Above left: Native agave (*A. inaequidens*; *"maguey bruto"*) freshly planted on eroded soil (Acrisol type) in the Cointzio basin, Michoacán de Ocampo state (Photo: C. Prat, IRD)
Above right: Example of a plantation (2002) of *Agave cupreata ("maguey papalote")* with and without a tree cover. Titzio project, Michoacán de Ocampo state (Photo: A. Martínez, UMSNH)

Land reclamation by agave forestry with native species

Mexico - *Recuperación de tierras degradadas por agaveforestería con especies locales de agaves, arboles y herbaceas (Spanish)*

Agave forestry land reclamation system with native agaves, trees, shrubs and grasses planted through participatory action for a sustainable production of mezcal and other products in order to generate high incomes for farmers.

Rehabilitation of degraded land is achieved using native agave (*Agave inaequidens*), trees and/or fruit trees, shrubs and grasses to create, over the medium-term (7-10 years), sustainable production of a traditional alcoholic drink (*mezcal*) made from agave and/or cosmetic and medicinal products, and/or fibres and/or fodder for cattle and/or wood. Between the agave plants, native vegetation is managed or planted for use as food, fodder and/or medicinal products. Depending on the slope and the level of land degradation, continuous planted rows of agave provide a 'green' barrier that controls soil erosion and runoff.

The main purpose is to achieve sustainable land rehabilitation while generating a high income for the farmer. This allows reducing the amount of livestock and overgrazing, which is the main cause of soil erosion in this region. The production of *mezcal* gives local farmers high incomes. Trees, shrubs and grasses for medicinal uses, food, and fodder are complements of agave production and are processed mainly by women, while agave harvesting is a male activity. As it is very attractive financially, farmers stay in the communities instead of emigrating to cities or abroad. Biodiversity is preserved and increased using native plants (agaves, trees, shrubs, grasses). These plant associations are effective at controlling plant pests and diseases. Turning eroded into productive soil sequesters carbon and increases water availability as a result of the new soil cover.
Unlike most agave, *Agave inaequidens* reproduces from seed, which requires harvesting the seeds from native plants in the fields. One plant generates 80,000 seeds with a 90% success rate of germination, which is enough to cover 25 ha of agave forestry plantations set up to control soil erosion. After harvesting seeds from native agaves, trees and shrubs, seedlings and small plants are raised in a greenhouse and nursery managed by the owners and tenants of the land in the first year. At the beginning of the rainy season, these are planted in plots protected from cattle grazing for at least the first two years after planting. The harvesting activity for trees, shrubs and grasses is done annually, but for the agaves only once every 7 to 12 years depending on the degree of soil degradation. Some months before harvesting, the flower from the stem has to be cut. The leaves are then cut and left in the plot while the 50 kg heart of the agave (*"piña"*) is removed. Mezcal is produced from the heart and requires an average of three weeks and at least two men to process 25 agave plants (1.5 tonnes), which produces about 300 litres of mezcal.
Poverty levels in the area are medium to high and the income from agriculture accounts for only 10 to 20% of the total family budget. People, therefore, do not have time to install soil erosion protection systems in the fields. Cattle graze freely everywhere and the number of animals is increasing annually, which also increases soil erosion. Locals know how to produce *mezcal*, but they prefer to buy it from other people who take wild plants from their lands to process them. The proximity of the site to the Michoacán of Ocampo state capital and the recognition of the designation of origin for *mezcal* by the authorities will enhance its value for future production.

Location: Morelia municipality
Region: Cointzio watershed, Michoacán state
Technology area: 0.1 - 1 km^2
Conservation measure: vegetative
Stage of intervention: rehabilitation / reclamation of denuded land
Origin: Developed through experiments / research, recent (<10 years ago); externally / introduced through project, recent (<10 years ago)
Land use: Grazing land: Extensive grazing land (before), Mixed: Agroforestry (after)
Climate: semi-arid, temperate
WOCAT database reference: QT MEX002 on cdewocat.unibe.ch/wocatQT
DESIRE site information: http://www.desire-his.eu/en/cointzio-mexico
Related approach: Participative actions for economic benefits of agave forestry (Mex002)
Compiled by: Christian Prat, Institut de Recherche pour le Développement (IRD), France and Alejandro Martínez Palacios, Universidad Michoacana San Nicolas de Hidalgo (UMSNH), Mexico
Date: 1st Oct 2010, updated Nov 2011

Classification

Land use problems: Soil erosion by water due to storms and improper land use, mainly overgrazing due to uncontrolled grazing by cattle.

