SOIL CONSERVATION AND AGROFORESTRY

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By tradition, the foresters' brief has always included soil and water conservation. Forests are, in effect, relegated to the least accessible zones which are most vulnerable to the onslaughts of climate, and it is the task of Forestry Departments to control torrents and protect river banks. Coastal regions are unstable, and endangered by the encroaching sea. Here, too, it falls to foresters to come up with mechanical solutions like protective earthworks, and biological solutions such as planting species capable of stabilizing soils.

In the tropical areas of the French colonies, operations are also in foresters' hands. Systems developed in France will first involve the introduction of biological methods, and then local people affected by the programme definition and management.

FROM MECHANICAL PROJECTS TO CONCERTED MANAGEMENT

Increasing population density and land clearance carried out for crop cultivation have been presented from the 1950s onward as the main factors responsible for large-scale land and soil deterioration.

Madagascar offers a good example of this, for the conditions in this country are very varied, and the areas affected or threatened are huge. Reforestation cannot be planned, because it would be too costly in steep, hilly areas where there is now little manpower left.

Among the different preventive methods recommended, the movement and distribution of local people to less vulnerable areas is being considered, as well as the introduction of land-use plans, in a more realistic vein. This is a period which abounds in great possibilities for environmental analysis and description, and for capitalizing on the corpus of available knowledge.

Terraced paddy fields and lavakas in the Madagascar highlands.

LAKE ALAOTRA IN MADAGASCAR : A HUGE TEST BENCH

The Lake Alaotra region, situated in the eastern reaches of the Madagascan Highlands, represented, at a very early stage, a popular area for carrying out experiments focused on the protection of catchment basins. The extent of the erosion phenomena, and of *lavaka*-type erosion in particular, together with the compounded upkeep cost of irrigated paddy fields, contributed in 1948 to the emergence of an agency called the Land Bureau, which dealt with informational matters and acted as a kind of think tank.

The major achievement of this Bureau was the "Valley demonstration", based on concepts involving land-use and agro-silvo-pastoral management. From 1953 on, extensive programmes were undertaken in an area covering 550 hectares : *lavaka* modification, the construction of dams for irrigation, the introduction of anti-erosion contour-lines, reforestation, the development of undergrowth and bush, which all went hand in hand with projects spreading information about farming methods and practices. An ambitious research programme was set up in tandem with these activities, so as to assess the recommended methods of mechanical and biological anti-erosion operations. In no time, the demonstration Valley became a national point of reference and, in the 1950s, 3,200 hectares of croplands were developed in the Lake Alaotra region as a whole.

From 1958 to 1969, the Madagascan Department of Waterways, Forestry and Land Conservation established the "Land Conservation Research Department". A multidisciplinary research department, bringing together both agronomists and foresters, was subsequently created. Preliminary studies for development programmes were carried out as from 1965 in several catchment basins around Lake Alaotra. Because of a shortage of funds, these projects would never be realized, but they have been re-introduced in the 1990s, to help set up the Development Project for the valleys in the southeast region of Lake Alaotra. In this same period, village nurseries were established to supply collective reforestation projects, managed by the *fokonolona* (village communities), with seedlings and saplings. Some 50 such nurseries now exist around Lake Alaotra, but the operation is rapidly running out of steam, because of a lack of adequate technical training and staffing. What is more, the law on "Reforestation, a national duty" was repealed in 1979.

A new approach was formulated in 1983, thanks to the Madagascar Conference on "tree policy". A National Action Operation to promote trees was introduced in 1985. The cumbersome nature of the various procedures was such, however, that in 1992 only two reforestation plots benefitted from this aid in the entire Lake Alaotra region. While Forestry Departments saw their means dwindling, managerial staff in the agricultural sector endeavoured to rekindle the flame of land and soil conservation. In 1985, the Lake Alaotra Research & Development Department introduced a Research & Development Programme. This programme provided for the development, in real environments, of farming and cultivation techniques causing less deterioration. Major recommendations and references were obtained, but the dissemination of the findings is still sluggish.

In 1990, two attempts were then undertaken in this same region under the label of "farmland management" [*gestion de terroirs*]. The first had to do with the involvement of Irrigation Network User Associations in anti-erosion programmes within the southeast valleys Development Project. The second consisted in forming and backing new Catchment Basin User Associations, as part of both the above-mentioned project and the Protection Project for the Imamba and Ivakaka catchment basins. In both instances, the intent was eventually to achieve a concerted management system for the area in question, founded on a real collective consensus.

