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Auroville: Wasteland reclamation through rehabilitation of eroded soil

1. GENERAL INFORMATION

*1.1 Title of practice **or** experience*

Auroville: Wasteland reclamation through rehabilitation of eroded soil

1.2 Category of practice/experience and brief description

The practices described below relate to two series of experiments in environmental regeneration conducted in Auroville, an international community located in coastal Tamil Nadu, India. Selected plant species were used to rehabilitate eroded plots of

(a) red lateritic soils, and
(b) saline-alkaline shallow black cotton soils.

Similar experiments have been replicated in other places in and around Auroville, pointing to the possibility of using plants to hasten wasteland reclamation.

1.3 Name of person or institution responsible for the practice or experience

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1.4 Name and position of key or relevant persons or officials involved

As in 1.3 above

1.5 *Details of institution*

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1.6 Name of person and/or institution conducting the research

As in 1.3 above

1.7 Details of research person/institution

As in 1.5 above

2. THE PROBLEM OR SITUATION BEING ADDRESSED BY THE PRACTICE/INNOVATIVE EXPERIENCE

It has been estimated that about one-third of India's lands suffer, in one way or another, from severe degradation. Rendered unproductive by the destructive forces of wind and water erosion or by salinity and waterlogging, these vast stretches of land have been abandoned and neglected, while food production centres around a few fertile pockets.

According to the 1985 Report of the National Remote Sensing Agency in Hyderabad, 53.3 million hectares of land are to be considered as wastelands. The situation has not improved since and more recent figures put the number at 69 million hectares. The drylands and marginal lands, where for ages millets and pulses were grown, have suffered the most in the last three decades. Small and medium farmers, unable to make ends meet and drawn to the ever-growing cities, gradually left these lands to the destructive forces of wind and water erosion.

The common grazing lands have suffered even more. With the introduction of short-stemmed, so-called high-yielding varieties, fodder became scarce and the already overstretched grazing lands have consequently been utterly ravaged.

Food production is now centred around big dams in a few districts of the various Indian states. But even there, degradation has become a major problem.

On level lands with convenient road access and assured water availability, urban and industrial development stands in competition with agriculture. Hence there is growing pressure on the marginal lands to produce food crops which may be very different from the crops grown earlier on them.

Various conventional methods are employed either to bring these lands to a better state of preparedness by bulldozing them into a desired size and topography or, curiously enough, to provide clones of a few tree species such as eucalyptus or, better, genetically engineered plants which must be able to grow in a ravaged land. Putting a bandage on a wooden leg is the solution offered.

The practices described below were formulated with the conviction that meeting the challenge of food security, given a growing population, does not rest on expensive and high technology to stretch the limits of food production in better-endowed areas, but rather on restoring the productive capacity of the extensive wastelands.

Land reclamation commonly fails when carried out as a 'single-phased' attempt. Survival rates in many afforestation programmes are abysmally low, even when the plantations are of indigenous species. This is because the condition of the land is far worse now than the native condition in which local vegetation/crops once thrived. The experiments carried out address the problem of how to initiate regenerative processes on degraded lands and whether it is possible to use certain plant species for this.

The specific objective of the experiments was to regenerate degraded lands in two very different soil zones:

(a) red lateritic soils, and

(b) saline-alkaline shallow black cotton soils.

Both the areas suffer from severe environmental problems. In the red lateritic soil area, erosion had washed away all the topsoil, carved out gullies, and left behind a barren, stony, rugged expanse. The black clayey soil area suffered from severe alkali formation due to previous agricultural malpractices, trampling and denudation. **A** white crust of 3-cm thickness was observable on the worst affected portions and there was no vegetation whatsoever. Rehabilitation of such lands was successful through a judicious use of plants and conservation measures.

Care and reverence for the land, the crops that it yields, the seeds, respect for the animals and all forms of life, for the rain, water in whatever form, in short, for the fostering Mother who has nourished and sheltered **us** for centuries is the only way which will help humanity out of its environmental and thus agricultural impasse.

