a valuable tool especially in dry marginal areas to increase crop yields and reduce cropping risk, to improve pasture growth, to boost re-afforestation, to allow a higher degree of food production, to fight soil erosion, to make best use of available water resources, to suppress soil salinity and to recharge the local groundwater.

1.4 The adoption of water harvesting systems

➢ *Biophysical and socio-economic criteria*

A critical characteristic of water harvesting is that even though each system can be applied in many different landscapes and societies (e.g. the principle concept of capturing gully flow for storage in tanks being generic), the way each system is designed and constructed is site specific (construction material, size, water extraction method, etc.).

This means that a successful technology at one site only with great care and most probably after thorough modification can be transferred to another location with different physical and/or social setting.

Some basic criteria determining the potential for different WH systems are:

- Hydro-climatic setting (rainfall, potential evapo-transpiration)
- Rainfall partitioning (the actual production of surface run off flows)
- Physical characteristics of catchment area (run-on areas, gullies, rills, roads, etc.)
- Soil types
- Soil depth
- Slope (most water harvesting methods are suitable only if slopes < 5%)
- Water demand (crops, animals, humans)
- Water quality (salinity, sodicity of harvested water as a result ofleaching
- Socio-economic setting
- Risk minimization achieved by water harvesting
- Cost/benefit and payoff
- Land tenure and availability ofland possibilities of using gravity-fed water supply (depending on the spatial location of WH components)

➢ ***Up-scaling of water harvesting systems to a water shed scale***

Our conclusion is that the few attempts of studying the biophysical and socio-economic implications of water harvesting systems have primarily been carried out on field scale, studying the functioning of individual technologies.

A large remaining challenge is to analyze the potential and the implications of up-scaling of water harvesting on a watershed and/or community scale. Based on the research discussed above on criteria determining the viability of WH implementation, the first spatial question to answer (that at present is unanswered) is to what extent various water harvesting technologies actually can be up-scaled.

For example, given the criteria required for successful implementation of earth dam reservoirs for gravity-fed supplemental irrigation, what proportion of farmers in a certain region can actually benefit from such systems, given the biophysical limitations involved? Similar spatial question shave to be raised for the full set of WH systems (in-situ systems, runoff farming systems, flood WH systems, and storage systems).

For the application of the harvested water there is a differentiation between supplemental or protective irrigation which is linked to a storage component and involves application of water to the crop a few times during the crop season, and run off farming which involves direct diversion of overland surface water flow onto the field. The method of application differs according to the monetary investments linked to it. Run off collection may involve land alterations, soil compaction etc.,to in crease the run off from the area.

The disadvantages of MIRF WH systems are:

*The catchment uses potentially arable land (exception: steep slopes)
*The catchment area has to be maintained, i.e.kept free of vegetation which requires a relatively high labor input.
*If over topping takes place during exceptionally heavy rainstorms, the systems may be irrevocably damaged.
*Low crop density, low yield in comparison with other irrigation methods.

1.5 Macro-catchments run off farming water harvesting (MARF WH) system

Macro-catchments run off farming (catchments area being 1,000 m^2- 200 ha) system is referred to by some authors as "run off farming water harvesting from long slopes", as "medium-sized catchments water harvesting "oras" harvesting from external catchments systems".
It is characterized by as:

*ACCR (Catchment to the Cropping area Ratio) of 10:1 o 100:1; the catchments being located out side the arable areas.
* The predominance of turbulent run off and channel flow of the catchment water in comparis on with sheet or rill flow of micro-catchments.
*The partial area contribution phenomenon which is not relevant for micro-catchments.
*The catchments area may have an inclination of 5 to 50%; the cropping area is either terraced or located in flatter rain.

1.6 *Runoff farming water harvesting*

- *New developments*

During recent years some technological developments took place in regard to run off farming water harvesting which might have some impact on the future role of run off farming water harvesting in general:

(1) Supplemental water system:

Run off water is collected and stored off side for later application to the cropped area using some irrigation method. The water stored allows a prolongation of the cropping season or a second crop.

(2)Dual purpose systems:

Ina dual purpose system the run off water flows first through the crop area, then the excess water is stored in some facility for later irrigation use.
Some time run off irrigation is combined e.g. with trickle irrigation, using sealed soil surfaces to in crease run off rates.

(3) Combined systems:

If the irrigation water from aquifers or from rivers/reservoirs is not sufficient for year-round irrigation, a combination with run off-irrigation (during the rainy season) is feasible.

- *Future prospects for run off farming water harvesting system*

Water harvesting for run off farming has the potential in some regions t improve rain-fed crop yields, and can provide farmers with improved water availability and increased soil fertility in some local and regional ecosystems, as well as environmental benefits through reduced soil erosion.

All the run off farming water harvesting techniques have the advantage to increase the amount of water available for agricultural and other purposes, and to ease water scarcity in arid and semi-arid areas.

They require relatively low input and, if planned and managed properly, can contribute to the sustainable use of the precious resource water. There sults of traditional irrigation methods are encouraging and should be promoted, but the methods described have to be supplemented by application techniques of high efficiency. All the engineering skills of scientists and practitioners area sked for to offer cheap and efficient supply systems.

The success of run off farming depends very much on rain fall and soil type. Run off irrigation is carried out mainly where the annual precipitation ranges between 300 and 500 mm. It is possible, however, to employ this method for areas where the rain fall is as low as 100 mm per annum and even if the rain fall is very erratic.

Investment in rain-fed areas, policy reform, and transfer of technology such as water harvesting runoff farming, require stronger partnerships between agricultural researchers and other agents.

1.7 Comments

Run off farming water harvesting has proved to be avaluable toole specially in dry marginal areas:

*to in crease crop yields and reduce cropping risk,
*to improve pasture growth,
*to boost re-afforestation,
*to allow a higher degree of food production,
*to fight soil erosion,
*to make best use of available water resources,
*to suppress soil salinity and to recharge ground water.

In comparison to former times, farmers today have to produce in a very different social and economic environment. Never the less, the positive elements of run off farming water harvesting remain valid and they can be used in future for the well-being of people in the dry areas of the world. Precondition is an adequate coverage of all technical, social, economic and environmental aspects of runoff farming water harvesting in planning and implementation.

