The Project "Fog as a new water resource for the sustainable development of the ecosystems of the Peruvian and Chilean coastal desert"

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Abstract : In the framework of the Programme "Science and Technology for Developing Countries" (STD3) the European Commission has funded a four year (1995-98) multidisciplinary project, which represents the first attempt in the world to produce water out of fog in one of the most arid regions in the world for applications to the environmental restoration and the sustainable development of an ecosystem, in which the water is used for plant cultivation, cattle growing and domestic use. The European Commission project should represent the first step towards a long term goal : the sustainable use of the natural resources of the ecosystem of the Peruvian coastal desert. The first step in this direction consists in a demonstration of the role played by fog in producing large quantities of water to restore the vegetation in the Peruvian coastal desert and to use the results obtained for the elaboration of a project aimed at the rational use of its resources : the development of a subsistence agriculture and controlled pasture; the controlled use of spontaneous vegetation; the use of the water obtained from fog for domestic use

1. INTRODUCTION

Fog collection by vegetation and experiments on the relationships between fog and mist precipitation and vegetation have been conducted during the last 100 year (Kerfoot [1968]). In regions where the advection of marine clouds originates high elevation fogs, water is intercepted by vegetation and reaches the ground through the branches and the trunk. On the other side, the collection of advection fog by man-made collectors is a relatively new research area.

The first experimentation with artificial collectors has been performed in Northern Chile, where the village of Chungungo (330 inhabitants) has been receiving the water supply for domestic use since May 1992 from 75 large fog collectors located 6 km from the village (Cereceda and Schemenauer [1992]). The system is able to provide an average of 11,000 liters of water per day, doubling the per capita supply at one quarter of the coast of trucked water.

The project represents the first attempt in the world to generate water from fog in a coastal desert, one of the driest on the earth, with very low and erratic precipitation, for potentially large scale applications in the managed development of an ecosystem, in which the collected water can be used for plant cultivation, grazing animals and for domestic use.

The project of the European Commission on the coast of Southern Peru is more focused on research and takes a multidisciplinary approach, resulting from integration of research on fog collection, agroforestry and water resource management applied to the recuperation of large areas of the ecosystem of the coastal desert in an environmentaly friendly fashion and to the sustainable use of its natural resources. One of the innovative points of the project is to set up an appropriate technology to mantain the equilibrium between environment and human activity: technology for the collection of fog water in the appropriate quantities, for its storage avoiding evaporation and leaching losses and for establishing high efficiency conveyance and irrigation methods.

2. OBJECTIVES

This project should represent the first step towards a general and longterm achievement : the sustainable use of the natural resources of the coastal hills of the Peruvian desert by exploiting the only water resource available, fog water. The first step towards this goal consists in a field demonstration of the role fog water

can play in producing large quantities of water for reintroduction and retention of vegetation. The field results and the experience gained will then be used to develop a plan for the rational use of the existing natural resource in the coastal desert : the development of subsistence agriculture and the growth of pasture for a controlled cattle grazing; the controlled use of the enhanced natural vegetation; the utilization of collected fog water for domestic use in small communities. Later on, the possibility of plants to sustain themselves by means of the water supply derived from their self-capturing abiliity could be tested and the surplus of water coming from the man-made fog collectors could be used for the development of subsistence agriculture and for forage growth.

The idea is to set up a basis for the recuperation of large areas of the coastal hills of Peru, a fragile ecosystem which is at present undergoing a process of rapid degradation and desertification, due mainly to overgrazing. In this general framework, the specific objective of the project is to set up a basic plan of sustainable use for the natural resources of the Peruvian coastal desert using collected fog. This plan will be based on the experimental verification of the following assumptions:

- the effectiveness of artificially collected fog water in the restoration of vegetation;
- the ability of the plants to grow by means of the water supply derived from the fog they collect, with no more need for man made collectors;
- the possibility that the surplus of water obtained by means of artificial collectors can be used for subsistence agriculture and for pasture growth.

