The role of forestry in combating desertification

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Yafong Berthe [1]

SUMMARY

Today all nations are concerned about the phenomenon of desertification.

Policies, strategies, projects and programmes have been formulated and implemented at both world and country level. At the same time, the role of forests and trees in land use should become more important in order to restore degraded land, support agriculture, strengthen food security, safeguard water reserves and enhance the well-being of local people.

Keywords: Desertification, forest, management, control, soil.

1. INTRODUCTION

The disastrous drought in the years 1968-1973 prompted the world community to examine the state of arid territories and to formulate strategies to combat desertification.

The Rio Summit in 1992 defined desertification as the degradation of soils in arid, semi-arid and dry subtropical zones under the impact of various factors, including climatic change and human activities.

In effect, when arid zones are affected by ever-increasing soil degradation, reducing reserves of productive soils, an environment similar to desert is created, hence the term desertification. Desertification not only destroys the productive resource base, but involves a loss in genetic resources, increases atmospheric dusts, upsets the natural recycling of water, and sends national economies into disarray, leading to the migration of peoples. Desertification is synonymous with a loss of productivity and biological and economic complexity in croppable land, and grazing and wooded areas.

The most serious consequence is the popular misery and poverty that results from desertification.

Today desertification affects a quarter of the world's land area; in Africa, more than a billion hectares are either moderately or extensively affected by desertification.

In Mali, desertification is vitally important as if affects the whole land area and is relevant to all socio-economic sectors. Forestry activities are considered the spearhead in combating desertification.

2. THE IMPORTANCE OF FORESTS IN MALI

The national forest estate covers 100 million ha, most of which is made up of woody formations covering 32.3 million ha. Agricultural plant formations contribute significantly to this estate, covering 5.8 million ha of cultivated and fallow land and 9 million ha of reserves.

The national forest estate is split up among 6 agro-climatic zones: Saharan, north Sahelian, south Sahelian, north Sudanese, south Sudanese, and Guinean.

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This localized ecological diversity is characterized by very contrasting forest contexts: shrub-like savannah in the north which yields less than 10 m /ha, striped bush (covering 25% of the southern part of the country) with volumes from 20 to 40 m /ha, forests in the Sudano-Guinean zone with yields of between 50 and 80 m /ha and sometimes more than 100 m /ha in tunnel like forests and forests in the west of the country.

Forests play an important role in socio-economic development and in maintaining ecological equilibria. The forestry sector contributes 2% to GDP. Besides fuelwood, forest have various uses: poles, posts, forage, honey, medicines, hunting meat, fruits, nuts, bobab leafs, gum, matwork, basketwork, watershed protection, restoration of soil fertility, erosion control. Forests also represent rangeland for livestock breeders and land reserves for farmers.

But forests are in continual decline due to drought and largely unrestrained exploitation, which are manifested by progressive environmental degradation.

3. DESERTIFICATION CONTROL

Desertification control is defined as "activity involving the integrated development of land in arid, semi-arid and dry sub-humid zones with the objective of sustainable development, aimed at preventing and/or reducing land degradation, repairing partially degraded land, and at restoring desertified lands."

People in arid zones have always applied elaborate types of land use such as stone-built dykes.

In 1973, Sahel countries set up a centre for desertification control. Since then, desertification control (DC) projects, programmes, policies, and strategies have been actively formulated and implemented.

In 1977, the UN conference on desertification led to the setting up of the United Nations Environmental Programme (UNEP) and to the formulation of a DC action plan. In June 1994, the UN Convention on desertification control was adopted in countries seriously affected by drought and/or desertification, particularly in Africa.

In Mali, the concept of DC is defined as a global approach to the rational and sustainable use of natural resources. The aims of DC are added to those of social and economic development. In 1985, Mali adopted a National Desertification Control Plan, broken down into eight sub-programmes containing 48 main projects. The outline of national forestry policy was adopted in 1995.

In 1991, the Plan's provisional monitoring and assessment unit revealed the existence of 236 projects for desertification control and natural resources management, covering various activities:

- Hydro-agricultural management (dams, ponds, shallows);
- Promotion of agricultural production;
- Erosion control (dykes, dune fixing);
- Agroforestry (tree nurseries, reforestation, regeneration, windbreaks, quickset hedging, savannah park management);
- Pisciculture development (stocking, pond pisciculture, coastal development);
- Forest and plantation management and planning;
- Bee-keeping;
- Promotion of livestock production: fodder production, rangeland management;
- Hydraulic works at village level: wells, fodder, and water supplies;
- Domestic energy: biogas, butane gas, improved fireplaces;
- New technology: solar water-heating, solar lighting, karité press;
- Accompanying activities: opening up, teaching people to read and write, agricultural banks, cereal stocks, health, communication.