2

The Vallerani system

2.1 Introduction

The Vallerani System (VS) is a relatively new system of water harvesting where a special tractor pulled plough is used to automatically construct water-harvesting catchments. This system is ideally suited for large-scale reclamation work. The Vallerani implement is a modified plough named “Dolphin”, pulled by a heavy-duty tractor. The Dolphin plough has a single reversible ploughshare that creates an angled furrow and piles up the excavated soil on the lower (downhill) side of the furrow.

This soil forms a ridge that stops or slows down runoff water as it flows downhill. The Vallerani System is intended for used with direct sowing of seeds of shrubs and trees. Seeds are sown along the ridges of the basins and in the wake of the ripper. With more moisture available for a longer period of time trees grow rapidly and the herbaceous cover improves in quality and in quantity - providing 20-30 times more livestock fodder (1,000-2,000kg dry herbaceous biomass ha/year), also helping to conserve the soil.

Synthetic Technical Details:

1. The plough’s blade moves up and down (i.e. in and out of the soil), creating micro-basins about 5 meters long, 50 cm deep and spaced about 2 m, each with a ridge.

2. Two rippers placed before the plough work the soil to a depth of 80 cm, allowing the micro-basin to be created by the plow blade.

The VS, named after its creator and producer, is a new approach to technical and socio-economic integrated management of human resources (optimization of manual work and participatory, reduction of heavy labor, environmental education) and natural (water, soil, resources of plants and animals) in arid and semi-arid regions of the planet.

It is a technical and mechanized multi-functional (agro-forestry-pastoral) treatment, or micro-accommodation surface of the soil, which - in these regions by introducing a form of cultivation intermediate between dry cropsand irrigation - can overcome both the insecurity and low productivity of dry crops and the many contra-indications of irrigated crops. Its application involves so many technical, socio-economic and environmentaladvantages.

On the technical side, the "system" allows for the collection / concentration of scarce resources still available (rainwater and runoff, fine surface soil and organic matter) in a series of trenches and micro-basins excavated by special plows . With this system it is possible to take action on large areas (1000-1500 ha / year for each UTM) and realize quickly - at minimal cost (+ US $ 40 / ha) - additional conservation of soil and water, as well as defense and restoration of soils, necessary and essential for the environmental rehabilitation and the implementation of sustainable crop development.

Thanks to the enormous increase in productivity achieved in relation to manual work (one machine does the work of about 2,000 men), the new technology, properly used, becomes a formidable accelerator and catalyst of development in arid regions. In addition to the increase of productive farmland and to the recovery of those abandoned, degraded or insufficiently exploited, the application of the system allows the direct seeding of forest species, being on effective practice in terms of technical and particularly good at educational and participative, since it transforms the actions of reforestation in a form of cultivation. In drier areas, finally, the application of the system can be combined advantageously with a micro-irrigation system fed by groundwater.

From a socio-economic mobilization and exploitation of energy and resources it allows to fight effectively against poverty, food insecurity and desertification in arid regions, and will implement a new agricultural revolution and ensuring at the same time better management of resources, the increase of agricultural production and environmental restoration and productive land. The ability to recover degraded and marginal lands, which constitute a potential important resource, but cannot be used with conventional techniques, it is also a very effective means to boost the development and oppose the rural exodus.

The economic effects of the system, which improves productivity and well-being of affected communities since the first crop season, are always positive and often exceptional. Its low operating cost corresponds in fact to a strong increase in yields and farm incomes. The result is a cost / benefit ratio particularly favorable (often greater than 1: 4), which puts the producers and / or rural communities interested in a position to take charge of a significant proportion of the costs of agricultural and rural development.

On the environmental level, this technology allows us to face and to put on the right track to solving most of the problems related to the three global UN Conventions and underlined by the Rio Conference (Biodiversity, Climate Change and Desertification), the severity of which will require more and more attention of world public opinion.
The intervention of the machines on large areas abandoned, run-down and in the process of desertification, makes it possible not only their recovery for production, but also their reforestation, minimizing manual labour more expensive and burdensome (preparation of soil and forest nurseries, transport of seedlings, transplanting and watering), while creating the necessary conditions for integrated resource management and sustainable development.

It therefore enables rural communities to devote an important part of their efforts - particularly during the dry season - to the light work and complementary land management, ranging from the collection of forestry seed the creation of hedges and windbreaks, and to the processing soil prior to the increase in agricultural production, planting of forests of the village and the improvement of pastures.

Among the greatest benefits from the use of this technology which allowed the regeneration of vegetation, and the naturalization of territory (with a strong increase in bio-mass), recharging groundwater and the preservation of natural ecosystems, which is the reverse of degradation processes and in the medium to long term, control of environmental factors. Particularly the new technology, easy to be introduced in rural areas, allows to address and correct the main problems for the development of the basis of the dry regions, which are:

- The lack of energy work and the lack of water;
- Inadequate erosion control and soil fertility;
- The lack of pastures and water points for livestock;
- The difficulties of reforestation and the increasing scarcity of firewood;
- The lack of environmental education.

Without overcoming these obstacles, it is virtually impossible to effectively combat environmental degradation and its inevitable consequences (increasingly scarce agricultural productivity, poverty, food insecurity, rural exodus, desertification, etc ...), which would continue to expand in space and time. The first of these obstacles (lack of energy work and the lack of water) is indeed the most important, because it determines the solution of all the others.

In addition to the environmental rehabilitation and production, the introduction of the "System", applied so far of about75,000 ha - mainly in the Sahel and Near East- allows finally to realize the integration / systems modernization of agro-forestry-pastoral (ASP) and the reorganization of the territories of the village.
This note refers in particular to the conditions of the Sahel, but with the necessary adaptations, this"System" is easily applicable in all arid and semi-arid regions of the planet.

2.2 The different types of plough

The manual techniques and traditional "water harvesting" - or collection of rainwater and runoff are able to realize a significant improvement in the productivity of the soils treated in arid and semi-arid. The effectiveness of these techniques has been recognized by all the agencies of cooperation, bilateral and international, which have encouraged the application and dissemination, especially in the Sahel region. Being based on manual labor, their impact has been weak production and low on 'environment.

Aware of the potential of these techniques, insufficiently exploited because of the weakness of human energy, Dr. Vallerani worked to mechanize and use over large areas and in the most varied soil conditions and morphology. This, in order to preserve and replenish the primary resources (water / soil / bio-mass) and boost the prospects for sustainable development in arid regions.