In this retrospective overview, it would be misleading to anticipate a simple development proceeding from interventionist methods to better concerted approaches that are more closely allied to the rural world. In its day, the demonstration Valley was nothing less than a local land management operation, though admittedly within a different historical context. Incidentally, this operation still acts as a point of reference and the anti-erosion techniques being proposed today are based on it to a large degree. It is also striking to observe the extent to which mechanical developments have held their own, while biological methods have been short-lived.

An analysis of all these actions taken as a whole points to an inexorable questioning of methods of dealing with the rural world. The crowning achievement of this development at Lake Alaotra is undoubtedly represented by farmland management schemes, an arena in which actual roles are played out – roles which play to those with the best speaking skills –, but at times underrate the beneficial aspects of the 50 years of land protection programmes carried out. The mobilization of rural forces would undoubtedly appear to be one key to the successful guarantee of better resource management, but what emerges above all with the wisdom of hindsight is the fact that the best integrated innovations are those which are situated closest to rural dynamics as they currently exist.

It is, for example, revealing to observe that foddering techniques, which were unsuccessfully proposed 40 years ago, are currently being adopted against a backdrop of rural insecurity, where it has become inconceivable for herds and flocks to continue to roam freely. Equally, it is interesting to note that, in the east of the region where rice cultivation is nowadays coming up against major obstacles, farmers are veering towards rain-irrigated crops, on hills, by resorting of their own accord to terrace developments which they have seen in the demonstration Valley. The constant evolution of the socio-economic environment, which varies from one place to the next, means that the peasants and farmers in the Lake Alaotra region are drawing from a breeding ground of techniques, some of which they still remember quite clearly, in order to come up with new methods and practices which respond to the limitations of the day.

The development of cash crops (mainly, but not exclusively cotton) and their at times anarchic intensification, in the 1960s, have emphasized and spread the problems to a large part of the West African countries. The increase in small livestock with its habit of straying in search of pasture, bush fires, and over grazing by large livestock are all contributing in a significant way to the deterioration of both plant cover and soils.

Wind and run-off water remove unprotected top soil, thus carrying away the richest layers. Projects dealing with erosion are still mechanical (like, for example, the construction of low banks using grading machines in Burkina Faso, but they go hand in hand with planting projects, including shrub plantations, and simple management rules for farmers. Foresters are still being called upon to take action on behalf of local people but "the execution of anti-erosion works must be regarded as a form of land improvement ; this investment must be profitable and this profitability can only be guaranteed if local people, who are both informed and trained, make the most of the development operations which are undertaken on their farmland, by adopting the principles of advanced agricultural systems : manuring land, ridge crops, looking for profits by increasing yields rather than extending the area of cultivated land – whence the need for hands on training" (M. Mulard, D. Groéné, 1961).

Several biological methods have been developed from this period on : reforestation, needless to say, but with the support of local people, although their role is often reduced to that of wage earning labour, the planting of slopes and dikes around fish-farming ponds with straightforward results involving the choice of species, adaptation to soil conditions, and the choice of techniques, as in Cameroon in the Adamaoua region (M. Piot, 1966).

Anti-erosion contour-lines planted with fodder grasses which slow up the erosion of fields established on steep hillsides with a 60-80 % gradient in Burundi.

ON REUNION ISLAND : FODDER HEDGEROWS PLANTED ON CONTOURS TO COMBAT EROSION AND DIVERSIFY FARMING METHODS

In the Highlands of Reunion Island, agricultural diversification calls for incorporating livestock in agricultural systems in order to produce the necessary manure. Among small farmers, goat-rearing is nevertheless still jeopardized because of problems to do with the fodder supply at the end of the dry season. The development of fodder hedgerows planted on contours on their farms makes it possible to reduce this restriction while at the same time conducting an effective campaign against erosion.

The species *Calliandra calothyrsus* is particularly sought after by these farmers. Up to 70% the biomass of leafy stems is ingested by goats, which also carry out a systematic bark stripping operation. The root systems of these hedgerows are of considerable help in increasing the infiltration of run-off water. The hydraulic conductivity of horizon A exceeds 200 mm/h whereas it remains less than 50 mm/h on the remainder of the farm plot. Lastly, these hedgerows act as mechanical barriers and encourage the build-up of earth particles uphill from them, with the result that actual terraces are formed quite naturally after five or six years.

