Chapter 14
Review of Efforts to Combat Desertification and Arrest and Reverse Land Degradation in Myanmar

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Synopsis Myanmar is located in a region less vulnerable to desertification. Although there is no place which can be strictly defined as a sandy desert, some specific areas in the vast central zone of the country indicate the potential for land degradation due to the combined impacts of both the adverse climatic conditions and the stress resulted from human activities. This chapter gives a summary of the current situation of Myanmar in respect to desertification and land degradation

Key Points

- Land degradation in Myanmar is caused by water erosion, wind erosion, soil fertility depletion, salinization, alkalinization and water logging. Visible land degradation is recognizable in the central dry zone area of Myanmar and extends partially over the Divisions of Mandalay, Magway and Sagaing covering 17 % of the total area of the country. In these areas, soil erosion is intensive and rapid as a result of heavy rain showers and the low degree of rock compaction. Surface runoff has been estimated to be 30 %. Removal of the natural savanna vegetation quickly leads to erosion, which is most intensive at the start of the monsoon rains on bare soils. In the dry zone, where rainfall is already low, reduced infiltration means less effective utilization of precipitation. An increase of runoff also leads to the expansion of rill and gully erosion.
- The term "Dry Zone" is now being used to represent the dry central part of the country. As Myanmar is endeavoring to maintain its natural resources, the Ministry of Forestry strives to undertake the greening project throughout the country with the cooperation of all levels of the governmental sectors. The greening operation was started by planting trees in the 9 critical districts of the arid zone of central Myanmar and extended to 13 districts with the creation of new department namely the Dry Zone Greening Department (DZGD). This

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project also focuses on improving socioeconomic survival of rural people who live in the central arid zone and are badly affected by an acute shortage of fuelwood supply since the foremost fuelwood deficit areas are located in this dry zone. The Dry Zone Greening Department promoted utilization of wood fuel substitutes. The activities for the development of wood fuel substitutes include distribution of fuel-efficient stoves, promotion of fuel briquette production and utilization of agricultural residues.

- The primary causes of desertification and land degradation apart from low rainfall and more frequent and prolonged drought is the destruction of the catchments of natural water sources leading to water shortages in this dry zone. It has been estimated that approximately 8,000 villages are facing water shortage. So, the Irrigation Department and Water Resources Utilization Department under Ministry of Agriculture and Irrigation have been implementing drinking water supply and irrigation water supply program for food sufficiency and promotion of crop-productions in the dry zone. The Dry Zone is in danger due to the scanty rainfall, sparse vegetation and poor land use practices.
- Widespread deforestation and unplanned land use change can harm the landscape. Forestlands are vulnerable to encroachment due to expansion of human settlements and the intensity is directly- related to population of the expanded or newly located settlement. Ecosystem of wetland areas is expected to have a significant change due to expansion of human settlement. Inlay Lake ecosystem in the eastern part of the country is a significant example that shows water pollution and sedimentation in the water body is due to human settlement in uplands of the lake. It is rational that biological diversity in coastal areas would be adversely affected by the expansion of human settlement. These implications that would be experienced in any expansion of human settlement are given due consideration for minimizing the unintended consequences. Challenges facing integrated land management still remain and they include, among others, inadequate inputs, low capacity level of inter- and intra-agencies related with the utilization of land resources, the need for urgent economic returns and absence of comprehensive land use policy respected by all parties.
- The Ministry of Forestry, and the Ministry of Agriculture and Irrigation are the main agencies responsible to manage fragile ecosystems, combat desertification, including land degradation in all its forms, and mitigate drought. The Ministries concerned collaborate with the stakeholders at the local levels. to implement programs and projects such as the greening programs and integrated land development projects being carried out in the dry zone area of Myanmar which is the area most affected by drought. Due to very low rainfall and deforestation the majority of rural population in the area have been facing the problem of soil erosion and land degradation. In order to address the problems, reforestation and afforestation the governments are implementing programs, irrigation and water supply projects. Land degradation problems and the resulting rural poverty in the semi-arid regions in Myanmar are now being addressed by the governments through practicing sustainable agriculture and forestry management.