Very briefly, the number of machines developed by Dr. Vallerani includes:

I) the plow-type "Dolphin", which allows to dig trenches and micro-basins in the shape of a half-moon (12-20 units / min) - separate and linked only by the wake of the ripper. This special plow can be used on any type of soil - up to a slope compatible with the use of thetractor - and is particularly suited to the agro-forestry, reforestation and improvement of pastures;

II) the plow like "Treno", heavier than the first, which traces a furrow "pre-punched" (with 15-25 micro- basins / min) laying in the furrow, at regular intervals, and a surface layer of fertile soil collected by a blade. This plow works preferably not stony soils, plans or with gentle slope, along the contour lines, and is particularly suitable for the implementation of agro-food crops or agro-industrial, but is also valid for the agro- forestry, the planting of tree crops and the improvement of those used as fodder;

III) the special 3-tooth ripper "Scrabble", working the soil with a sinusoidal movement (15-20 waves / min), favoring the accumulation of rainwater in troughs of the wave; This car, driven by a caterpillar, is particularly suited to work the compacted and/or stonysoils, for the improvement of pastures and sowing / planting of trees or shrubs, in the slopes compatible with the use of the tractor.

IV) the seed drill injection "earthworm", conceived especially to favour - in arid regions - with the administration of a small amount of water (3-5 l) at the time of sowing - early germination of the seeds and the development of plants (shrubs and forest) even before the arrival of the first rains, that allows them to takethe best advantage of the short rainy season.

V) a number of manual and craft (fertilizer, seed tube, other tools), realized locally, that simplify and significantly increase productivity in manual operations and complementary following mechanical intervention.

The Technical Unit of Mechanization (UTM), which is the basic unit lighter and more manageable technology in question, should have the "know-how" and the following equipment:

a) Personal (or know-how corresponding)

- 1 specialist in Combating Desertification (SCD), senior agronomist or agro-forestry-pastoralist,expert in managing complex water / soil / biomass (WSB), connoisseur of traditional socio-economic systems and ensuring the best use of the machines for the various types of intervention and motivate its employees ON the importance of the work to be performed;
- 1 expert in agricultural mechanization, connoisseur of the machines of the "system", putting them inSHAPE and maintenance, as well as to train tractor drivers-mechanics;
- 3 tractor drivers-mechanics, with general knowledge of mechanics;
- Animators or advisers, to ensure a constant link between UTM (technical unit of mechanization) and rural communities concerned.

b) Technical equipment

- 1 wheeled tractor (or caterpillar) of 180 hp
- 1 plow "Dolphin", for treatment of most soils (heavy or light, slightlystony, with gradients of up to 25%, destined to agricultural crops or agro-forestry or reforestation or pasture improvement;

- 1 plow "Treno" for the treatment of floodplains and hard lands, characterized by aslight slope, especially suited to the agro-food or agro-industrial crops, including agro-forestry;
- 1 all terrain vehicle for the transport of persons;
- 1 all terrain vehicle to transport the material;
- Other equipment that may be necessary.

Given the working conditions, the condition of the materials, the need to avoid shutdowns and the minor impact of the purchase costs in relation to operating costs, in the interventions on a large scale the unit should be provided the UTM equipment as complete as possible .

New technology is applicable to a wide range of agro-ecological conditions and soil conditions, characterized by a rainfall of between 150 and 500 mm / year.
As a first approximation, the benefits of the application of the system, and the sectors and types of intervention are:

- A sharp increase in yields of agro-food; forestry and pastoral species, the recovery of marginal lands, degraded or abandoned, and the improvement of soil fertility in arid regions (by combating erosion, creating green belts of multi- functional trees and shrubs - windbreaks, village regreening, green belts, hedges and fences plants, etc ..);

- The conservative management of resources and the 'integration of systems of agro-silvo- pastoral (ASP) systems in regions with incompatible practices with sustainable development (by means of: accommodation agro-forestry, improvement and pasture management; redevelopment of "forets classées", protection of surface water points and rivers by ranges windbreaks or green belts);

- The redevelopment of the area in the framework of programs of sustainable and integrated rural development (with the recovery of the vegetation cover, the protection of natural ecosystems, actionsreforestation environmental and /or production);

- The fight against desertification (LCD) on a large scale, the protection of bio-diversity and agro-biodiversity and the balance of eco-systems, bio-climatic regions desertified and degraded by over-exploitation of resources - Sahel, MediterraneanBasin, Middle East,other arid regions (multiplication of seeds of plants - grasses, shrubs and trees - of particular interest for environmental restoration, for the improvement and upgrading of parks and nature reserves).

2.3 Socio-economic implications

- Socio-economic Compatibility

The new technology proves to be easily integrated into traditional production systems, within which introduces the factors of very dynamic development and renewal. With a participatory approach, it carries a transformation more or less accelerated and profound of these systems, leaving the affected communities the control of changes wanted and needed.

- Participation / Empowerment

The objectives sought and the types of possible intervention (increase crop yields, development of agro-forestry, reforestation and productive crops, windbreaks and hedges, accommodation anti-erosion of various types, improved pastures) must be examined and defined with the local populations, who remain free to apply them and adopt them, assuming the cost of which are nevertoo heavy. And it is possible to promote a massive and spontaneous participation of thepeople, who will understand perfectly –being so intuitive and pragmatic - the importance of the benefits resulting from its application.

The main interest is naturally directed more to the short-term benefits (increase in agri-food), than by the medium to long term, but in the present, increasingly difficult environmental situation, we see the growing of a significant sensitivity for actions of environmental restoration (reforestation and productive environment, etc.).

The new system so quickly acquires the role of a "locomotive technology", which affects all the processes of agricultural and rural development.
Such an important role should not overly affect the exercise of normal farming activities. The intervention of the plows, to be progressively extended to all cultivated areas, shouldin fact only it is carried out "one-off", being possible to farmers to restore with ease, by the use of hand tools, the efficiency of micro-basins.

- Appropriation of socio-cultural and education development

The full integration of this technology in the agricultural and rural world, both modern and traditional, is related to its use and dissemination and to the cost-benefit ratio obtained. In fact the farmers, although they cannot handle it directly, however could be able to bear much of the costs of intervention.
So its application allows participatory rural communities involved not only to become fully aware of the problems they face, but also to seize quickly thetechnical knowledge necessary to not repeat most serious mistakes in the management of renewable resources.