Land use

extensive grazing land (before)

agroforestry (after)

Climate

semi-arid, subtropics

Degradation

soil erosion by water: loss of topsoil / surface erosion, gully erosion,

biological degradation: reduction of vegetation cover, quality and species composition / diversity decline

Conservation measure

vegetative: tree and shrub cover

Stage of intervention

- Prevention
- Mitigation / Reduction
- Rehabilitation

Origin

- Land user's initiative: traditional (< 50 years ago)
- Experiments / research: < 10 years ago
- Externally introduced: < 10years ago

Level of technical knowledge

- Agricultural advisor
- Land user

Main causes of land degradation:
Direct causes - human induced: soil management, overgrazing.
Indirect causes: poverty / wealth

Main technical functions:
- improvement of ground cover
- increase of biomass (quantity)
- promotion of vegetation species and varieties (quality, eg palatable fodder)
- control of concentrated runoff: retain / trap
- sediment retention / trapping, sediment harvesting

Secondary technical functions:
- improvement of surface structure (crusting, sealing)
- improvement of topsoil structure (compaction)
- increase of infiltration
- control of raindrop splash
- control of dispersed runoff: impede / retard
- control of concentrated runoff: impede / retard; drain / divert
- water harvesting / increase water supply
- improvement of water quality, buffering / filtering water

Environment

Natural Environment

Average annual rainfall (mm)

- > 4000
- 3000-4000
- 2000-3000
- 1500-2000
- 1000-1500
- 750-1000
- 500-750
- 250-500
- < 250

Altitude (m a.s.l.)

- > 4000
- 3000-4000
- 2500-3000
- 2000-2500
- 1500-2000
- 1000-1500
- 500-1000
- 100-500
- <100

Landform

- plateau / plains
- ridges
- mountain slopes
- hill slopes
- footslopes
- valley floors

Slope (%)

- flat
- gentle
- moderate
- rolling
- hilly
- steep
- very steep

Soil depth (cm)

- 0-20
- 20-50
- 50-80
- 80-120
- >120

Growing season(s): 190 days (June to November)
Soil texture: medium (loam), fine / heavy (clay)
Soil fertility: medium, low, very low
Topsoil organic matter: medium (1-3%), low (<1%)
Soil drainage/infiltration: medium

Soil water storage capacity: medium, low, very low
Ground water table: 5 - 50 m, > 50 m
Availability of surface water: medium, poor / none
Water quality: for agricultural use only or not usable
Biodiversity: high

Tolerant of climatic extremes: temperature increase, seasonal rainfall increase, seasonal rainfall decrease, heavy rainfall events (intensities and amount), wind storms / dust storms, floods, droughts / dry spells, decreasing length of growing period
Sensitive to climatic extremes: The native plants used with this technology are adapted to the local climate and they are therefore not sensitive to the climatic extremes and are used to living in these extreme conditions.

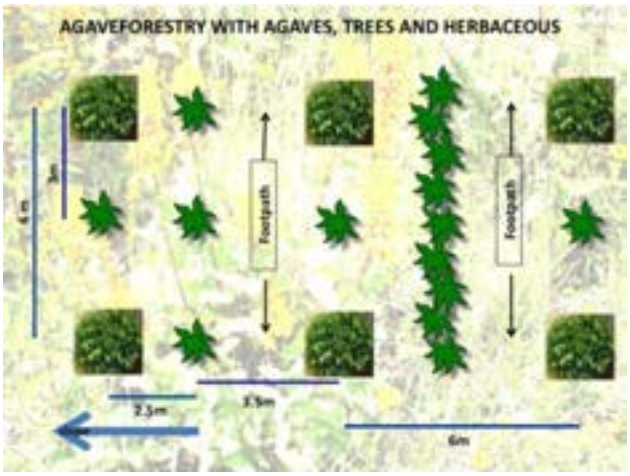
Human Environment

Mixed land per household (ha)

- <0.5
- 0.5-1
- 1-2
- 2-5
- 5-15
- 15-50
- 50-100
- 100-500
- 500-1,000
- 1,000-10,000
- >10,000

Land user: groups / community, small scale land users, common / average land users, men and women
Population density: 10-50 persons/km^2
Annual population growth: 1 - 2%
Land ownership: communal / village, *"ejido"*
Land use rights: communal (organised): *"ejido"* is the community organisation in Mexico: land belongs to the state but it is managed by the community. Some areas can be used by everybody; others are assigned to the land user families.
Water use rights: water concession given by National Water Authority to the *"ejido"*
Relative level of wealth: average (owning 34% of the land); poor (owning 33%), very poor (owning 33%)

Importance of off-farm income: Off-farm incomes represent between 80-90% of the annual incomes: "external" job, business, trade, or by money sent by family members from the USA
Access to service and infrastructure: moderate: technical assistance, employment (e.g. off-farm), financial services; high: health, education, market, energy, roads & transport, drinking water and sanitation
Market orientation: mixed (subsistence and commercial)



Technical drawing

Agave production is based on planting them with trees along the contour. Herbaceous plants are maintained / planted or sown between the plants. Depending on the slope, one or more dense lines of agaves (1 plant every 25 cm) is planted for control of soil erosion and runoff, including a lateral gradient to the gully which will evacuate the excessive runoff. Footpaths are planned for the maintenance of the plantation (Design of Alejandro Martinez).