Keywords Dry Zone • Dry Zone Greening Department (DZGD) • 30-year Master Plan • Afforestation • Fuelwood • UNCCD • Fuel-efficient stoves • Water shortage • Drought • Irrigation soil erosion • Vegetables • Grains • Rice • Salinity • Ayeyawady Delta

1 Introduction

The Union of Myanmar is the largest country of South-East Asia. It is a tropical country located between latitudes 9° 28′N and 28° 29′N and longitudes 92° 10′E and 101° 10′E. The length from northern to southern tip of the country is about 2,060 km. The total land area of Myanmar is 676,577 km^2, of which about 51 % is covered by forests and about 27 % is arable (or potentially arable) land of 13 % is sown at any one time and 14 % is under fallow or is idle land. Existing farmlands are protected against changes to other uses so some land awaits development for cropping. Myanmar is regarded as an agriculture based country as it accounts for 40.2 % of the GDP and employs 64.1 % of the work force.

The country has several distinct climate zones ranging from the temperate region of the north to the Dry Zone in central Myanmar and the monsoonal belts in the northwest, west and south. It has a tropical climate with three seasons namely Rainy (mid-May to mid-October), Winter (mid-October to mid-February) and Summer (mid-February to mid-May). There is large variation in average precipitation as coastal areas receive average precipitation in the range of 4,000–5,600 mm while central dry zone receives precipitation in the range of 600 and 1,400 mm. During the wet season annual rainfall received by each region is quite different. In general, there is shortage of soil moisture in the dry zone even in the wet season, while excess moisture prevails in lower Myanmar. At the end of the wet (monsoon) season it is totally dry and most of the crops planted in the season need to rely on residual soil moisture, except those in irrigated tracts. In order to provide supplementary irrigation for monsoon crops and full irrigation for winter season sown crops, dams, weirs, reservoirs were constructed and pump stations were established so that enough food will be produced for the growing population.

2 Implications of Human Settlement Expansion on Farmland, Landscape, Forestland, Wetlands, and Biological Diversity in Coastal Areas

The government's policy objectives to boost agricultural production included development of land resources for agricultural expansion, provision of adequate irrigation water for agricultural purposes, support for agricultural mechanization accelerated transfer of improved new technologies and development and utilization

of high yielding quality seeds. There is potential for this policy to impact on the nation's natural resource base.

- Farmlands: Existing farmlands are protected against changes to other uses. In the case of dam construction, existing settlements are to be shifted to new areas where new farm lands are to be developed.
- Landscape: Widespread deforestation and unplanned land use change can occur.
- Forestland: These are vulnerable to encroachment due to expansion of human settlements and the intensity is directly related to population of the expanded or newly located settlement.
- Wetlands: Ecosystem of wetland areas is expected to have a significant change due to expansion of human settlement. Inlay Lake ecosystem in the eastern part of the country is a significant example that shows water pollution and sedimentation in the water body due to human settlement in uplands of the lake.
- Biological Diversity in Coastal Areas: It is rational that biological diversity would be adversely affected by the expansion of human settlement.

These implications that would be experienced in any expansion of human settlement are given due consideration by government agencies so that the unintended consequences are minimized.

3 Myanmar's Dry Zone

The Dry Zone, which possesses one-third of both the population and area of Myanmar is vulnerable to the processes of land degradation and desertification.

According to the rainfall pattern, the Dry Zone has an area of about 67,700 km^2 or about 10 % of the country (Fig. 14.1). The Dry Zone comprises Lower Sagaing, Mandalay and Magway Divisions. There are altogether 13 districts and 57 townships in the Dry Zone. The Dry Zone suffers intense heat of monthly temperature ranging from minimum of 10 °C in the cool months to maximum of above 40 °C in dry months. The dry zone is surrounded on three sides by mountain ranges.