Applied correctly, and with a sufficient strategic vision, the introduction and spread of technology thus allows not only to reduce and minimize the risks of classical conventional development projects and programs - such as the precariousness of positive results and the return to back after the stopping of the external intervention - but also to lay the foundations for a development role of important private or semi-privateservice facilities.

Properly controlled and oriented, they can be rapidly placed in a position to self-manage themselves and to turn the critical mass of activities and initiatives which alone can set in motion a process of real development, what would restore confidence to the population and oxygen to the economies of developing countries , made asphyxiated by an ever more difficult and unsustainable.

2.4 The physical parameters

The following notes relate to the management of complex Water / Soil / Biomass (ASB)and parameters - physical and socio-economic - that characterize the Sahel region, where the "system" was born and found, so far, its wider application (with the necessary adjustments, the technology is applicable in all arid regions).

a) The rainfall

The "system" is based primarily on the collection and concentration of runoff surface formed by the rains. In these arid regions, the rains, irregular but intense, are collected on the surface in correspondence of the watersheds in runoff wild lines capable of eroding the soil and cause serious environmental damage. The erosion, both caused by water and wind, not infrequently assumes the appearance of a real calamity, susceptible of transforming fertile land surfaces in sterile areas

In fact, it is responsible not only for the loss of much of the rainwater, but also of the fertile layer and surface soil and organic matter that are lost and transported downstream.
The control and management of these waters can not only reduce the damage, but to conserve and use precious resources for development. It follows that the conservation of soil and water is the first priority of any serious program development.

The best application of the "system" is located between the rainfall ranging from 150 to 500 mm/year, but with pluviometricallevel below or above these values can be also used, according to the particular cases.
In arid regions the rains helpful, embodying runoff, generally exceed 10 mm of rain. Then it needs 2 or 3 important rains to allow the system to exert its full effect.
In the range between 100 and 250 mm / year, finally, and for rich crops (fruit trees, vegetables), the system may be associated with micro-irrigation (with groundwater), what, in addition to reducing the risk of salinization, allows the best possible use of available water resources.

The examination of the average rainfall of recent years is indispensable to decide - on the basis also of the nature of the soil to be treated - the right distance between the lines of the micro-basins. The results of the treatment will be better the more the initial options (distance between lines, the type of crop expected) have been made properly, and even in the case where it is necessary to provide for a second treatment, to be done in the second year.

b. Soils

Since the first limiting factor is the water, the application of the system gives proof of its efficacy on all types of soil. Their nature is however a very important factor. In the Sahel, erosion (water during the rainy season, wind during the dry season) impoverishes the farmland on the plains and on the slopes, and feeds the wetlands, rich in elements fertile but hard and difficult to work with tools of traditional work.

When the vegetation is reduced, the erosion progresses and the runoff also. The erosion of cultivated land, population pressure and the modernization of agricultural techniques thus inevitably push towards the cultivation of the flat, without necessarily appealing to irrigation, (expensive, often unhealthy, and difficult to manage in the arid tropical regions, especially African) and subject to a particularly high evapo-transpiration.

For the qualities application of the "System soils have to possess a depth and a sufficient structure, and must be free of large stones or dead roots, in order to allow both the intervention of plows (who can work up to 60 cm of depth) and the formation and collection of rain runoff. As for the physical characteristics of the soils, we refer here particularly to the soils of the Sahel, briefly examined on the basis of their morpho-soil.

- Lateritic plateau: poorly suitable, because too hard and difficult for the plows
- Soils of "glacis" suitable for processing
- Soils and sandy dune: poorly suited, because of high permeability
- Soils inter-dune: Suitable
- Sandy-loam soils: Suitable
- Soils of alluvial plains: Suitable

Soils, suitable intervention plows, including "glacis" and alluvial plains - fallow because they are too hard to work with hand - represent a variable, but certainly important, cropland and arable land in the Sahel. In addition to the expansion of production areas, the application of the "system" has always demonstrated - on virtually all types of soil - an increase in productivity and an improvement of the structure due to the contribution of organic matter. Given the importance of the role that the new technology has to play in the development of arid regions, and in order to develop a rational strategy for its practical use, it would be useful to provide - in the face of expected rates of population growth and needs agro-food (and on the basis of experience gained in various countries), a general inventory of soil resources that respond better to the mechanical treatment, as well as their potential agro-forestry-pastoral development.

c) The vegetation cover

The environmental restoration tends to restore plant cover sufficient, necessary and essential condition for ensuring sustainable development.
One of the first activities to be carried out is therefore the collection of seeds of tree species, to be made over the vesting period of the same and on the basis of the required quantities (20 seeds per half-moon-type "Dolphin"). These must be cleansed, stored and processed before being sown. The preservation of seeds should be done under the best conditions, so that their power of germination is maintained. The empirical system of conservation in the ash is valid when applied immediately after theircollection, before the attack of pests.

The growth potential linked to the use of this technology will stimulate a deepening of the botanical studies of all plant species potentially useful for accommodation agro-forestry, the hedges, the ranges windbreaks, etc .., as well as the revitalization of Overall Water / Soil / Bio-mass (WSB) and the implementation of agro-ecosystems stable and long-term.

2.5The application of technology to the three production systems

The introduction of the "system" in rural areas must not create an excessive dependence of farmers. In this respect, it is necessary that the treatment of the soil (or the digging of a mechanical micro-basins) bothdesigned and built - to the extent possible - as an intervention "one-off", to be performed only once on the same land, and that farmers are in a position later - through instruments appropriate manuals (hoes, shovels and rakes) - to ensure themselves the maintenance of micro-basins.

On the basis of knowledge and application of good agricultural and rules of proper management of the complex Water / Soil Bio-mass (ASB), the introduction of this technology does not involve anycontraindication.
We see now, in summary, the condition of application of this technology to three production systems.

a) Agriculture and agro-forestry

The agricultural sector is of course a priority. The intervention of special plows on cultivated land does not have to respect the limits ownership of household plots. Therefore, when the parcels are too small, the mechanical intervention can them cross the limits without problems (the tractor driver raises the blade of the plow), to treat more parcels at the same time. The alignment of the micro-basins, or the orientation of the working lines, must be more or less perpendicular to the slope of the soil - so as to allow the best water collection in the sliding surface. The treatment of the soil, to be carried out in dry and before rains, does not require a topographical survey, but only the indication of the surface to be treated, that a good driver can work in a more satisfactory manner.