An analysis of the results of these projects demonstrate successes (improved cooking stoves, dune fixation, anti-erosion control, natural forest management, water control, river mouths) as well as non-successes (industrial reforestation, total hunting bans, total bush fire bans).

I f these activities had only a minor impact, it is worth noting that certain results remain definite assets in DC, including:

- the training of technical staff and rural people;
- improvement in the state of knowledge of resources;
- improvements in equipment and infrastructure;
- the promotion of new technologies;
- an increase in productivity and production during years of normal rainfall; and
- more effective involvement and accountability of rural people.

4. THE ROLE OF TREES AND FORESTS IN DESERTIFICATION CONTROL

Forests have a major role to play in reversing desertification trends. However, tree cultivation is much more difficult in arid zones: growth is slower, survival rates are lower and plant protection presents great difficulty. Additional problems include variability in ecological and socio-economic conditions, making it difficult to classify arid lands for mono-uses; low popular participation in arid zones in national development owing to the prioritization of favourable areas for development; lack of investment and elaboration of scientific elements to maintain and develop productivity.

These various constraints mean that forestry activities in arid zones are oriented toward both production and protection and that they benefit on a large scale from the positive effects of soil and water conservation generated by plant cover, enabling the environment to be kept stable.

Tree cultivation in arid zones is not only a forestry practice, but also a land use exercise. In Mali, the main types of forestry activity aimed at combating desertification are afforestation, natural plant management, silvo-pastoral systems, agroforestry systems, watershed management, and the setting up of national parks.

4.1. Afforestation

Reforestation is an effective method for repairing degraded lands. Above 300 mm, dry reforestation can be effective when the plantation site is wisely chosen and stream water collection techniques are applied. Below 300 mm, extra watering is required according to the particular features of the intervention area. This watering is done by hand. In the interior delta of the Niger and beside the irrigation canals along the water courses, water is readily accessible and the irrigation increases tree growing capacity.

Large-scale reforestation was particularly used in the 1970s and 1980s. Today reforestation is undertaken by local people and private individuals, and the most widely used species are eucalyptus, neem, *terminalia, ficus*. *tamarix*, *acacia* sp., karité, néré, fruit trees.

The utilization of trees and shrubs is a widely used method of dune fixation. In Mali, the project to control silting and sanding up in the Gao and Timbuctu regions applies the following method: dunes are first stabilized mechanically using fencing techniques, which constitute a linear obstacle facing the prevailing wind so as to reduce speed and accumulate moving sand, fixing it mechanically. Some time later, dunes are fixed indefinitely by installing perennial arboricultural vegetation. The species used in Mali are *Tamarix aphyla, Balanites aegytiaca, Euphorbia balsamiphera, Prosopis juliflora, Acacia radiana*, etc, as well as various perennial grasses.

Windbreaks and shelterbelts have proven to be effective in arid zones. Benefits include better microclimate, reduced wind erosion, greater yields from crops and livestock, lower heating costs, and

availability of forage, fuelwood and other wood products. They may be made up of one or several rows that are perpendicular to the prevailing wind. The application of windbreaks is not very common in Mali, and can be seen mainly in the Niger zone and in orchards. In the northern and southern parts of the country, mixed results have been obtained from the following projects: the wood project in the village of Segou, the agroforestry project in Koro, reforestation projects in villages in 50 areas, and the support for village forestry project in Koulikoro.

4.2. Natural vegetation management

Natural vegetation not only guarantees soil cover, erosion protection, and regulation of underground water reserve levels, but also wood resources, forage, and non-wood forest products. In areas of weak and uncertain rainfall, farming is risky and gives way to grazing which is a subsistence form of land use, generating extra pressure in addition to direct cutting and harvesting, and leading to the disappearance of surface vegetation. Effective management systems aim at conserving the original perennial cover in order to create a stable but productive environment.

The level of specific knowledge on forest ecology in arid and semi-arid zones makes natural vegetation management problematic.

Nevertheless, satisfactory results can be obtained from the control of rotation systems, brush fire control, and rational management of grazing. These approaches have been used in the forest management project in Kita, the project for managing classified forests in Segou, Baraouéli and Macina, and the forest and food security project in Sikasso, all carried out in Mali.