Towards the South it consists of undulating plateau with elevation of 150–200 m and a number of steep hilly chains rise above the plateau with peaks of hill reaching an altitude of 300–400 m. The arid and semi-arid zones are characterized by an extreme diversity such as soils, geomorphology, vegetation, water balance and human activities.

The annual rainfall in the central part of Myanmar known as the Dry Zone is less than 600 mm. The dry zone is prone to droughts. According to characteristics of drought using rainfall series, the worse drought that hit the area was during 1979 and 1980. The second worse drought that hit lower Sagaing and Mandalay (but not Magway) took place during 1982 and 1983. The third worse drought hit the whole area of the dry zone during 1993 and 1994.

The original vegetation of central Dry Zone is described as Savanna woodland which consisted of short deciduous trees and a ground flora composed of different

Fig. 14.1 Map of Myanmar, the 5th largest country in Asia showing the location and extent of the Dry Zone in central Myanmar (*inset*)

species of grass. Dry zone is the most important vegetable oil production region, which includes sesame and sunflower. Other important crops are rice, millet, cotton and tobacco. The major cash crops grown in the Dry Zone are cotton, sesame, pulses and beans. Seasonal vegetables such as onion, garlic, chillies, and tomatoes are also grown on some alluvial soils on the banks along the Ayeyarwady river. All suitable land is cultivated and there is hardly any scope for expansion. The farmers of this

zone are mainly commercial, cultivating a variety of crops in a double cropping and rotational system. Intercropping is widely practiced in Chaung U, Sagaing and Kyaukpandaung, Mandalay while less in Magway. Poorer farmer families and laborers fulfill their incomes by cutting fuelwood or making *jaggery* both of which contributed to overexploitation of forest resources that tends to lead to deforestation.

4 Land Degradation/Desertification

The soils have eroded to varying degree and at some places they have been completely removed by water and wind erosion. The soil erosion is intensive and rapid as a result of heavy showers and a low degree of compaction of rocks. The surface runoff has been estimated to be 30 %. Removal of the natural savanna vegetation quickly leads to erosion, which is more intensive at the start of the monsoon rains on bare soils. Rates of soil erosion depend on the type and effectiveness of cover on the soil surface (Table 14.1). Some arid and semi-arid lands can support crops, but additional pressure from greater populations or decreased rainfall can lead to the loss of the present plants. Under these circumstances, the soil becomes exposed to wind, causing soil particles to be deposited elsewhere. A result of this is the erosion of the top layer of soil. The rate of evaporation increases due to the absence of shade and salts become drawn up to the surface. This leads to salinization and inhibits plant growth.

Wind erosion is a problem of arid and semi-arid regions with a dry season of more than 6 months. In such areas, natural vegetation is steppe-like with much bare soil. The fine particles of the soil such as clay, silt and organic matter are blown away by strong winds while coarse materials are left behind. The wind erosion starts at a wind speed of 25 km/h. Sand grains of 0.5–2 mm are rolled, fine sands of 0.1–0.5 mm are transported over few meters and finer particles such as clay, silt and organic matter go into suspension in the air. In Magway, dust cloud or 'Red sky' during March and April is due to this suspension.

About 11 % of the total land area is affected by wind erosion, which occurs mainly in central dry zone areas that are economically important to the national economy. Wind erosion effects are well recognized in the central dry zone areas for the following reasons:

Table 14.1 Areas of problem soils in Myanmar

No.	Soil type	Area (000 ha)
1.	Saline soil	607.54
2.	Alkaline soil	52.63
3.	Localized problem soils (acid sulfate soil, degraded structure, peaty soils, swampy soils)	300.04
	Total	959.52

- Light-textured Luvisols;
- Scanty rainfall and arid soils throughout the year;
- Unprotected crop fields, lack of natural forest barriers;
- Soil-loosening crops such as major oilseed crops predominate;
- Hot and dry winds suck away meager moisture stored in the topsoils.