The distance between the lines of micro-basins depends on two main parameters: the nature and permeability of the soils and the average rainfall in the area of intervention.
With an average rainfall of 300 mm / year and an average of permeable ground, the distance to be observed is of the order of 3 meters, which is likely to raise about 1,850 liters of water per half-moon. With a smaller rainfall - or a more permeable soil - this distance can be increased up to 2 times (6.5 m).

To better assess the relationship between average rainfall and distance between lines, it is considered - to simplify - that the water collected by the micro-basins is constituted by the rain falling directly on the micro-basins, plus 50% of those which fall on the interlinear areas(water slide).

In agriculture, the treatment of cultivated land should preferably be followed by the implementation of accommodation agro-forestry, necessary to protect crops, enriching the soil and reduce the evapo-transpiration. In this regard, it should be noted the particular importance of Acacia Albida for farmland Sahel, on a scale that goes from 80 to 40 plants / ha, according to the distribution and the age of the plants.

b) Breeding and pasture management

The introduction of the system in this sector contributes not only to increase and improve significantly the amount of bio-mass forage, but also to put in place an effective system ofpasture management. In the Sahel, the maturation of the forage essences occurs one to two months after the end of the rains. In order to collect the micro-basins a large amount of seeds - with plant remains and other organic matter - and thus improve the production in the following years, the intervention of the plows in the areas of pasture can begin very soon, as early as the month December / January.

On the other hand, to reduce the winds and the evapo-transpiration, pasture improvement should include, in addition to the regeneration of forage species, the introduction and spread of species and better varieties and planting of trees and shrubs as of windbreaks.

The Vallerani system has been able to contribute significantly to the qualitative and quantitative improvement of the bio-mass forage in arid countries and of consequence to the increase of livestockproductivity. However, the farmers understand that they cannot indefinitely increase the load of cattle. In fact, if the improvement of pastures were not accompanied by a population control measures in animals, this would only increase over time the problems and shifted periodic problems of the plants bio-mass and animals.

Since it is not possible to intervent in an authoritarian manner on the farmers, the only real possibility to reduce the pressure on pastures is to introduce, along with their improvement, management principles based on the retention and rotation of pastures themselves. Hence the priority of the fences (or hedges), so far unsolved problem technically in the Sahel, but not difficult to resolve with the application of this new technology.

All efforts should therefore be put in place to raise awareness among farmers and make them understand the importance of this issue.

c) Reforestation and forestry

The first form of reforestation is the re-greening of the village, to be carried out near the village, if possible in watersheds not used for agricultural purposes, to allow rapid growth of the trees. The choice of essences, the distance between the lines and the use of wood, are to be done in agreement with the communities involved and on the basis of rational criteria and standards coppicing (training must be provided in this regard). Germination of the seeds must be checked before the start of field operations.

To facilitate the germination of seeds, in particular those fitted with cuticle hard and resistant, it is necessary to scarify (but do not boil, or treated with acids) at least 1/3 of the seeds. The reforestation will be made by direct seeding, and the whole community will have to ensure, for at least two years, maintenance, monitoring and protection of plantations from animals00. A rational approach minimizes the effort and expenditure in terms of physical, economic, and time.

The application of the "system" aims to implement and strengthen the natural mechanisms of vegetative propagation of plants. As close and during the rainy season the farmers are engaged full-time with the farm work, the actions of reforestation must be made in full dry season, following what are the natural mechanisms of plant propagation. The sowing of the seeds of forestry crops will therefore be carried in the micro-basins after treatment of the soil, or in dry, by means of pipes inseminators, to a depth of about 10 cm, to avoid that the excess water can, with the arrival of the rains, damaging the seeds.

For the reforestation of large areas not sufficiently populated, or where there is a lack of manpower, it is also possible to provide a semi-mechanical sowing, which must be made together with working the soil. The plantations arising from direct sowing not require more water, since the seeds remain dormant until the arrival of rains, and the water collected by the micro-basins is largely sufficient to cover the water requirements of the young plants for the duration of thenext dry season.

Depending on the characteristics sought (growth rate, water needs, quality of timber - Firewood and from work - defense against animals and winds, provided fodder for the dry season), many tree species can be considered for the reforestation of the villages agroforestry. The actions of reforestation must still be conducted in a participatory manner.
In addition to allowing the rapid reforestation of large areas, direct seeding of trees and shrubs is the propagation system more economical, educational and effective, because it promotes the developmentof deep root systems and better plant resistance to drought. It should be emphasizedthe preferential use of the native plant species and the local ecotypes, the most appropriate to ensure the recovery of the vegetation cover and the environmental education of the people, who, motivated by the effectiveness and productivity of the system shall be brought to participate in the actions of reforestation.

The disappearance of the tree line at latitudes north of the Sahel, caused mainly by the need for firewood, it has reached the point that the population of these regions are using animal waste as fuel for cooking. This fact is serious, also because the disappearance of the seed producing plants prevents any possibility of spontaneous regeneration. The new technology allows to meet this problem by developing accommodation forestry and pastoral, and by means of specific interventions - to the level of the water points and watersheds - in agreement with the breeders.

The operations of land can be divided into three phases (preparatory actions, work the soil and plant cultivation), to be planned with local communities and lead with a participatory way:

- **1stPhase** - Preparatory actions (Seeds)

. collection of seeds
. drying / sorting, storage and preservation of seeds
. germination tests and pre-sowing treatment
- **2ndPhase** - The processing of the soil
. Mechanical excavation of micro-basins
- **3rdPhase** - The cultural practices
. Drill Manual or mechanical (pre-germination is possible in the arid areas)
. manual weeding
. maintenance, monitoring of plantations and protection of animals in an aside (P)

d) The traditional land tenure and improving land

The traditional land tenure is sometimes an obstacle to the management of the territory and its resources, which are essential for the implementation of sustainable development. Since the redevelopment and reorganization of the territories of the village in any case require a profound transformation, and the reconstitution of an adequate vegetation cover, we need to find adequate responses to these kinds of constraints, which, in the name of rights (management, exploitation and usufruct) now clearly outdated, sets limits to the positive transformation of the environment - such as the planting of trees - and therefore the possibility of development.