3. DESCRIPTION OF THE PRACTICE/INNOVATIVE EXPERIENCE AND ITS MAIN FEATURES

The technology presented here, combined with other complementary measures like soil and water conservation, makes it possible to regenerate for crop production even the most degraded lands very effectively and inexpensively. The combined measures present an alternative to the conventional reclamation methods (for instance, bulldozers, soil amendments, drainage using pipes, etc.) which are expensive and most often do not provide durable solutions. The only serious inputs are in fact time and care.

The practices described below concern rehabilitation work on sites representative of two types of soils:

(a) red lateritic soils, and
(b) alkaline black cotton soils.

Both the sites are situated in Auroville, an international community located in the Vanur Block of VRP District, Tamil Nadu, India.

THE REGENERATION OF RED LATERITIC SOILS

Description of the area

An area of three acres was earmarked for regeneration in a red soil area where erosion had carved out, in some places, huge gullies. The topsoil had entirely vanished. The subsoil on which the reclamation work was to be done, consisted of 80% stones and pebbles, with 20% soil having a pH of 5.2. The entire area before regeneration was, practically speaking, barren.

The average annual rainfall in the area is 1,200 mm, most of which is received in the months of October-November. Rainy spells are heavy and unevenly distributed – at times producing 200-300 mm of rain in 24 hours.

The aim was to regenerate the land for planting of timber wood *(Dalbergia latifolia, Pterocarpus santalinus, Kigelia pinnata)*, non-edible oil seeds like neem *(Azadirachta indica)* and minor fruits like *Diospyros melanoxylon*. Attempts at reforestation directly with these species had been made earlier but were unsuccessful. Their failure indicated that the environment and soil condition was not yet conducive to their growth even though most of the species tried out were indigenous. Experiments were therefore conducted, as described below, in, which select plant species were used to serve as 'pioneers' for improving the environment and soil condition prior to the planting of these desired timber and minor fruit trees.

Soil and water conservation

As a first step, soil and water conservation measures were undertaken. These consisted of

(a) contour bunds at regular intervals (earth bunds stabilised with local grasses), and
(b) water harvesting ponds in the gullies (made by constructing simple earth check dams).

Identification of pioneer species

Considering the devastated condition of the land, extremely hardy species were selected to serve as a 'pioneer vegetation'. The criteria for selection of a plant, shrub or tree as a pioneer are as follows:

(a) can grow in very poor soils under adverse conditions
(b) fast-growing
(c) can produce large amount of biomass in a short time
(d) grows easily from seed or easy to plant, without need for pitting or any other care
(e) drought- or flood-resistant
(f) capable of recovery after stress
(g) deep root system
(h) nitrogen fixing
(i) ability to unlock or accumulate nutrients from subsoil reserves
(j) unpalatable to livestock
(k) economically valuable, even if only to a minor degree

Four species of plants with at least five of the abovementioned characteristics were accordingly selected for trials as pioneers.

Two exotic species: *Acacia holosericea (coleii)* (first introduced in India by Auroville foresters); and *Stylosanthes hamata* (grown by some farmers as a fodder crop).

Two indigenous species: *Dodonaea viscosa* (grows wild here and there in surrounding areas); and *Cassia auriculata* (grows wild nearby, used for medicinal purposes and green manure).

Seed requirement

Seeds of *Stylosanthes hamata* were purchased from outside while the rest were collected locally. The seed rates used were as follows:

Acacia holosericea (coleii)	1 kglacre
Stylosanthes hamata	5 kglacre
Dodonaea viscosa	ad libidum
Cassia auriculata	1/2 kglacre

Method of sowing

Untreated mixed seeds of these species were broadcast on the barren land during the summer months. Only *Stylosanthes hamata* was sown at the onset of the monsoon rains. Broadcasting of seeds turned out to be a suitable technique because the land surface was covered with stones and pebbles which protected the broadcast seeds from being washed away with the rains. The seeds which did get carried off with the rains, accumulated in the trenches of the bunds. An alternative practice recommended for areas where the surface of the land is not as rough is to make, with a stick, small furrows in the soil, in which the seeds are sown.