In the Kyaukpadaung area, the erosion problem is severe with 50 % of the cultivated land losing its top horizon; this means that most of the fertile soil has been lost through severe sheet and rill erosion. Infiltration and the water holding capacity of these soils are limited. Erosion rates on cultivated land range from 50 t/ha/year for optimum soils on gentle slopes to 150 t/ha/year on slopes of 3–15 % with sandy–loamy or sandy–clay–loamy soil. Many hillsides are almost bare, rocky, compacted and heavily crusted. In the Magway area, there is a high level of erodibility, because of the sandy topsoil. Soil loss was estimated at 30 t/ha/year on better lands with gentle slopes (<3 %) and over 75–100 t/ha/year on undulating lands with sandy loams, surface crusts and low water holding capacity. In the Chaungoo area, the erosion problem follows the same pattern as Kyaukpadaung, mainly in the upper parts of township areas, showing similar severity and rates of erosion and runoff.

Depletion of soil fertility is a serious problem in Myanmar as the most economically important soils of the country are found in these problem areas. It was estimated that about 12.3 % of the total land area situated in the central dry zone faced depletion of soil fertility as well as soil nutrient imbalance. All the agricultural lands on Luvisols in central dry zone areas have depleted soil fertility generated by the following factors:

- Very light in texture (sandy loam to loamy sand);
- Too low in moisture and very high in temperature;
- Rolling and undulating and prone to wind and water erosion;
- Completely deprived of organic matter;
- Yearly cropping without any fertility improvement measures such as green manuring, composting and balanced fertilizer application.

Soil fertility depletion is also found in the Shan Plateau due to water erosion, high acidity and lack of soil improvement techniques. Since this degradation problem is a serious one, it needs to be addressed urgently.

Approximately 1.4 % of the whole country is affected by both salinization and alkalinization that cause land degradation. Coastal strips, deltaic and arid regions are impacted by salinization while alkalinization is confined only to certain areas of the arid region. Types of soils under the salinization category are Gleysols and Vertisols, while Vertisols mainly occur in the alkalinization category. Salinization occurs in the coastal and delta regions due to seawater intrusion. Although heavy rainfall (over 4,000 mm) and flooded rice cultivation annually flush out deposited salts, high tides and high evapo-transpiration in the summer make the soils more saline. Thus, the salinity effect is more harmful to dry season crops. Salinization in the central dry zone is mainly caused by saline groundwater evapo-transpiration which results in salt crusts on the soil surface.

Unfortunately, scanty rain is not enough to wash out the accumulated salts. In addition, using saline irrigation water causes salinization. Alkalinization also occurs in the same way in dry zone areas.

The area of land degradation due to water logging is smaller than other affected areas. Less than 1 % of the total land area found in the Ayeyawady Delta Region is affected by water logging. Although the extent is small, water logging creates adverse effects because of its occurrence in major rice production areas. Thus, the nature and extent of water logging need to be studied to develop preventive measures. Unfortunately, scanty rain is not enough to wash out the accumulated salts. In addition, using saline irrigation water causes salinization. Alkalinization also occurs in the same way in dry zone areas. The area of land degradation due to water logging is smaller than other affected areas. Less than 1 % of the total land area found in the Ayeyawady Delta Region is affected by water logging. Although the extent is small, water logging creates adverse effects because of its occurrence in major rice production areas. Thus, the nature and extent of water logging need to be studied to develop preventive measures.

5 Deforestation

The Dry zone was once a heavily forested region. The heavy cutting of forests to fire brick kilns for construction of stupas and pagodas are said to be primary cause of forest destruction since 11 AD. The inevitable consequence of forest destruction was drastic change in climate, gradually moving from bad to worse. Other main causes of deforestation in Dry zone can be grouped into the following heads:

- Population growth
- Agricultural encroachment
- Increasing livestock population
- Increasing demand for fuel wood

The population, as well as population density, increased in all three Dry zone divisions. The population density from 32 persons per km^2 in 1941 increased to 70 persons per km^2 in 1993. It led to encroachment on reserves and protected areas. The increased population led to extension of agricultural fields and thus encroachment of reserved and protected forests. In addition, it also led to increased demand for domestic fuel as well as industrial usage. The deterioration of land due to erosion and deforestation has made the agricultural production base unstable. The main reasons include increased human as well as cattle population and demand for fuel wood for domestic as well as industrial use. The natural resources of Dry zone are being depleted more rapidly than nature can renew itself.