2.6Technical features of special plows and other equipment of Vallerani System

The VS aims at the arrangement and restoration of the production potential of arid regions, as well as to the stabilization of their populations, combining the mechanical treatment of the soil (micro-accommodation) with the development of the area by the population concerned, by means also of complementary techniques , simple and manuals.

This technology has a number of special machines, the main of which are two:
- The plow like "Delfino", digging machine of micro-basins in the form of semi-moon, and
- The plow like "Treno", digging furrows continuous divided;
The use of these plows, which requires a tractor of about 180 HP, allowing recovery of large areas of marginal land, abandoned or under exploited.

Particularly suited to the conditions of the Sahel, this system rests on the basic principles include:
- The collection and concentration - within the micro-basins (half-moons, furrows diaframmati), which remain active for several years - runoff (the fine earth and theorganic substance), which creates the most favorable condition for seed germination and vegetative growth of the plants;
- The direct sowing of seeds of tree and shrub species to the local level of the micro-basins.

➢ ***Dolphin* type**

Especially conceived for mechanical excavation of the half-moons, this machine is a plow monovomere led, non-reversible (Mod. 50 MI / CM), equipped with a ripper, a knife, a hydraulic pump and a lifting device.

It includes two parts:
- A fixed directly to the tractor - fitted with a ripper and other technical tools to improve the working of the soil;
- The other furniture - which constitues the plow proper - with a plow, a moldboard and two side wings.

This plow is particularly suitable for the recovery of the agricultural lands of "glacis", and for actions of reforestation and improvement of pastures. It can be used on heavy soils, clay or sandy-loamy, from compact to very compact, but also on sandy-loam soils, provided they have sufficient depth, whose slope-limit is represented by the possibility of the tractor (wheeled or tracked).
The working of the soil includes a furrow of ripper deep and the excavation of micro-basins in the form of semi-moon, of a length of 5 - 7 m. The moldboard down the ground to the right of the half-moon. This system allows not only to work in deep soil hardened and not exploitable by traditional means, but to capture the surface runoff and promote recharge of groundwater over large areas (as evidenced by Projet agro-sylvo-pastoral
/ PASP of GTZ in Niger).

To understand the importance of technological innovation represented by this machine, consider that the practical manual of "water harvesting", whose usefulness has always been recognized, permit the construction of no more than 3-4 semi-lunes / day / man , with all the limitations related to this transaction (poor availability of manpower, financial means, of technical support and logistics; transplantation of seedlings from nursery also presents a series of drawbacks, such as the irregular development of the root system and the tap root, which causes a lower resistance of plants to drought).
With this special plow, instead, it is possible to dig from 5.000 à 10.000 semi-lunes / day (at the rate of 10-15 semi-lune / minute), which corresponds to a surface arranged to 10-20 ha/day - from 5.00 x 0.5 x 0.50 m, (or 1.35 cubic meters of volume of earth excavated) with an average capacity of the collection and storage of water much higher than those of the half-moons manuals .

Technical data
- Characteristics of the tractor
. Power: 180 hp
. attacks of second category
. outlet unipolar current 12 VDC for the propeller radiator
. auxiliary distributor double-acting for the lifting ploughshare
. PTO shaft to 1000 rev / min for central control hydraulic
- Type of work: packaging of micro-basins (half-moons)
. width: 40 to 60 cm
. length: 5-7 m
. depth: 50-60 cm
. furrow over the bottom: 15-25 cm
. distance programmable line: 2.1 m
. distance between lines: 3.6 m (depending on rainfall)

. average size of a half-moon: 2.50 m2 (0.50 x 5m)

- ***Treno* type**

This machine, especially conceived for the excavation of continuous furrows, is a reversible plow monovomere brought (Mod. 130-119 POR MZ / RCM), equipped with a ripper tooth, with a hydraulic device for the inversion of the ploughshare and a collection device of the fertile layer of soil, which is deposited in the furrow.

As the plow "Dolphin", it allows for working at two levels, with a deep furrow ripper and packaging of micro-basins, but enhances better - with alternating furrows - scarce resources (water and soil) remaining regions arid and semi-arid.
It is particularly suitable for agro-forestry-pastoral interventions on flat lands consist of heavy and compact soils (alluvial) or gently sloping, and for the development of agro crops slimentary or agro-industrial, and has an operational capacity superior to that of the plow "Dolphin".

Technical data
- Characteristics of the tractor
. Power: 180 hp
. attacks of second or third category
. unipolar socket of current at 12 VDC for the propeller of the radiator
. auxiliary valve double acting for renversement coulter
. shaft PTO 1000 rpm / min for the control of oleodynamic

- Type of work: pack of furrows diaframmati
. width: 60 cm
. length: 4-5 m
. depth: 50-60 cm
. sous-Solage over the bottom: 15-25 cm
. number of micro-basins par 100 m: 18 (optimum)
. distance between lines: 3.6 m (depending on rainfall) (see Tab. All. VIII)
. average size of a micro-basin: 3.0 m2 (0.60 x 5m)

For a distance of 4 m, the number of rows / ha is 25 and the micro-basins of approximately 450 In general, limits to the use of the plow are related to the depth of the soil and the absence of strains and rocky outcrops. In this regard, investigations must be carried out by technicians to ensure the conditions for use plows before starting work.

- ***Scrabble* special ripper**

This machine, particularly suitable for the improvement of natural pastures and their subsequent transformation into improved pasture, is constituted by a sturdy frame on which are appli-ed three teeth, of which the central one is longer than the side of about 30 cm. The ingress of workers in the

soil is characterized by a movement undulate, in which the central body works between 80 and 50 cm depth and the side bodies between 50 and 20 cm.
The special ripper allows you to improve and remediate soils and stony hard for the retention of runoff into the soil; an indicator indicates the point of maximum depth of the teeth of the ripper, where one has the greatest accumulation of water, in order to allow sowing in correspondence of that point.

- ***Earthworm* special drills**

Equipped with a portable tank and a special injector, to enter small amounts of water into the soil, this drill is intended to allow, in arid regions, the early germination of the seeds of trees and / or shrubs planted in dry, as well as the development of seedlings, even before the arrival of the rains.
Thanks to the early development of the root system and growing, young plants have the advantage to take full advantage of the short rainy season, which ensures the
further development of the plants. One of the most useful applications of this tool is, in
association with the plow train, the creation of hedges for the protection (by animals in an aside) of cultivated fields and young forest plantations and agro-forestry, the disclosure of which is essential for an effective fight against desertification, as well as, special cases, irrigation rescue (fruit plantations, forests of the village).