4.3. Agroforestry systems

In arid zones, agroforestry practices help mitigate the consequences of irregular and unforeseen rainfall and of economic fluctuations; they do this through the regular and reliable supply of substitute products for man and livestock, reducing pressure on local resources and encouraging sustainable production.

The traditional system in Mali involves keeping trees for multiple uses on agricultural land, providing both cover and a source of fibrous fruit, energy and forage (acacia, néré, karité).

In some instances, fertility and soil moisture conservation are strengthened by the introduction of versatile trees or shrubs.

4.4. Silvo-pastoral systems

Desertification control in the Sahel in general and in Mali in particular combines ecological and socio-economic factors in order to ensure sustainable development.

Development strategies aim for a total production that involves *inter alia* contributing to animal production through silvo-pastoral systems, supplying forage stocks such as forage trees and shrubs.

Arid over 58% and semi-arid over 30%, Mali is a renowned producer of livestock, which represents the second largest export. For nine months of the year, cattle nutrition is mainly air-borne fodder, particularly in areas where rainfall is less than 800 mm.

Nevertheless, persistent drought has meant that silvo-pastoral systems have developed in the south, where rainfall oscillates between 800 and 1 200 mm. Against this background, grazing is fast becoming the main form of land use. The main woody species appreciated by cattle are acacia in Sahel areas, mainly *Acacia albida* and *Pterocarpus erinaceus*, and *Khaya senegalensis* in sub-humid zones. This is why these species are protected not only be law but also by the rural people who profit from them.

4.5. Watersheds and small irrigated perimeters

Current forestry legislation provides for the protection of hillslopes and riverbanks. This illustrates the important role that trees and forests have to play in watershed management and in regulating the flow of water courses.

Although watershed management is not established practice in Mali, it is set practice that their exploitation should combine soil protection and restoration techniques with proper works regulation in order to avoid erosion and conserve plant cover.

As for small irrigated perimeters along water courses, especially in the Sahel zone, the agricultural context ensures that their exploitation does not damage riverbanks to bring about a shrinkage in riverbeds.

4.6 Conservation of national parks

National parks play an important role in the conservation of genetic resources and therefore represent a useful reservoir of species for the selection of valid and drought-resistant varieties. Protected areas in Mali cover 3 920 000 ha.

5. CONCLUSION

It is no longer necessary to demonstrate that countries acknowledge the need to combat desertification. Policies, strategies and programmes are being formulated everywhere, and the role of forestry in DC is highlighted.

As in other affected countries, desertification control activities are implemented in Mali, based on socio-economic and cultural criteria and upon developments of traditional practices.

These practices now need to be made more rational and effective.

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Summaries of voluntary papers

(also published in Spanish, French and Turkish)

STABILIZATION AND REFORESTATION OF AEOLIAN FORMATIONS

Tolba Kamel [1], Makhlouf Laïd [1] Sadji Ahmed [1]

Two experimental plots of 50 ha were established in El Mesrane, Wilaya of Djelfa. The tests carried out for almost a decade (1983-1992) have given encouraging results with regard to combating sand invasion through techniques of mechanical and biological fixation of aeolien formations. In this respect, many dead vegetal materials, such as branches of Alep pine and rose laurel, offer good fixation capacity of sand grains and are an efficient tool against aeolian activity. They also permitted a good biological recovery within a few years. The species planted have replaced the provisional effect of mechanical fixation. The plantations of *Tamatix gallica, Retama retam* and *Atriplex* grew higher than the palisades within two years. This allowed us to select the most appropriate species from the point of view of fixing capacity and adaptation to dune environment. Materials such as fibro-cement palisades and bitumen were abandoned because they presented many drawbacks. However, the use of plastic nets is deemed very efficient in mechanical fixation since it resists the climatical conditions. Its lasting quality exceeds five years, moreover availability and rapidity of execution are also an advantage. The palisades of branches and plastic nets have produced a stable micro-climate in the dune environment, thus allowing the success of the plantations.

Keywords: Algeria, steppe, dunes, fixation.

[1] INRF, BP 37, Cheraga, Alger, Algeria.