Fuel wood consumption is one of the main causes of deforestation, and excessive cutting of trees for fire-wood before they are fully grown, leads to the loss of growth potential of the forest stands. Therefore, Forest Department had launched fuel-wood substitution program to reduce pressure on the utilization of wood for

fuel. The DZGD since its creation in 1997 had distributed some 100,000 efficient cooking stoves, 9.2 million numbers (7.4 million kg) of briquettes and, the use of 45,000 metric tons of agricultural residue by villagers in the dry zone was recorded over the same period. About 600,000 improved cooking stoves are scheduled to be distributed during the period from 2001 to 2010, and some 108 million kg of briquettes are also planned to be distributed over the same period.

6 Focus on Combating Desertification

Myanmar is a country affected by desertification and drought in some areas. The main area affected by desertification and drought is the Dry Zone in the central part of the country.

The exact causes of desertification are often complex and arise from a variety of factors including settlement of marginal lands, overgrazing, poor management of water and soil, and changing climate with decreasing rainfall and greater incidence of drought.

In Myanmar, the government has stepped up its efforts on preventing land degradation and combating desertification in recent years. The Ministry of Forestry leads efforts to combat desertification with the participation of other ministries but Myanmar is still in the process of developing specific mechanisms for combating desertification. The Government launched a special program and drafted a 30-year Master Plan for greening of this zone (see Sect. 7.1 below).

From the forestry point of view, one of the major tools to fight the spread of deserts is the planting of trees and other plants that retain water, maintain soil quality and micro-climate. Greening work has been carried out in Sagaing and Monywa Districts in **Sagaing Division**, Myingyan, Maiktila and Yemethin Districts in **Mandalay Division**, Magway, Pakokku, Minbu and Thayet Districts in **Magway Division**. Although originally intended for 9 districts, greening work has been extended to 13 districts. Over 80,000 ha of forest plantations have been established, and over 240,000 ha of remaining actual forests have been conserved and protected. The arid zone greening work is being done in accordance with a 30-year Master Plan. During the implementation period, 3.3 million ha of green and lush forests will emerge. The Greening Project will prevent desertification of dry regions.

The Irrigation Department and Water Resources Utilization Department under Ministry of Agriculture and Irrigation have been implementing drinking water supply and irrigation water supply program through judicious utilization of water from surface, rivers, creeks and groundwater sources for food sufficiency and promotion of crop-productions in the Dry Zone.

Furthermore, the tasks for development of wood substituted fuels have also been carried out. With many of the local people using trees for firewood and cooking, the problems on forest depletion/degradation has become acute. To solve this problem, the DZGD under the Ministry of Forestry has endeavored to promote utilization of

wood fuel substitutes. The activities for the development of wood fuel substitutes include distribution of fuel efficient stoves, promotion of fuel briquette production and utilization of agriculture residues.

6.1 Problem Soils

In Myanmar, problem soils occupy an area of about 0.96 Mha representing about 7.8 % of total cultivable land stock of 12.31 Mha (Tha Tun Oo 1989). Again, out of the problem soils area, about 18.7 % (0.66 million ha) is occupied by the saline and alkaline soils, most of which are currently under utilization (Table 14.1). The remaining problem soils area of about 0.3 Mha are occupied by acid sulfate soils, degraded soils, peat soils and swampy soils. Among them saline soils and alkaline soils are the most predominant problem soils of the country. Farmers in the problem soil areas grow rice varieties which are moderately tolerant and soil salinity or adjust the sowing time when the crop can stand the salinity level, or wash out the soil with rains or irrigation water. Farmers are aware that gypsum can improve the situation.