Implementation activities, inputs and costs

Establishment activities

1. Selection and collection of agave and tree seeds
2. Building of greenhouses incl. soil and organic matter
3. Fencing of greenhouses with barbed wire, poles and nails (0.5 ha)
4. Sowing & maintaining seedlings in greenhouses (3 months)
5. Installation of a nursery for agaves and trees and transplantation of seedlings into plastic bags
6. Plant care and maintaining in nursery (9 months)
7. Transportation of plants in plastic bags
8. Planting of plants (agaves and trees)

Establishment inputs and costs per ha

Inputs	Costs (US$)	% met by land user
Labour	153	10
Equipment		
- greenhouse (10 years life)	18	10
- transport (trucks)	16	10
Construction material		
- earth	23	10
- plastic bag for plants	12	10
- barbed wire (10 years life)	11	10
Agricultural		
- seedlings	100	10
TOTAL	**333**	**10**

Maintenance/recurrent activities

1. Weeding around plants to give them space during the first 3 years (10 person days/ha)
2. Cutting the stalks before the harvest (15 person days/ha)
3. Replanting of agaves after 7 to 14 years (restarting of a new cycle of production, see establishment activities)

Maintenance/recurrent inputs and costs per ha per year

Inputs	Costs (US$)	% met by land user
Agricultural		
- cleaning around plants	37	10
- cutting scape	17	10
TOTAL	**54**	**10**

Remarks:
The most important factors determining the costs are: 1) the materials to build a greenhouse and the personnel to take care of young plants; 2) the difficulties of making holes in the indurated soils, which takes time and efforts; and 3) the distance between the nursery and the field requires time and efforts (truck carrying the plants).
Calculations are for the plantation of 200,000 plants (agaves and trees) which correspond to the numbers of plants for 100 ha in the agave forestry example presented here. The main portion of these plants is planted by the community on their own land; the rest is given or sold to other communities or private people. The lifetime of the greenhouse, nursery and fencing installations is around 10 years. The local wage rate is 12 US$/day.

Assessment

Impacts of the Technology

Production and socio-economic benefits

+++ increased farm income, diversification of income sources
+++ increased production area and diversification
+++ increased crop yield
++ increased wood and fodder production and quality

Production and socio-economic disadvantages

+++ reduced animal production
+++ anticipated impact on the community due to the huge benefits which may induce corruption, violence, etc.

Socio-cultural benefits

+++ improved conservation / erosion knowledge
+++ improved situation of disadvantaged groups
+++ improved food security / self-sufficiency
++ conflict mitigation
++ improved health (through medicinal plants and income)

Socio-cultural disadvantages

+++ socio cultural conflicts
++ increased health problems (due to alcohol)

Ecological benefits

+++ improved harvesting of water, increased soil moisture
+++ reduced surface runoff and soil loss
+++ improved soil cover
+++ increased animal, plant and habitat diversity
++ increased biomass and nutrient cycling

Ecological disadvantages

+ increased fire risk

Off-site benefits

+++ reduced downstream flooding and siltation
+++ reduced damage on neighbours fields and on public / private infrastructure
+++ increased biodiversity
++ increased water availability

Off-site disadvantages

Contribution to human well-being/livelihoods

+++ the production of the mezcal drink (with designation of origin) from agaves, and/or medicinal products, will generate very high incomes for stakeholders which change their life and allow farmer's sons to stay in the community and work in their fields.

Benefits/costs according to land user

That is why state institutions fund the installations of this system, although the production has not started yet. After that, benefits generated will be enough to motivate people to increase the surface to remediate by themselves, without economical helps.

Benefits compared with costs	short-term:	long-term:
Establishment	negative	very positive
Maintenance/recurrent	negative	very positive

Acceptance/adoption:

All the land user families (50 families; 10% of area) who implemented the technology received an external material support. As the programme only started in 2010, it is impossible to have an exact overview of the results (end of 2011). As the land users belong to the same community ("ejido"), formally, all the inhabitants are involved in some way. It is too early to identify an adoption trend.