This verification will be based on the results of a pilot

- to measure meterological parameters: wind direction and velocity and air temperature in all the stations; wind velocity and direction on a continuous basis in at least two stations;
- to measure the precipitations in several sites in the area of interest and distinguish between rain, drizzle and fog.

The study area is located between 17°00'00''S-17°00'45''S and 71°59'50''W-71°59'30''W (national map 1:100,000 Punta de Bombón) in the Department of Arequipa, province of Islay and district of Valdivida (La Curva) approximately 170 km far from Arequipa. In each of the sites chosen, which were initially ten with two additional ones added later on, a Standard Fog Collector (SFC) as proposed by Cereceda and Schemenauer [1994] was installed.

SFC is a flat panel made up of a metal frame (1m×1m) and mounted 2m above the ground level, supported by two vertical posts which are supported by four cables firmly tied to pegs hammered in the ground. Below the frame, there is a little pipe which conveys the water

experiment which is being carried out in a station installed in the hills of the coast of Southern Peru, near the town of Mollendo.

The results of this pilot experiment, together with the results of research aimed at analysing ecological history, succession and human influence on vegetation dynamics, fragility and vulnerability of the system, causes which led to its deterioration, possibility of recuperation and maintainance of an equilibrium between human intervention and natural development, will form the basis for a plan of sustainable use for the natural resources of the ecosystem.

3. DESCRIPTION OF THE RESEARCH WORK

The pilot experiment has been preceded by a preliminary part which consisted in evaluating the fog collection potential of various locations, preselected after a direct inspection on the basis of such criteria as presence of a hill range; height of the hills; closeness to the coast line; orientation of the hill range; exposition of the hill sides in the range; enough space to build an extended line of fog collectors; slope of the hill sides. This part, besides being a research activity in itself, was carried out in order to choose a site suitable for installing the experimental station where the pilot experiment would have to be carried out.

The specific objectives of this activity, which was carried out during the period May-December 1995 were the following:

- to know the behaviour of fog in the area of interest and to measure the fog water collected in several sites inside that area;

coming from the mesh into a little tank. The polypropylene mesh is placed on the frame in a double layer covering approximately 60% of the surface area. The material is a 35% shade coefficient polypropylene mesh produced in Chile. The fiber width goes from 0.5 to 1.5 mm depending on how it is stretched. The mesh is woven in a triangular pattern and the space between the horizontal lines is roughly 1cm.

After an experimental campaign and a careful analysis of the results, the location for the "atrapanieblas" was chosen in the area of Cordón Las Cuchillas with an altitude of more than 800 m a.s.l.. On the top of the Las Cuchillas ridge (830 m a.s.l.) 20 "atrapanieblas" have been mounted, 9 double and 2 simple for a total area of 960 m2. Each "atrapaniebla" is 12 m long and 4 m high and mounted at a heigth from the ground depending on the topography; a double one is 24m by 4m. The collection surface is represented by the same mesh used for the SFC's. The two posts - or three in the case of a double one - are made of Eucaliptus, 7m in height, and with a diameter of around 12 cm. A PVC pipe (10 cm diameter) is used to collect water coming

down from the mesh . The pipe is cut in half by the length and hung to the bottom mesh with the open surface upward. Since under the effect of the wind the mesh swells, the collecting pipe cannot be made in one piece, but by several overlapping sections, inclined to convey the collected water, which goes into a large funnel placed on a side of the pipe.