Observations

Stylosanthes hamata

The *Stylosanthes hamata* was the first to germinate. The growth rate was excellent considering the soil condition. A fairly dense stand of plants developed, measuring between 10 and 15 cm height after six months of growth. After three years, a dense carpet of *Stylosanthes hamata* covered the whole area, except in places where waterlogging occurred. The *Stylosanthes hamata* was left uncut and quickly spread to adjacent areas. It now forms a lush, self-seeding soil cover. It is, however, possible to harvest the *Stylosanthes hamata* for fodder in the second year of growth.

Acacia holosericea

After the rains started, it took one month for the seeds to start germinating. Some seeds germinated even after one year, with the onset of the next rainy season. Plants grew up to 1 m in height in the space of a year. Some exceptional plants even produced seeds in their very first year. Within the space of three years, the *Acacia holosericea* had grown into dense bushes reaching a height of 3 to 4 m. At the end of the third year, a considerable amount of leaf litter had accumulated on the soil surface. In the fourth year, the bigger trees were ready for harvesting as firewood.

Dodonaea viscosa

The broadcast seeds started germinating 14 days after the rains commenced. They grew up to 20 cm in the first year. In the second year, two to three plants per square metre were observed, with an average height of 75 cm. Some leaf litter started forming in the second year. The soil development under three year-old *Dodonaea viscosa* plants was remarkable and these spots were found to be ideal for direct sowing of secondary species. From the third year onwards *Dodonaea viscosa* started spreading on its own by self-seeding. The *Dodonaea viscosa* plants were not harvested except occasionally as mulch material. They could be harvested for firewood from the third year onwards.

Cassia auriculata

Only a few plants grew, and with great difficulty at that. *Cassia auriculata* can thus not be considered a suitable pioneer in this particular area.

Planting of secondary species

After the third year of growth of these pioneers, the environment and the soil condition had improved considerably. There was sufficient protection against the desiccating summer winds, the soil was covered with plenty of organic matter and aerated as well by the root activity of the pioneers. Subsequently, planting of the secondary species was commenced. Secondary species were indigenous trees either bearing fruits or oilseed, or for use as timber. In this case, several species of trees were planted, of which the following performed very well: *Pterocarpus santalinus, Dalbergia latifolia, Tectona grandis, Khaya senegalansis, Diospyros rnelanoxylon, Hardwickia binata, Azadirachta indica, Terrninalia tornentosa, Terrninalia bellirica, Ernblica officinalis, Syzygium cumini, Anacardium occidentale.*

Nursery techniques, planting and after-care

Various methods were tried out to raise these trees:

(a) plastic bags
(b) nursery beds – planting bare-rooted seedlings
(c) direct sowing/dibbling
(d) broadcasting pelletted seeds

It was found that no general rule regarding the suitability of any one method over the others could be made. Species respond differently and various other factors like timing and working convenience are also at play. A combination of these methods, based on experience, was found to be the most practical approach. For instance, *Hardwickia binata* grows best if sown *in situ*. *Pterocarpus santalinus* is hard to germinate in the nursery but seedlings which are found abundantly under a mother tree can be carefully dug out and planted. *Santalum album* needs to be raised in plastic bags as the seeds, with their short viability, have to be sown immediately and this might not coincide with the monsoon.

For plastic-bag seedlings, small holes of 1 square foot were dug out and refilled with the same soil. **At** planting, two to three handfuls of compost were added and, in some cases, a little bio-fertilizer as well. The bare-rooted seedlings were defoliated before planting, retaining only the topmost young leaves. Dibbled seeds were found to perform better if a small hole was made and refilled with **a** handful of compost.

Planting was done at the onset **of** the monsoon. All the 'just-planted' trees were mulched immediately after planting. For mulching, *Stylosanthes hamata* and mainly the lopped leaves of *Acacia holosericea* were used. For this, the young branches of a close-by *Acacia holosericea* were lopped off and chopped into pieces of about two inches, using a small hand axe. **A** three-inch mulch layer was maintained around the planted trees the whole year round for the duration of three years. The *Acacias* growing very near – 1 m – to the new saplings were cut away completely. No watering whatsoever was done for the secondary species.

Survival rates were reasonably good – 80 %. Growth rates were excellent. For example, *Pterocarpus santalinus* grew up to *5* **m** with a girth of 8 cm and *Dalbergia latifolia* (rosewood) from 2 to 4 m with girths of 4 to 7 cm after three years.