TESTING RESEARCH OF POPLAR DEEP PLANTING IN KEERQIN SAND AREA

Guosheng Yu [1]

The Keerqin sand area has a barren soil of poor condition, a severe climate and low population density. A trial of poplar deep planting was carried out in 1992. The survival rate of deep planted poplar was almost 100%. The technology of deep planting will be extended to other parts of the area. A medium-depth planting trial had a survival rate of 78.5%, a trial of planting machines showed that the medium-depth planter was very efficient in poplar planting. Another important factor in the high survival rate was related to pre-planting treatment of the cuttings. These were buried during the winter and soaked in water for seven days prior to planting.

Keywords: Poplar, deep planting, survival rate.

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DESERTIFICATION IN CHINA AND REHABILITATION TECHNIQUES: A BRIEF INTRODUCTION TO CHINA NATIONAL RESEARCH AND DEVELOPMENT CENTRE ON COMBATING DESERTIFICATION

Lu Qi [1]

The China National Research and Development Centre on Combating Desertification (RDCCD) is established to assist the Chinese Government to implement the UN Convention to Combat Desertification, to facilitate China and other countries to combat desertification by developing profitable techniques and environmentally improved practices, and to meet the needs of poverty alleviation. The major tasks of the Centre are set as follows, a) to provide consulting services in the field of policy-making and planning; b) to organize and coordinate national or international research programmes and the implementation of projects; c) to focus on import substitutes and develop the export potential of its technologies; d) to develop and propagate extension programmes through education, training and extension systems; e) to undertake, aid and promote international projects; f) to establish and improve a national information network for combating desertification; g) to do other things considered necessary to attain the above.

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AFFORESTATION OF ARID WASTELANDS THROUGH ENERGY PLANTATIONS A CASE STUDY FROM INDIA

Kulbhushan Balooni[1], Katar Singh [2]

India has vast tracts of arid wastelands. Afforestation of these wastelands is one of the alternatives for rehabilitating them. Energy plantations is one form of afforestation for efficient utilisation of arid wastelands and could help in stabilizing soil conditions as well as meeting the increasing demands for firewood and fodder. Considering this, the Government of India has started energy plantation programmes in various parts of the country to promote non-conventional sources of energy. In this paper, an attempt has been made to elaborate different aspects of energy plantations on arid wastelands carried out by the Gujarat Energy Development Agency in the village of Lathedi in District Kachchh of Gujarat State in India. The case study revealed that the model of energy plantations on wastelands in the Kachchh was technically and economically viable and may be replicated in other parts of India and in other countries of the world. The energy plantations are desirable also from the environmental point of view.

Keywords: Afforestation, arid, energy plantation, wastelands, environment.

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COMBATING DROUGHT AND DESERTIFICATION BY ENLISTING PEOPLE'S PARTICIPATION: STRATEGY FOR ECOLOGICAL RESTORATION

Bharat Lal [1]

Desertification is the degradation of land in arid, semi-arid and dry sub-humid areas, caused primarily by human activities and climatic variations. It occurs because dryland ecosystems, which cover one-third if the world's land area, are extremely vulnerable to over-exploitation and inappropriate land use. Poverty, increasing anthropological pressure, deforestation, overgrazing and bad agriculture practices, all contribute in undermining the land productivity. Forest loss by constantly fiddling with nature in areas like Gujarat with a dry climate, poor soils and high biotic pressure is often followed by desert formation. Once deserts are formed, it becomes extremely difficult to restore the area to its natural habitat, due to associated changes in micro-climate, loss of fertility and resultant problems in establishing seedlings, and the social problems that come with desert formation. Prime natural resources – fertile top soil, vegetal cover and healthy crop – are the first victims of desertification and people themselves begin to suffer when food and water supplies become threatened, which leads to famine, mass migration and colossal economic loss.

To deal with the situation, the state has over the years made considerable efforts to combat desertification in consonance with its diverse socio-economic circumstances and requirements, with varying degree of success and has gained invaluable experience. The Forest Department, with active participation of local people, NGOs and VLOs is carrying out eco-restoration works on the basis of a fundamental, ecosystem-based approach, greater respect for traditional indigenous knowledge and wisdom, and multi and interdisciplinary management and developmental models to restore the ecological balance, simultaneously improving the socio-economic conditions of local people. Well-planned SMC works and improved habitat protection has given the desired result. As SFR-1995 reveals, in the Junagadh District alone where, large-scale SMC works have been done with improved habitat protection, 104 km^2 open forest (density 0.1 to 0.4) was converted into dense forest (density 0.4 and above) whereas, during corresponding period, in rest of the country an area of only 76 km^2 was converted into dense forest.