The water obtained from fog collection is being used throughout the year to experiment with the species of plants selected, which are cultivated in plots in the experimental station area. The hydraulic system for collection and distribution of fog water to the plots consists in two tanks, one located in Las Cuchillas area The two tanks are linked with a 32 mm diameter hose. The siphon method is used to regulate the flow of the water. The small tank has an approximate size of 30×1.5×1 m, the main one of 50×3.5×2 m, and both have rectangular shape and trapezoidal section. The two tanks were dug using an excavator, and the bottoms were adjusted by hand and smoothed with clay in order to prevent damages and tears in the plastic bottom cover sheets, just 0.7 mm thick. The main tank has been covered by a plastic sheet of the same thickness in order to reduce the evaporation and to prevent the deposition of fine material lifted by the wind on surface of the water. Another tank, not planned at the beginning of the project, was dug by taking advantage of a depression in the ground close to the main tank. This tank has a capacity of 200-250 m3 and is endowed with a 1.5 m high embankment dam which prevents water from flooding out and getting lost in the valley. At the end of August 1996 the two tanks were full and had eough water to irrigate the plots during the period of low or no fog at all.

Starting from the main tank a 32 mm diameter hose conveys water to the experimental area. Two filters are mounted to ensure water quality before going into the drip irrigation system. The filtration group is made up of a sand filter and a mesh filter. Then the 32 mm diameter hose reaches the mini-reservoirs, plastic containers of 200 liters volume, in the two experimental areas. From the mini reservoir a 20 mm diameter hose gets to the bottom of the plots.

The area is approximately 7.5 ha and is mainly orientated to the South. The slope varies from moderate to strong and this is the reason why ploughing the area has been really difficult with common machines. The altitude varies between 740 to 600 m above sea level.

The experimental area has been fenced in order to prevent the entrance of animals and to protect it from any kind of disturbance to the experimental equipments. The area has been cut in two different sub-areas separated by 200 m distance; each one has two blocks and each block contains 6 plots (15m×15m). In each plot trees and shrubs have been planted following an appropriate scheme and each block is characterized by a different treatment in terms of duration of the irrigation period and presence of a protection pipe for plants.

and the other 100 meters below near the experimental area. The 20 fog collectors are connected with a 32 mm hose which gets into a rectangular tank (40 m3) located near the collection system. The upper tank has two main purposes:

1. to favour the sedimentation process of the suspended material possibly present in the fog water collected;

2. to allow the regulation of the water flow to the principal tank, with a volume of 350 m3 and located 100 m below.

The scheme for the six parcels in each block is the following :

- no irrigation and no protection
- no irrigation and protection
- irrigation 1 year and no protection
- irrigation 1 year and protection
- irrigation 2 years and no protection
- irrigation 2 years and protection.

Each plot contains 36 trees of five different species and 13 shrubs of four species. They are:

TREES: *Acacia macracantha*
Caesalpinea tinctorea
Citharexylum flexuosum
Casuarina equisetifolia
Parkinsonia aculeata
Prosopis pallida

SHRUBS : *Acacia horrida*
Citharexylum flexuosum
Heliotropum sspp
Viguiera weberbaueri

4. RELEVANCE FOR DEVELOPMENT

The region where the project is being carried out is located has one of the lowest rainfall in the world. In Peru, the ecosystem of the coastal desert is undergoing a process of severe degradation and this project will tackle the recuperation of large areas of this region and the rational management of its natural resources. This means to regenerate the vegetation in order to allow the development of subsistence agriculture and controlled cattle grazing, and to collect and store water for domestic use in small communities. If this project is carried out succesfully, its results will contribute to develop a methodology of work suitable for applications

in other regions of the world with the same or similar climatic characteristics.

5. ENVIRONMENTAL IMPACT

The presence of fog in the coastal desert of Peru is due to the simultaneous action of the Pacific anticyclone and of the Humboldt current, which are permanent phenomena. Therefore, fog water is a resource available in practically unlimited amounts and it would get lost if not utilized naturally by vegetation, or artificially by man made fog collectors. Since the vegetation is the most important natural collector of fog water, its restoration will enhance the collection process and this is going to produce a beneficial environmental impact in the region as far as the improvement of humidity conditions, availability of underground water, regulation of basins and seasonal coastal streams are concerned.

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