THE REGENERATION OF ALKALINE SALINE BLACK COTTON SOILS

An area of land of 135 acres of alkaline shallow (0.5 to 1 m) heavily eroded black cotton soil was made available for an experiment in regeneration. On roughly one-third of this land a white crust of 1 to 3 cm was observable.

Another third had a thinner white crust. Here and there on the remaining area, cracks appeared on the land every summer. The soil pH was found to range between 7.2 and 8.5. The E.C. ranged from 1,500 to 2,300 mmhos/cm. At the start of the experiment, this area was virtually barren except for some grass sods on the better patches.

The degraded condition of the land was due to several reasons. With the change in diet from coarse grains to polished rice, the cultivation of *Paspalum scrobiculatum* (kodo millet), *Sorghum vulgare* (greater millet) and *Vigna siniensis* (cow pea) was stopped. The lands were left fallow. Overgrazing and severe trampling during the rainy season led to denudation and compaction.

Initial trials

An attempt was initially made to plant various recommended indigenous and exotic species.

Pits of 1.5 ft x 1.5 ft were dug to loosen the soil and filled up with the same earth. No soil amendments were used. Six-month-old seedlings were then planted. The species included: *Enterelobium dulce, Prosopis julifera, Albizzia lebbeck, Azadirachta indica, Pongamia glabra, Leucaena leucocephala, Acacia leucophloea, Cassia siamea.*

In the first few years, none of these species grew beyond the height of the seedling stage while many withered and dried, including *Prosopis julifera*. This disastrous experience indicated that the soil condition was not conducive to the growth of these recommended species. It was evident that pioneer species would have to be employed to bring back a certain balance in the soil before indigenous tree planting was attempted.

Soil and water conservation

Soil and water conservation measures in the form of earth bunds were undertaken on part of the land. In many places, this proved to have a negative effect on the seedlings planted in the area. During the rains, water started to stagnate for weeks on end, ultimately killing even the few grasses that had held out for years. This proved that soil and water conservation works need to be designed with care after studying the soil conditions, rainfall pattern etc. or else they might even have a detrimental environmental effect.

In black cotton soils, rather than earth bunds to control erosion, the planting of vegetative barriers along the contours is recommended. For instance, vettiver grass or valuable fodder grasses such as *Chenchrus* species, can be planted along the contour lines. Once the plants are established, they prevent erosion, the roots help in water percolation and the continuous buildup of organic matter improves the general soil structure.

Varying soil conditions and approaches

Variations in soil conditions were observable within the selected regeneration area. Specifically, three land categories were identified, namely 'most degraded', 'degraded' and 'poor', requiring different approaches (or combinations of them) in the regeneration work:

(a) The most degraded areas, where even *Prosopis julifera* suffered, die back in summers. The aim was to regenerate these areas for growing mixed forest species (category 1).

(b) In degraded areas, after some regeneration, a firewood cash crop of *Casuarina equisetifolia* could be grown (category 2).

(c) In the relatively better portions, which were however still very poor, simultaneously with regeneration work, dryland crops such as millets, pulses and oilseeds could be grown with organic inputs and appropriate soil and water conservation methods (category 3).

Approach 1: Use of leguminous species

A portion of land, totalling four acres from 'land categories' 1 (three acres) and 2 (one acre) was selected for these trials. **A** mixture of the following green manure seeds was broadcast:

Sesbania aculeata (common name: dhaincha) 2 kg/acre

Stylosanthes scabra 5 kg/acre
Sesbania bispinosa 250 gm/acre

The seeds of *Stylosanthes scabra* and dhaincha were purchased from outside while *Sesbania bispinosa* seeds were collected locally.

Untreated seeds of these species were broadcast during the summer rains (July-August, 360 mm) when most of the cracks had filled up, but without tilling the soil. Minor soil and water conservation measures were taken.

The area to be regenerated was fully fenced off so that no grazing or trespassing could take place.