To achieve short, mid and long-term objectives of eco-restoration programme along with the goal of combating drought and desertification, the need for a holistic overview and integration seems paramount. Integration is required at two levels: a) all environmental, social and economic factors including impacts of various socio-economic activities on ecosystem and its resources; and b) the interaction of all environmental and resources components together. In the state of Gujarat, Rajasthan, Madhya Pradesh, Maharastra and other semi-arid and arid regions of the country, carrying out soil and moisture conservation and allowing the area to regenerate naturally is the appropriate strategy. Simultaneously sharing the benefits, e.g. non-wood forest products, grass and water, by local communities without emphasizing on the final harvesting of crop, is the most effective way to reverse the process of degradation and desertification.

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MYCORRHIZAL DEPENDENCY OF *ACACIA NILOTICA* AND *EUCALYPTUS TERETICORNIS* TO INOCULATION OF INDIGENOUS VA-MYCORRHIZAL FUNGI CONSORTIUM IN MARGINAL WASTELAND SOIL

Mahaveer P. Sharma, Naveen P. Bhatia, Atimanav Gaur, Alok Adholeya [1]

The response of *Acacia nilotica* and *Eucalyptus tereticornis* to phosphorus application and VAM inoculation with the native consortium of vesicular-arbuscular fungi (VAM) were evaluated in marginal wasteland soil under nursery conditions. Both the species showed positive growth response to mycorrhizal inoculation at all soil P levels except at the highest, i.e. 30 ppm. Significantly, higher dry-matter yield was obtained in both the species at soil P level of 7 ppm over the native soil P level. Beyond 7 ppm soil P level, the dry matter did not improve significantly. Percent root length colonized by VAM in both tree species was negatively correlated to soil P. VAM inoculation significantly improved shoot P concentration of *Acacia nilotica* and *E. tereticornis* at all soil P concentrations. A consistent increment in P uptake by *Eucalyptus* seedlings with increased soil P levels suggested that an effective symbiosis develops between VAM fungi and *Eucalyptus* roots. Mycorrhizal dependency of both species declined with increasing concentrations of available soil P.

Keywords: Infectivity potential, *Acacia nilotica, Eucalyptus tereticornis*, native VAM consortium, phosphorus requirement.

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THE ROLE OF FORESTRY IN COMBATING DESERTIFICATION IN THAR DESERT, INDIA

D.N. Tewari [1], R.N. Mishra [1]

The desert ecosystem poses difficult problems to man. The forest area in Thar desert is scanty with poor growth of vegetation. While the productivity is extremely low, the demand for fuel and fodder is very high. Consequently there is over-exploitation of vegetation cover accentuating the pace of desertification.

To cope up with this situation, desert afforestation activities have assumed an important place. Of the total budget allotted for desert development, 40% is utilized for forestry and pasture development. People have been motivated to practise agroforestry, silvipastoral and other types of plantations.

The Arid Forestry Research Institute, Jodhpur, is strengthening the research base on desert ecosystems. It has also started extension of development of technologies and education of masses about environment improvement by accelerating the pace of afforestation and sustainable management of tree groves.

Tourism is developing in this desert, where visitors come to enjoy the solitude, silence, and serene beauty of the desert. Avenue plantations of neem and *Tecomella* attract the attention of all.

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IRRIGATED PLANTATIONS IN ARID ZONE OF WESTERN RAJASTHAN

A. K. Upadhyaya [1]

Irrigated plantations in the arid zone of western Rajasthan (India) started almost 25 years ago using water from the Indira Gandhi Canal. An area of 0.18 million ha has been planted. Of this area, about 29 500 ha is command area and rest is uncommand area. The command area plantations, using flow irrigation methods, are almost 2% of the total command land of the Indira Gandhi Canal Project. Based on the studies conducted in the area, the mean annual increment of various tree species, viz. *Dalbergia sissoo*, *Eucalyptus camaldulensis*, *Acacia nilotica*, *Prosopis cineraria*, *Tecomella undulata*, *Ziziphus maurtiana* and *Acacia tortilis* has been discussed. The mean annual increment in 5-year old plantations was found maximum in the case of *Eucalyptus camaldulensis* (42.75 m^3/ha) and minimum in *Prosopis cineraria* (5.23 m^3/ ha). Strategies are suggested in the paper n order to effectively combat desertification in the arid zone of western Rajasthan.