This equipment allows you to:
- Pre-moisten the seeds when planting in dry;
- Lay the seeds ready to germinate at a depth of approximately 5 cm, the soil treated by machines (Delfino, Train et Scrabble) and distribute at this depth a small amount
of water (1-2 l);
- Deploy, in depths greater (30-50 cm), each second amount of water (2.3 l), possibly fertilized with manure;
- Reduce the evaporation of the water distributed by covering the point of sowing for
using a small amount of dry earth;
- Get the seedlings that, in addition to cost less, they are more resistant to drought and any other adversity in relation to plants from the nursery.

- **Technical characteristics of the tractor**

The nature of the soils to be treated and the type of processing to do with the different machines require a tractor double traction of an optimum power of 180 hp (*), with an appropriate weight and ballasted, to avoid that the tractor is raised or that , at the time of the maximum tractive effort (for the penetrating-tion of the working parts in the soil) there is a reduction of adhesion and power. It should also be noted that - in order to allow these tools to work better (or to break, fissurare and lift the ground harder, and allow the runoff and plant roots to go deep) - the working speed of the tractor It must be of the order of 5-7 km / h.

The section of the wheels, which is an important factor, must be as large as possible to minimize the skating of the wheels and give stability to the tractor in the lands sloping. A good ballast weights is also necessary to put the tractor in good working conditions.

(*) This power has been preferred as a result of various tests made with tractors from 130, 160 and 180CV.

2.7 **Comments**

The Vallerani System, is considered one of the key technology for mechanized rain collection and vegetation recovery for arid regions invented.
It is a very efficient technology that utilizes the limited natural rainfall in the arid and semi-arid regions to recover vegetation and to prevent and to control desertification. This technology can loosen soil and improve soil physical and chemical properties through special mechanical trenching and land preparation and collect of rain, accumulate water, preserve soil moisture and prevent water loss and soil erosion to create favorable environment for trees. Additionally, large scaled and highly efficient engineering forestation and grass planting can be made to increase survival rate and ecological environmental construction effect.
Greatly increase survival rate and make forestation a success under the arid and no-irrigation conditions. Direct sowing in China of tree planting of Caragana microphlla Lan and wide apricot forestation had success, although it was dry and precipitation was only 50% that of normal years, other forestations failed in the same conditions.
Great trenching depth (70cm) and high ground breaking ability. It is possible to penetrate the soil calcic horizon and difficult hard stone area that restrict tree growth so that the difficult area where artificial forestation is impossible makes a success. This means to make forestation in the difficult areas, where artificial forestation is impossible, become true through deep plowing, soil moisture preservation and soil loosening and release the people from the heavy physical labor.
Rain collection in the reverse slope trench (Treno Plow) and semi lunar forest cultivation pit (Dolphin Plow), not only collects natural precipitation and greatly increase utilization of natural precipitation, but also prevent rainwater loss, reduce soil evaporation, increases soil water content, reinforces soil water conservation function and increases soil water content 2-4 times.

Automatic land preparation in reverse slope trench and automatic making of barrier in reverse slope trench; surface layer mellow soil backfill technology prevents outflow of the collected rainwater, improves soil structure and increases fertility of the soil where root system is distributed.

High adaptability; applicable to construction operation in plain, wavy hill and piedmont slope and especially usable in the sloping areas at 10-20 degree slope and has wide application range; its technology is highly practicable and is easy to grasp and operate and suitable for dissemination.

High forestation speed, high efficiency and labor saving and time saving.

This technology has high degree of mechanization and strong ground breaking ability and greatly eliminates heavy physical labor necessary for land preparation. It can complete 2-3 ha area every hour which is far higher than artificial land preparation according to the same criteria.

Calculated as per earthwork, it is 2,000 times artificial land preparation efficiency. It greatly increases work efficiency and reduces waste of manual power and material resources with small expense and low cost.

The land preparation cost for this machine is less than 1/4 artificial forestation cost and therefore cost is greatly saved. If calculated as per ground breaking amount, the cost for plowing 1 m3 of land is only 1/32 labor cost.

Ground breaking area is small and native vegetation is protected.

Dolphin type plow is used to afforest and belt spacing is 4m and a half round rain collection pit is formed for every 7m. This greatly collects surface runoff produced from precipitation to increase soil moisture and on the other hand ground breaking rate is only 17% (1/6) total area, thus greatly reducing damage of native vegetation.

Investigation results for several planted lands indicate that vegetation coverage in the planted land increases for 40% and height increases 50% compared with before forestation and species diversity also greatly increases, many new plant species emerge and the quantity and species of wildfowl also increase considerably.

Vallerani system concept is that “by directly sowing local drought enduring tree species and through artificial means, quickly promote vegetation recovery, increase biodiversity, prevent land deterioration and desertification, restrict climatic change, improve ecological environment and realize sustainable human development.

3

The Vallerani system with AGRFOR changes

3.1 **The AGRFOR system**

The world today is experiencing a very critical period: the last century, the human population has increased from 2 to over 7 million; the global warming, a rise in the CO2 and other greenhouse gases caused mainly by the increase in energy needs of humanity, it is causing profound environmental imbalances, linked mainly to the increase of the evaporation of the oceans and the extremes of environmental events.
This is causing a number of imbalances, for which in some areas there is a strong increase in precipitation and in other areas a strong decline.
Today the desert areas are increasing, with serious consequences for the food supply of the planet, with more and more acute phenomena of population migration and political instability, with poverty, rebellions and ethnic conflicts, which threaten the lives of many people.
In this situation, the deployment of technologies that enable a more favorable water resources, both to increase food production in order to restore that vital balance of the various semi-arid environments, becomes an important tool for mitigating the negative effects of the problem of the desertification.