Ipomea carnea, dry thorns and agaves were planted on raised bunds of 1 m wide and 0.5 m high. Further fences consisting of three-month-old seedlings of *Acacia melifera, Acacia seyal* and *Gmelina asiatica* were planted in holes filled up with soil and 3 **kg** of farmyard manure per hole. The area was further protected by a patrolling watchman. Non-trespassing was found to be an absolute prerequisite for speedy regeneration.

Observations

From the four-acre plot, only one acre of degraded land (category 2) had a dense stand of *Stylosanthes scabra* plants. *Sesbania bispinosa* came up here and there as individual specimens. The dhaincha plants never really made any growth and withered away soon after the end of the rainy season. The *Stylosanthes scabra,* however, grew up to1.5 m and, in some cases, more after two years. Grass started growing more abundantly between the *Stylosanthes scabra* plants. The grasses and *Stylosanthes scabra* were occasionally grazed by cattle (controlled grazing). After four years, this one acre was ready for planting *Casuarina equisetifolia.* On the remaining three acres of most degraded land, only a few plants **of** *Stylosanthes scabra* were noticed as it did not succeed in spreading by self-seeding.

Approach 2: Use of weed species

For this trial, a total area of five acres **of** land (separate from the land outlined for the first approach) was selected. It consisted of patches totalling four acres of the most degraded soils (category 1) and one acre of degraded lands (category **2).**

A mixture of weed seeds was collected from black cotton **soil** areas nearby. Care was taken to have as great a variety of weeds as possible. Large quantities of untreated seeds were broadcast on this five-acre plot at several intervals during the dry season. No soil preparation was undertaken.

Observations

A similar situation as in the *Stylosanthes scabra-Sesbania bispinosa* experiment developed here as well. Only in the patches of category 2 soils did the weeds grow thick and tall. After three years, these plots were ready for planting secondary species *(Casuarina)*.The weeds did not succeed in colonising the other 'most degraded' plots.

Conclusions

Though weeds from the locality can be used for regenerating heavily eroded black cotton soils, the experiment showed that hardier species of perhaps trees/ shrubs were needed to start a process of regeneration in the most degraded portions of the land.

Approach 3: Use of indigenous/exotic tree and shrub species to rehabilitate most degraded lands

Since the abovementioned approaches did not give satisfactory results in some of the most degraded areas, a screening process of various small trees and shrubs which could perhaps fare better was started. Both exotic as well as indigenous species were selected for an initial trial. The seeds of the exotic *Acacias* were obtained from a Forest Research Station in Tamil **Nadu.** The seeds of the indigenous shrubs, *Dodonaea viscosa* and *Cassia auriculata*, were obtained from nearby areas.

A five-acre plot of the worst soils was selected for this trial. Approximately one-fifth of it was covered with a white crust of 1 to 3 cm thick. The soil here was very hard. On the remaining area, the salt crust was much thinner and here and there, cracks in the soil appeared in the summer. The entire soil surface was virtually barren. No soil and water conservation measures were taken.

(a) Selection and first trial of various Acacia species

At first, **a** test was run to identify which plants would be able to function as pioneers. The exotic Australian *Acacias* selected included, among others: *Acacia auriculiformis, Acacia holosericea* (now *coleii),Acacia tumida, Acacia seyal, Acacia salicina, Acacia saligna, Acacia victoriae, Acacia sclerosperma, Acacia ampliceps, Acacia pachycarpa.*

The *Acacias* were raised in nurseries in plastic bags of 5 x 8 inches. The seedlings were planted out after three months in the nursery. To plant the

Acacias, only a small depression was cut with a pickaxe in the otherwise undisturbed soil, the depth and width of which was just enough to insert the seedlings after removing the plastic cover. No other after care such as mulching or watering was done.

Observations: After one year, it was observed that the growth of only *Acacia ampliceps* was remarkably good. So well, in fact that anyone would have thought that the plants were being watered and manured. *Acacia ampliceps* was therefore shortlisted for further experimentation. *Acacia seyal* also did well though was relatively less impressive. It was rejected, however, because of its thorniness.