Keywords: Combating desertification, irrigated plantations, afforestation techniques, mean annual increment.

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STRATEGY FOR SUSTAINABLE FORESTRY IN ARID AND SEMI ARID LANDS OF INDIA: A CASE STUDY OF RAJASTHAN

A.K. Upadhyaya [1], R.P. Kapoor [2]

Hot arid, semi-arid and sub-humid regions of India are affected by the process of desertification. The world famous Thar desert, with its great biological significance supporting unique endemic species of desert flora and fauna, is severely affected. Indigenous technical knowledge regarding forest and wildlife protection and management already exists in the area. There is a need to incorporate these traditional value systems into the ongoing and future programmes of Natural Forest Resource Management. This can be achieved only through area and region-specific strategies. The strategies which centered on joint forest management having a watershed/cluster approach with the aim of enhancing land productivity have proved a powerful tool in combating desertification and improving the socio-economic conditions of the people of Rajasthan.

Keywords: Combating desertification, micro-planning, joint forest management, watershed development, cluster approach.

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GROWTH AND PRODUCTION MODELS OF *POPULUS NIGRA* CV ITALICA IN ARGENTINE PATAGONIA WINDBREAKS.

Peri, Pablo Luis [1], Guillermo Martínez Pastur [2]

The principal disadvantage for agricultural development in south Patagonia is the wind and an alternative is the installation of windbreaks that allows the plantation of fruit-trees, pastures and horticultural crops. The forecast of height growth dynamics allows the estimation of the area protected by windbreaks, while it could be possible to establish the economic efficiency of timber production through the forecast of the volume growth and crown dynamics. The aim of this work was to establish biometric models for *P. nigra* CV Italica windbreaks for several site and plantation conditions. Total volume with bark, site index (11.5 to 21.5 m SI_{40}), DBH growth (two inter-tree distances and two crown classes) related to age and site index, and crown dynamic equations were presented. The developed models possess very good biological significance. The multiple factors that influence windbreak growth could be explained through easy mensuration variables. These models offer a simple tool for agricultural and forest planning both for crop protection and wood production from windbreaks in south Patagonia.

Keywords: *Populus nigra*, windbreak, growth models, site index, crown dynamics, Patagonia.

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ATRIPLEX NUMMULARIA – A PIONEER SPECIES IN CONTROLLING DESERTIFICATION

Guido Soto [1]

In arid environments, the excessive encroachment of agriculture and stockfarming on unirrigated land often has adverse effects, particularly in territories where social and economic structures are precarious. Hence, crops on unsuitable land, excessive timber clearance and the over-extraction of woody species have resulted in extensive territories being degraded, their common denominator being landscapes with denuded soils subject to strong erosion processes and populations normally living under conditions of poverty.

Hence stockfarming is in many cases the main source of family income. The sustainability of the system is, however, generally uncertain due to the fact that, with the non-existence of an appropriate thicket cover, the availability of fodder will depend solely on annual herbaceous plants and on precipitation, whose quantity and distribution are normally erratic. Because of this, production systems collapse when any water deficit is experienced – with natural, social and economic consequences.

To achieve greater stability in stockfarming in arid areas, it is essential that multi-stratified plant associations, where annual pastures are represented as a resource, should be available although there must be accompanying multi-purpose trees and shrubs so that the effects of irregular rainfall are minimized.

As from the 1970s, CONAF (the National Forest Corporation – Chile's Forest Service) began the first extensive plantations with fodder shrubs and soon incorporated them in the list of species qualifying for improvement by Decree Law No. 701, which promotes forest activity in the country, with improvements in afforestation and the management of these resources. At the present time, in the Region of Coquimbo (Region IV, Chile), there are over 48 000 ha afforested with fodder shrubs, of which the majority (over 90%) are *Atriplex nummularia*, followed by *Atriplex repnada* and a minimal area of *Acacia saligna*, which has recently been the subject of growing interest.

Thus it may be concluded that *Atriplex nummularia* has now become the most important species for afforestation projects and for the control of desertification in the arid area of Chile (Region IV). The characteristics which make it preferable are its substantial fodder yield, high resistance to conditions of extreme aridity, resistance to browsing, high resistance to pests and easy propagation. The wood is also a worthwhile fuel source, similar to that of local native species.

The aim of this report is to bring together some of the available information in order to disseminate the experience and knowledge of this important species for the development of arid areas and in the control of desertification.