Concluding statements

Strengths and → how to sustain/improve

Remediation of degraded land turning it to a sustainable production generating very high incomes in the medium term → life will change drastically and not necessarily for the better. Transparency and communication regarding benefits and land use are necessary

Low-cost project but it needs to be funded and supported with technical and institutional advice to initiate the first cycle of the project → Farmers can start to produce their *mezcal* from the wild agaves to sell them to wholesalers and use this money to pay for the project.

As a result of the economic benefits, young people will stay in the communities → Involve the young to guarantee the future: develop the marketing, the diversification of the products, the quality of production, etc.

It will hopefully reduce the number of cattle, which are the main cause of soil erosion, as farmers lose interest in cattle raising → Authorities need to monitor this and inform the farmers about the ecological impact of too much free cattle grazing

Weaknesses and → how to overcome

Obligation to find external funds to pay the first steps of the system (greenhouse, planting etc.) due to the lack of incomes amongst farmers → Involvement of all stakeholders in the project

Ensuring that alcohol production will not be consumed in excess in the community → control of the volume of the production, and the sufficiently high selling price should avoid "losing" the production at local scale

Risk that the benefits will be captured by few people → transparency and stakeholder communication in accounting for the benefits

Marketing and selling the products → authorities help the farmers to contact sellers. The formation of communities of producers, leading to products conforming to regulations that maintain good quality and provide certification.

Owing to the high incomes, life will change drastically and not necessarily for the better.

Key reference(s): Colunga-García Marín P., D. Zizumbo-Villareal, J.T. Martínez. 2007. Tradiciones en el aprovechamiento de los agaves mexicanos: una aportación a la protección legal y conservación de su diversidad biológica y cultural. In: En lo Ancestral hay Futuro: del Tequila, los Mezcales y otros Agaves. P. Colunga-GarcíaMarín, L. Eguiarte, A. Larqué, D. Zizumbo-Villarreal (eds). CICY-CONACYT-CONABIO-SEMARNAT-INE. México D.F., pp. 85-112.

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DES!RE

Desire for Greener Land

Options for Sustainable Land Management in Drylands

WOCAT

World Overview of Conservation Approaches and Technologies

Desire for Greener Land

Options for Sustainable Land Management in Drylands

Desire for Greener Land compiles options for Sustainable Land Management (SLM) in drylands. It is a result of the integrated research project DESIRE (Desertification Mitigation and Remediation of Land - A Global Approach for Local Solutions). Lasting five years (2007–2012) and funded within the EU's Sixth Framework Programme, DESIRE brought together the expertise of 26 international research institutes and non-governmental organisations. The DESIRE project aimed to establish promising alternative land use and management strategies in 17 degradation and desertification sites around the world, relying on close collaboration between scientists and local stakeholder groups. The study sites provided a global laboratory in which researchers could apply, test, and identify new and innovative approaches to combatting desertification. The resulting SLM strategies are local- to regional-scale interventions designed to increase productivity, preserve natural resource bases, and improve people's livelihoods. These were documented and mapped using the internationally recognised WOCAT (World Overview of Conservation Approaches and Technologies) methodological framework, which formed an integral part of the DESIRE project.

The DESIRE approach offers an integrated multidisciplinary way of working together from the beginning to the end of a project; it enables scientists, local stakeholders and policy makers to jointly find solutions to desertification. This book describes the DESIRE approach and WOCAT methodology for a range of audiences, from local agricultural advisors to scientists and policymakers. Links are provided to manuals and online materials, enabling application of the various tools and methods in similar projects. The book also includes an analysis of the current context of degradation and SLM in the study sites, in addition to analysis of the SLM technologies and approaches trialled in the DESIRE project. Thirty SLM technologies, eight SLM approaches, and several degradation and SLM maps from all the DESIRE study sites are compiled in a concise and well-illustrated format, following the style of this volume's forerunner *where the land is greener* (WOCAT 2007). Finally, conclusions and policy points are presented on behalf of decision makers, the private sector, civil society, donors, and the research community. These are intended to support people's efforts to invest wisely in the sustainable management of land – enabling greener drylands to become a reality, not just a desire.

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SIXTH FRAMEWORK PROGRAMME

Desire for Greener Land

Options for Sustainable Land Management in Drylands

Editors and lead authors
Gudrun Schwilch, Rudi Hessel and Simone Verzandvoort

Associate editors and authors
Erik van den Elsen, Hanspeter Liniger, Godert van Lynden, Coen Ritsema and Sarah Buckmaster

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WOCAT – World Overview of Conservation Approaches and Technologies

DESIRE – WOCAT 2012

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