Calliandra calothyrsus was introduced to Reunion Island in 1990. Today it is being disseminated by the Chamber of Agriculture which sees to the seed supply from abroad. The seedlings are produced by the farmers themselves. As from 1995, and thanks to financial incentives acting as back-up for the upkeep of agricultural landscapes (Agro-Environmental Measures, Countryside Management Fund), the spread of fodder hedgerows has assumed an altogether new scope.

These recent developments represent an advancement of older practices. Some 20 years ago, contour-lines where food producing root crops grew were established on most geranium plots. In addition, farmers in lower altitude areas had for a long time been using another member of the Mimosaceae *Leucaena leucocephala*, which suffered a great deal of damage in the early 1990s when the island was invaded by the *Leucaena* psyllid (*Heteropsylla cubana*). The success of *Calliandra* thus took root with pre-existing practices associated with recent crop-protection restrictions.

In the late 1960s, the approach became more scientific with the quantification of erosion phenomena and their analysis. Madagascar represented an exceptional test bench, because of the scope and diversity of the erosion phenomena that could be observed there. Tests were set up with the cooperation of the Madagascan Institute of Agronomic Research, carried out in real environments, and the impact of human activities was tested. The importance of ground cover for soil protection was clearly demonstrated for tropical soils ; "the advantage of the Wischmeier formula is that it also highlights the need to exhaust all the so-called "biological" methods for combating erosion before becoming involved with costly and often problematic terracing projects" (M. Goujon, 1968).

One outcome of this was the enactment of management rules for farming areas based on soil and land types :

- on land for farming with anti-erosion developments and crop cultivation methods,
- in grassy steppes by the control of fires and the rotation of rangelands,
- for areas selected for protection with the help of reforestation programmes and banning access to grazing animals.

These changes are still going on in the direction of a concerted land management and development scheme. Analysis of land limitations includes those restrictions linked with local people and the socio-economic backdrop. Programmes are drawn up together with the local people affected, who take part in the choice of the methods used. Foresters thus turn into key players involved in the fight against erosion and the maintenance of fertility, on a par with agronomists, socio-economists, and pastoralists.

The various multidisciplinary teams have pursued their work to do with knowledge of the physical, biological and sociological mechanisms of natural resource management, as well as their projects developing agro-silvo-pastoral methods ensuring the maintenance of land and resource potential. Management and development plans are drawn up in cooperation with these different parties and, in particular, they make possible the establishment of an ongoing dialogue with the peasants and farmers concerned.

This development goes hand in glove with an essential evolution in the mentality of development agents (foresters in particular), as well as with a necessary training and back-up structure among local rural people who are having to cope with new responsibilities. This is the price to be paid for the sustainability of such programmes. ❑

THE REHABILITATION OF MINING SITES IN NEW CALEDONIA

New Caledonia has been affected by open mining operations, and is consequently suffering from far-reaching environmental degradation. This nickel mining, which has been carried on ever since 1870, involves the removal of soil over hundreds of hectares and the construction of many access tracks. Because there are no rules and regulations, the slag has for a long time simply been tipped into the valley. The development of mechanical methods and the sheer scale of the amounts of slag to be removed have prompted the mining companies to improve their extraction methods, which are now considerably reducing both damage and pollution.

However, the natural process of replanting the stripped areas is extremely slow and means that rehabilitation and replanting projects are necessary. CIRAD-Forêt projects have shown that exotic species failed to survive in these environments with very low levels of N, P, K and Ca and high levels of Mg and Ni. Conversely, two endemic nitrogen-fixing species are very well suited to this environment : *Acacia spirorbis* and *Casuarina collina*. The ease with which seeds may be obtained and their rapid growth now makes it possible to conceive large-scale replanting operations. But, under the guise of these two species, a return to the initial ecosystem still seems to be problematic.

The research carried out in collaboration with the ORSTOM has thus tended to focus on other species where seed gathering and growth can be planned on an economically viable basis. Satisfactory tests have been obtained with Proteaceae (*Grevillea exul*), a member of the Myrtaceae (*Carpolepis laurifolia*), several members of the Casuarinaceae of the genus *Gymnostoma* and various Leguminosae (*Storckiella, Serienthes*).

Some of these species live in symbiosis with nitrogen-fixing bacteria ; research is thus being carried out on improving plant installation by inoculating the best bacteria.

These replanting operations, which were for a long time restricted to small areas, now take up much larger areas, which in turn help to justify the interest of these studies.

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