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DESERTIFICATION VULNERABILITY OF TURKEY WITH RESPECT TO CLIMATIC VARIABILITY

Murat Türker [1]

Climatic factors that may lead to desertification in Turkey were investigated by analysing the spatial and temporal variations of rainfall and aridity index series, for the period 1930-1993. Mean annual rainfall totals are below 500 mm over the Central Anatolia Region and most of the Eastern Anatolia. Rainfall is generally seasonal over the western and southern regions of Turkey, whereas it is generally uniform over the Black Sea Region. Semi-arid and dry sub-humid conditions are dominant over the continental interiors and South-eastern Anatolia Region. Persistent dry conditions were evident during about last two decades over the considerable part of Turkey. Annual and winter rainfall series tended to show a decreasing trend, particularly over the Aegean and Mediterranean regions. There has been a general tendency from humid conditions of around 1960s towards dry sub-humid climatic conditions in the aridity index values for all of Turkey. In some stations of Aegean Region, there is a significant change from humid conditions to dry sub-humid or semi-arid climatic conditions. Regarding climatic factors, the South-eastern Anatolia Region and continental interiors of Turkey appear to be the aridlands that prone to the desertification. When other natural and anthropogenic factors, such as high topography, unsustainable use of agricultural lands and forest fires, are also taken into account, Mediterranean and Aegean regions could be considered as areas that may be more vulnerable to desertification processes in the future.

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SAND DUNES STABILIZATION IN BALOCHISTAN (PAKISTAN)

Shah Rehman [1]

An extended operational programme for Coastal Sand Dunes Stabilization approved by the Government of Balochistan with a total cost of Rs.88.00 million through World Bank assistance under the Natural Resource Management Project is being implemented. The project launched by the year 1994-95 to 1999-200 will cover about 50 000 ha. So far the plantation over an area of 707 ha has been covered under the project. The sand dunes stabilization in Balochistan could be enlarged to combat desertification . The afforestation has marked impact on macro and micro climate of the sandy areas, but it also ensures security and comfortable life to the people living in the vicinity of these areas.

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SUGGESTIONS TOWARDS THE DEVELOPMENT OF THE TRADITIONAL LIBYAN OASIS AND ROADSIDE PLANTATIONS AS MEASURES

M. Sait Ketene [1]

Traditional oasis in all deserts of the world have survived desertification conditions and are the best location for studies and findings of the best methods to combat desertification.

Libya is one of the unique countries in the world which has more than 90% of its area and with real traditional desert life. The people here have experienced how to combat desertification through centuries as oasis residents or as Bedouins within natural balance among the natural resources.

After the 1960s and the discovery of oil in the desert, Libya became very rich, thousands of million dollars were spent on all aspects of development without knowing the relationship among the natural resources in the desert in general and in the oasis in particular. Therefore, groundwater was pumped out extensively; mega-agricultural projects and many cities were built all over the desert; bedouins with no agricultural education were settled and granted land and water; trees and crops unsuitable to the desert were introduced; and, in general, land and water was misused. As a result, the groundwater level was lowered drastically, water quality in many places was deteriorated and became unusable, soils became salinated and farmers abandoned their farms to join the army or oil industry with higher income.

Regardless of the great development of all socio-economics of the desert area, the development of the traditional oasis was limited and gradual. By securing the balance among the natural resources, traditional oasis could contribute continuously to all services needed for the welfare of the country.

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DYING OF THE FORESTS

B. Serafimovsky, V. Papazov, B. Ivanov, M. Kamilovski

The dying of the forests especially oak ones in some regions in our country is on a worrying level and the trend is of further spreading and worsening. The condition of the pine forests is pretty much the same. The reasons for that are the influence of complex biotic and abiotic factors which in the threatened areas mainly are: soil conditions, extreme climate conditions (extremely high or low air temperature and lack of rain), the presence and influence of some specific kinds of harmful insects and plant diseases and, to some extent, atmospheric pollution of the atmosphere on a global scale (this should be the object of future research).

However, it has to be stressed that the problems and the effects from the dying of the forests cannot be resolved only within the boundaries of forestry. The most important part of the decisions are taken by the society and in the planning of the society. Since with the dying of the forests the present and the future social needs (which are well known by everyone) are being jeopardized, there is a need for the social community to set up the conditions to assess the status of the forests, through surveys (which we do not do in our country) by the unified Middle-European methods. There is also the need of controlling the health of both plantations and natural stands with the purpose of finding the causes of destruction and of taking the right measures to stop this long-term phenomenon.