3.2 **Available technologies today**

Numerous and various technologies for the collection, conservation and rational use of rainwater have been developed by various populations in semi-arid areas for at least two millennia, in various ways, even and especially in the light of specific features of the environments involved and cultivation performed.
The basic concept is very simple: in areas not cold and frost, where rainfall is only of the order of 50 to 300 mm per year, in order to use such water for plant cultivation, both seasonal and perennial, it is necessary to collect water falls on surfaces much broader and concentrate them where you have to raise the plants (and animals) useful for the environment and for human nutrition.
Obviously, in the past, the processes used for this purpose have been mainly manual and therefore required a large amount of labor and very long times for their realization.
Nowadays there are machines which, in a few days, are able to produce works that in the past required months or years, so that the execution control technologies, conservation and appropriate utilization of rainwater are today more timely and effective.
This has allowed in the past and will allow in the future, if properly implemented, the provision of basic food to various populations living in these areas, limiting the processes of mass migration related to the unavailability of food and a normal life, now present in many areas the planet.

3.3 **The main technologies used in the past**

In many semi-arid areas where in the past it developed agriculture, which has allowed man a sedentary lifestyle, the social and economic development and greater control of the living environment, the residential areas were almost always near rivers or lakes from which you can have the water resources necessary for everyday life and to raise plants anddomesticated animals.
Then, later, the man had to and could also take advantage of other areas where you could also simply change the territory in order to accumulate rainwater useful for agricultural development.
This could be achieved by the simple constitution manual embankments or depressions, of different sizes and extensions, which keep the water, which could then penetrate deeply and thus be more used by annual or perennial vegetations present, with particular reference to those of possible human food consumption.
These simple steps have been made in the past centuries in various ways and called by different names in the Middle East (in the current Israeli and Palestinian areas, in Iran, Iraq, Turkey), North Africa, sub-Saharan Africa, in the areas Subdesert India, China and other Asian semi-arid areas, in semi-arid areas of South America and so on.

3.4**The technologies currently available**

The current availability of machinery able to implement processes of the territory that previously required hundreds or thousands of manual workers even for a very long time (like the construction of dams on water courses and channels to develop irrigation) has enabled us to implement environmental changes of considerable magnitude.
In fact, currently, also the availability of equipment, such as a tractor, it allows to carry out works that were previously much more difficult to implement.
The concentration system of rainwater and their accumulation in mini basins, obtained with the Vallerani system, by the use of powerful tractors (150-200 HP) and heavy plows that allow to work large surfacesproficiently in depth, obtaining furrows very deep in the soil and the establishment of mini-basins, some 5-10 meters long, for the collection of rainwater in soils of slight slope or even flat, it is an example of how today it is possible to obtain significant results in a very short time (a few weeks) and large areas (hundreds of hectares).

However, this technology has some important limitations:
1) The availability of very deep soils (preferably about 1 meter) and are not present in rocks in surface;

2) The gradients are not excessive (also to ensure the stability of the tractor that has to make the furrows along the contour lines);

3) To know, in the area to be processed, the average and the highest rainfall at least of last 10 years;

4) The soil is not sandy, easily filled with basins in case of sandstorms;

5) At least initially, to be available labour that can correct any incorrect operation;

6) Of course should be available tractors and plows fit for purpose.

In fact, the mini-basins should be in a condition to be effective for at least 3 years in order to allow, especially for perennial crops, a rapid and continuous vegetative growth.
Obviously this technology, which can be implemented with a few people, in addition to the tractor driver, is particularly suitable for reforestation and re-greening of the territories concerned.

(See the publication of Vallerani and Antinori on the equipment of Treno Delfino and the final report of the project Acacia recently implemented by AGRFOR in 5 Countries of the Sahel, attached to this report).

It should underlined that, if you want to preferentially use Vallerani technology, in order to increase food production growing with seasonal or annual crops (cereals, grain legumes, oil etc.). The Vallerani methodology may be partially modified using the AGRFOR (according to the suggestion of prof. A. Bozzini, who has long experience as a Director of FAO's Plant Production) as follows.
The Vallerani technology, which requires special mechanical structures, such as the so-called treno or Dolphin, with heavy plows, controlled hydraulically by the driver for their lowering (to implement the furrows) and their elevation of the ground to stop the excavation (to constitute the mini-bacins and prevent the flow of water), has a very high cost and greater ease of incurring failures, particularly in the hydraulic system.
Later sowing or transplanting of seasonal or perennial species will be made in the appropriate method to the species and determined mainly by mechanical operators implementing the project.
Moreover, this process takes just a few people and in fact may not involve the local population, as they are often carried out by Forester, in the case of prevalence of the needs of re-greening of the affected area or industrial perennial plantings, as in the case of formation of plantations of Acacia senegal, for the production of arabic gum, as was done for the project Acacia, or for the cultivation of date palms etc.
The modification AGRFOR consists in the use of a normal tractor and a normal plow (no hydraulic equipment for raising and lowering the plow) with which to perform a furrow continuously along the contour lines, with the distances between the rows, depending by rainfall (distance between the furrows larger with less rains) and according to the local slope of the soil, which may speed up the flow of rain falls between the furrows. Such equipment will then have a much lower cost, if not already available and then rented locally.
Subsequently, the local farmers, who will benefit from the work carried out for their products, mainly food, will be involved in the processing, filling the gap, for about a meter, with the earth moved downstream by the plow, every 5-10 meters (depending on the amount of expected rain) and thus realizing the mini-basins.
In this way the local population will be involved in the realization of the basins and their subsequent maintenance over time, as well as in the planting of species of interest to them, both seasonal and perennial.
In addition, the soil which remains between the grooves, may be worked, both by farmers (manually) by effecting mini holes with hoes (Zai in the Sahel) in which also put the seed (for example, sorghum, corn or legumes grain) or with harrows or mini-listers, driven by domestic

animals, so that the land can be used for a variety of seasonal crops, especially if the rainfall will be more abundant than usual.
Ultimately it is believed that, in the case of realization of reforestation or land use with perennial species, of various use, the technique Vallerani is certainly more suitable to improve large surfaces, while the technique AGRFOR is more suitable for the cultivation of seasonal food species operated directly by local farmers and then from them maintained over time, providing basic food for their own consumption or for their marketing in urban areas.

3.5**Comments on the plow proposed in Pakistan**

It is believed that the success of the operation of "Water Harvesting" given to the affected area in Pakistan is related with to the properties of the tools used.
Without these tools, we believe that the system can not be efficient and appropriate to the major objectives scheduled.
It should be available a larger plow that allows to perform larger and deeper furrows.
The photo that was sent shows two paired small flows, which can reach a maximum depth of 30-40 cm, with a plough which is about a third of the Vallerani plow and therefore not suitable for the effective application of such a system, also because the furrows would not have the necessary duration of 2-3 years.