(b) Second trial with **Acacia ampliceps** *and indigenous shrubs*

Among indigenous species, the following shrubs were selected: *Dodonaea viscosa* and *Cassia auriculata.*

While *Cassia auriculata* was found to occur in the adjacent black cotton soil area, it was not found in the experimental area. *Dodonaea viscosa* was not found at all in the back soils and was in fact accidentally selected for trial because seeds were so abundantly available in the nearby lateritic soil area.

The untreated seeds of *Dodonaea viscosa* and *Cassia auriculata* were broadcast after the first rain had partially filled up most of the cracks. A small number of 40 *Acacia ampliceps* seedlings, three months old, were planted here and there in the same area, using only a pickaxe. No after care in the form of mulching or watering was given.

Observations: The *Acacia ampliceps* grew in the form of a spreading bush and within a year, it had reached a height of 1.5 m. It was observed that from each mother plant, several root suckers had emerged. In one such case, 14 root suckers were counted in the first year, as far as 6 m away from an isolated mother plant. In the second year after planting, over 100 suckers ranging from 5 cm to 2 m in height could be found within a radius of 20 m from the very same single mother plant. In the space of three years, a dense cover of young trees 2 to 2.5 m high had developed. A thick layer of leaf litter 3-5 cm thick covered the once-barren soil. Various leaf-shredding insects were noticed. The soil underneath had drastically changed and the white crust had almost disappeared. One could also see, emerging spontaneously from within the leaf litter, various shrubs, grasses and trees like Neem *(Azadirachta indica)* and *Morinda tinctoria*. Wherever sunlight could reach the soil surface, the grasses grew tall and thick.

Surprisingly, the *Dodonaea viscosa* plants came up very well and grew to a dense stand of 20 to 30 cm in height within six months. The results with

***Cassia** auriculata* were relatively poor. Only a few seeds germinated and grew to a height of 10cm after **six** months. In the second year, the *Dodonaea viscosa* plants reached 90 cm and the leaf litter started forming below them. At the end of the third year, a dense stand of *Dodonaea viscosa* shrubs had developed over the entire area, with a corresponding increase in the leaf-litter formation.

The results of growing *Dodonaea **viscosa*** and *Acacia ampliceps* mixed together were rewarding. Even areas with 2 or 3 cm white crust were fully covered. After four years, the soils where 'nothing could grow' were sufficiently transformed to be cultivated for food and commercial crops.

Conclusions

Selected shrubs and small trees (indigenous and exotic) are excellent for the regeneration of even the most degraded lands. A relative disadvantage is that initially, *Acacia* seeds need to be acquired from outside. Once the trees are established, seeds can be harvested abundantly. Another relative disadvantage is that since *Acacias* and some weeds are prolific seeders, there is a chance that they might invade adjacent agricultural areas. This should be prevented by cutting the branches back at flowering stage. *Acacia ampliceps* was found to be easy to uproot, did not coppice and did not spread easily by seed. Several *Acacia* seeds like, amongst others, *Acacia arnpliceps* and *Acacia holosericea **(coleii)*** can also potentially be used as cattle feed and even as human food.

Strategies for integrating land regeneration with dryland farming

The best portion of the entire 135-acre plot consisting of category 3 soils had been identified for the cultivation of dryland crops like millets and pulses. Although this portion was in a much better condition than most of the land, it was by no means ideal for agriculture. The organic-matter content in the soil was very low. Some measures needed to be taken to improve the structure of the soil. The soil was susceptible to waterlogging and erosion during the monsoon. **As** caution was needed while implementing soil and water conservation methods like bunding, some other more appropriate technique needed to be used to control erosion.

At first, an attempt was made, on a four-acre plot, to integrate measures to restore soil life and improve fertility along with some farming trials with dryland crops using only organic inputs.

Method

In a four-acre plot, *Canavalia rosea* was planted together with perennial pigeon pea in lines 4 m apart (line to line). The pigeon pea was grown not as a food crop, but rather, given its deep root system, to serve as a hedge and form alleys. The seeds were sown during the summer rains. **A** tiny portion of the seed coat of the *Canavalias rosea* was cut away with a nail cutter.

The clipped seeds were sown at 1 ft intervals and untreated seeds of pigeon pea, every 2 ft. In the 4 m spaces between the rows of pigeon pea and *Canavalia rosea*, millets, pulses and oilseeds were cultivated using organic inputs only.