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THE SUCCESS OF FIXATION TECHNIQUES OF TERKOS SAND DUNES AFFORESTATION WITH STONE AND CLUSTER PINES

Ömer Saraçoğlu[1], H. Ferhat Bozkuþ [2]

In this research relevant to the fixation of Durusu (Terkos) sand dunes, three-way layouts of variance analysis have been applied to the measurements obtained in 1989 from the permanent plot that was already established, in order to determine which of the fixation techniques and sapling types is most convenient. The F values of factors have been commented on and, in case the populations had significant differences, the Duncan test was used. Research was also conducted to ascertain whether the significance levels of factors change depending on time and sapling characteristics.

Keywords: Afforestation, sand dunes, fixation, variance analysis, Duncan Test Factor.

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RESULTS OF ELIMINATION TRIALS WITH TREE SPECIES IN THE SEMI-ARID ZONE OF IRAN (WEST-AZARBEIDJAN)

Kh. Sagheb-Talebi [1], M. Dastmalchi [1], S. Gheisy [1]

This paper presents the results of elimination trials with 16 tree species and provenances in non-irrigated plantation conditions in north-west Iran (Uromieh, west-Azarbeidjan). The natural vegetation in the experimental area shows high overgrazing. The study area after EMBERGER's classification is characterized as a semi-arid zone with cold winters (Q_2=34.5). The mean annual precipitation is 360.9 mm, mean annual temperature 10.7°C and the mean minimum temperature of the coldest month is -6.4°C, respectively. The summer drought lasts 132 days and the frost 115. The geological formation consists of sedimentary limestone. The degree of alkalinity and salinity is high and the organic matter is due to destructive human influence at low level.

The results showed that a limited number of species could be selected for planting in species growth trials. The most promising, with more than 70% survival, include: *Celtis australis, Fraxinus xanthoxyloides, Robinia pseudoacacia* and *Ailanthus glandulosa*. The non-wood products, soil conservation, usage on windbreak and shelterbelt, as well as production of fuelwood, are the most important aspects of plantation with these species.

Keywords: Elimination trials, semi-arid zone, survival, promising species.

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EUCALYPT AND PINE SPECIES TRIALS ON THE CASPIAN LITTORAL SANDY DUNES OF IRAN

Hossein Sardabi [1]

In order to present this paper, the adaptability and performance of 25 eucalypt and five pine species were investigated through two of the RIFRI's species trials. The trials were carried out during 1971-1987 at the RIFRI's experiment site at Miankaleh peninsula (36°50¢35² N, 53°18¢15² E, -20 m altitude). The soil was a deep dune sand with sea shell and was highly alkaline.

The species were planted under the statistical design of completely randomized blocks by four replicates. In every plot 25 seedlings of each species were planted 2x2 m. Stem height and diameter and survival have been annually estimated and recorded from 1971 to 1977 and once in 1984. In addition to the above measurements, tree quality was recorded in 1987. The survival data have been recorded twice a year, after warm and cold periods. The climatological factors, water table depth fluctuation, physical condition of soil and water, and chemical and morphological properties were studied to investigate their effect on survival and growth of the exotic species.

Overall, the most promising species at the species trials were *E. camaldulensis, E. dalrympleana, E. viminalis, P. pinea, P. eldarica*. Some of the species, including *P. elliottii, P. pinaster, E. grandis, E. ovata and E. bicostata,* were good and could be tested with the promising species in the pilot phase of the species trials.

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STRATEGY FOR THE GREENING OF THE UNITED ARAB EMIRATES

Abdel Magid Hassan [1]

The soils of UAE are either highly saline or unstable sand desert. The sub soil water available for irrigation is brackish. The climate is hot and extremely arid. Despite all these adverse factors to plant growth, remarkable achievements have been made in greening the country. So far over 200 000 ha have been planted as forest plantations. Highways have been planted with shelterbelts. Date-palm trees have been planted in gardens, avenues and agriculture farms which exceed 20 million in number. Agricultural farms over more than 71 000 ha have been put under cultivation. Landscaping works have been done with ornamental plants, grassy lawn, avenues, etc., in cities, towns and other installations like airports, seaports, education institutes, hospitals, government and residential buildings, roads and streets. The coastal areas have been planted with mangrove species.

All this has been done with able guidance, good zeal, sound planning and strenuous efforts.

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