Observations

The pigeon pea grew as normal within a year into dense, tall bushes. The *Canavalia rosea* grew vigorously and its vines were pruned when needed in order that they did not get entangled with the millet and pulse crops, grown between the hedges. Instead, after the harvesting of the crop, the *Canavalia rosea* was allowed to grow into the Pigeon Pea shrubs. This severely reduced their yield but was not considered a loss, as the prime objective here was to maximise biomass production. Gradually, the pigeon peas were covered with *Canavalia rosea* and even the 4 m open space between the hedge lines was gradually covered by the *Canavalia rosea* vines. In fact, as the season became drier and hotter, the *Canavalia rosea* seemed to grow more and more vigorous. With some sporadic pre-monsoon showers, an incredible amount of biomass formed all over the four acres.

For planting the following season's crop, a tractor-driven disc harrow was used to cut and mix the *Canavalia rosea* biomass into the top few inches of the soil. The crop seeds were sown at the same time. In addition, the pigeon peas were trimmed and the prunings put down as mulch. While the crop was growing, the growth of the *Canavalia rosea* vines was kept under control by regular pruning with a simple hand sickle.

In the second year, some native grasses began to appear spontaneously in the lines between the *Canavalia rosea*. Strips *50* cm wide had formed, composed of the hedge plants along with various weeds and grasses. The grasses were regularly harvested for fodder or were sometimes also used as mulch.

The perennial pigeon pea, however, started to die in the second year. It was observed that *Canavalia **rosea*** lost some of its vigour in the second year and almost stagnated in the third year.

While in the first year the crop yield was poor, in the second year they grew as per normal standards. Since then, the crop yields, depending on weather variations, continued to improve.

Conclusions

The strips, planted with *Canavalia rosea*, pigeon pea and where later grasses came up spontaneously, acted as an effective soil-erosion barrier. Rain water which could not penetrate the soil could flow off towards a water harvesting pond without carrying soil with it. Enough biomass could be produced during the dry summer months for green manuring the following mixed pulse-millet-oilseed crops.

Pigeon pea had to be replaced. Instead, *Gliricidia sepium* was chosen because it is easy to establish and has a longer life and because of its luxuriant growth. *Canavalia rosea* had to be resown after two years. Young pods of *Canavalia rosea* and leaves of *Gliricidia sepium* were also cut in the summer for fodder when other forage became scarce.

GENERAL CONCLUSION

Evaluation of the usefulness of specific plant species in their role as pioneers is context- dependent. For instance, the fact that legumes and weeds were found to be useful in one part of the experimental plot but not in another, does not diminish their importance. However, the most dramatic pioneers (in the sense of being able to colonise severely eroded portions) in red lateritic soils were *Acacia holosericea*, *Stylosanthes hamata* and *Dodonaea viscosa;* in black cotton soils, *Acacia ampliceps* and *Dodonaea viscosa.*

The collective conclusion of the above experiments **is** that select plant species can indeed play a major role in reversing erosion and restoring soil health. It is possible to bring back to productivity even the most degraded soils.

The practices described above were subsequently followed elsewhere in and around Auroville and have had a remarkable effect on the local environment. Specifically, many areas in Auroville now have a lush forest cover (after 20-25 years), wildlife has returned, erosion is under control, groundwater levels have recorded a marked improvement and the micro-climate has changed. Some lands have even been transformed from their hitherto eroded condition into productive organic farms. Efforts are underway to extend these successes to village lands in the entire bio-region. Outreach programmes have also helped in disseminating the methodology to other Indian states as well.

For the successful rehabilitation of eroded lands using plant species, there are certain prerequisites:

(a) Total closure to trampling, grazing and trespassing is essential for speedy regeneration of severely eroded and denuded lands. Due to such protection, some weeds and grasses are likely to come up and spread on their own. This protection was achieved by planting live fences of agaves, and other thorny local trees, shrubs and creepers.

(b) Soil and water conservation measures must, as far as possible, be undertaken. Several possibilities exist offering low-cost, unorthodox, appropriate techniques, using locally available resources and skills, to conserve soil and water (for instance, the simple digging of numerous small pits on a slope, eventually along the contours). **As** this is not the focus of this paper, the topic has been covered summarily.

The failure to meet one of the above conditions greatly undermines the efficacy of the other and the overall process of land rehabilitation is slowed down. For instance, plant species will not be able to perform their function as pioneers as well in an area that is unprotected from grazing and trespassing.

The practices, however, cannot be considered a 'package' applicable anywhere. **As** plant performance varies greatly even within a similar soil type, identical results cannot always be expected in another area. There are of course vast expanses in the dry tropics where the species mentioned would do very well. There is a lot of scope for systematic and extensive research along these lines. The general methodology can certainly be followed to design similar experiments (identify suitable species) and develop similar sets of practices for various agro-climatic zones.

The practices are relevant, considering the larger problem of India's expanding wastelands, which is a matter of concern to policy-makers and conscious citizens. They address the challenge of food security, given the growing population and the fact that the urban sprawl and industries are replacing the best agricultural lands. The only sustainable solution is to stop further degradation, and unlock the productive potential of our vast waste and marginal lands. The practices described do not require any special skills for implementation and are effective and inexpensive ways out of the impasse.

4. DESCRIPTION OF THE INSTITUTION RESPONSIBLE AND ITS ORGANISATIONAL ASPECTS

Bernard Declercq is a long-term resident of Auroville, an international community of 1,400 members from around the world dedicated to human unity, located in coastal Tamil Nadu, India. Auroville functions autonomously and has been granted a special legal status by the Government of India. Since its inception in 1968, the early settlers of Auroville have dedicated themselves to restoring the surrounding lands which were ravaged by erosion. Bernard has been involved in afforestation, land reclamation and regenerative organic agriculture for 23 years. He has also conducted several training/awareness programmes for farmers, non-governmental organisation (NGO) staff and government officers and for the past three years, he has co-ordinated a national network of organic farmers, named ARISE. The Auroville Greenwork Resource Centre (AGRC) was the institution that oversaw the practice of wasteland reclamation. It is now no longer active.

5. PROBLEMS OR OBSTACLES ENCOUNTERED AND HOW THEY WERE OVERCOME

Not applicable.

6. EFFECTS OF THE PRACTICE/INNOVATIVE EXPERIENCE

The experience has helped in extending reclamation work using the same methodology to other areas of the Auroville bio-region. The cumulative effect of regeneration projects designed along similar lines in Auroville and the surrounding village areas has been the restoration of land fertility, a spectacular re-establishment of forest cover and a noticeable improvement in water levels. By means of outreach programmes, the know-how has also been disseminated in other Indian states as well. A very successful rehabilitation programme was initiated in the desert areas of Rajasthan state as an outcome of the experiences described here.

7. SUITABILITY AND POSSIBILITY FOR UPSCALING

The scope for upscaling is ever present. The practices described have involved testing a limited number of plant species. The search and experimentation will continue. Moreover, similar practices for different regions would need to be tailored to regional variations in soil type, climate etc.

There is a need to study how the leafy biomass produced by the pioneer species can best be used to enhance the growth of desired secondary species. For instance, in the experiment on red lateritic soil, termites were harnessed to 'process' the ligneous ***Acacia*** leaves used as mulch material. There could be more efficient ways to make the most of this available biomass.

8. SIGNIFICANCE FOR (AND IMPACT ON) POLICY-MAKING

The practices described here assume larger significance, considering the rate at which wastelands are expanding. Coupled with urban/industrial development encroaching on prime agricultural lands, the question of food security looms large. The only sustainable solution seems to be that of restoring the productivity of wastelands and marginal lands. Cost effective, simple technologies using low external inputs do exist. The use of plant species in the rehabilitation of eroded soils is one of them.

9. POSSIBILITY AND SCOPE OF TRANSFERRING TO OTHER COMMUNITIES OR COUNTRIES

While it might not be possible to transpose to another area the specific details of the practices described because the performance of plant species **is** location-specific, the general approach and methodology can indeed be followed in designing similar trials anywhere else in the world. There are of course vast expanses in the dry tropics where the species discussed would do very well.