The research wing of Myanmar Agriculture Service continues working on the problem to ameliorate the soil at low cost by using crop residue, and other measures.

In the delta region this problem is somehow managed by constructing polders with the assistance of Lower Burma Paddy Land Development Project to protect saltwater intrusion into the field and by washing out the salt from the affected soil with rainwater. The problem in dry zone is expected to gradually improve as its greening program proceeds. Furthermore, pump irrigation projects are also very helpful in preventing salinity problems. The government is also attempting to improve water infiltration in the catchment area by planting trees. Water quality also depends on using level of use of agro-chemicals. But at present Myanmar is not suffering serious effects or water quality since agro-chemical utilization is quite low in comparison with other countries.

6.2 Deforestation and Land Clearing

Many forms of watershed degradation are evident as some form of direct damage to the soil. In the case of soil erosion and deposition, for example, the effects of degradation are manifested in the loss or transfer of soil, which has direct consequences in reducing the productivity of the site. In the case of soil degradation, the effects are manifested in a deterioration in the *in situ* properties of the soil, again with direct consequences in terms of reduced productivity. In the case of ecosystem alteration, however, the immediate consequence is a reduction in the quality and integrity of the entire ecosystem which the land unit under threat supports. The effects will be manifested in a loss of vegetative biomass, a reduction in vegetation productivity and species diversity, and an impairment of habitat for native flora

and fauna, as well as the secondary consequences of water and wind erosion and other forms of soil degradation that will be an eventual result of the reduced or impoverished vegetative cover.

Deforestation is here taken to mean the large-scale removal or partial removal of trees from forested areas, which may be deliberate or due to natural causes. Deliberate causes of deforestation include commercial logging, firewood production, clearing for agricultural or timber plantation purposes, "slash and burn" techniques of shifting agriculture, and clearing for such purposes as urban development or the development of infrastructure such as dams, road, railways or mining facilities.

Natural causes of deforestation include wild fire, predation by a variety of pests and parasites, disease, damage by pest animals or grazing animals and human traffic or occupation. Forests shield the soil surface from heavy rainfall, reduce the rate of run-off by increasing the rate of infiltration and as a consequence decrease the amount of flooding, mitigate soil erosion and limit the sedimentation of rivers. They can also act to control landslides and other forms of mass movement of the land surface.

On the other hand, deforestation of watersheds, especially around smaller rivers and streams, can increase the severity of flooding, reduce stream flows by lowering the watertable and increase sedimentation of rivers. Accelerated erosion, soil salinization and impairment of water quality are other common adverse consequences of deforestation. These secondary forms of degradation and ways and means for controlling or mitigating them will be discussed in some detail in other sections of this chapter. The factors contributing to deforestation can all adversely affect land and water resources. The loss of protective tree cover has resulted in erosion, landslides and the silting of rivers and dams, as well as increased flooding downstream. The loss of trees also results in reduced organic matter and the loss of nutrients from the soil by leaching. This leads to further degradation of the quality and extent of forest cover. The destruction of trees on steep slopes and along the banks of rivers and streams can significantly increase erosion and sedimentation problems in the lowland areas of watersheds. In the Asia Pacific region, the rate of deforestation is a major factor contributing to watershed degradation and the increased severity of water related natural disasters. Until comparatively recently, the rate of deforestation in areas of forest has been a cause for much national and international concern.

Land clearing is here taken to mean the large-scale removal of vegetation from woodlands, shrublands and grasslands in order to use them for such purposes as grazing, cropping or irrigation development. This form of activity is practiced in low to marginal rainfall areas where the climatic and soil conditions are not suitable for forest growth but there is potential for large-scale crop or livestock production. As with deforestation, the removal of vegetation makes the land susceptible to water erosion and wind erosion, the latter in particular being a major potential problem in arid and semi-arid areas. Other associated adverse effects may be various forms of soil degradation as a consequence of cropping or irrigation practices, as well as potential invasion and damage by pest species. As is also the case with deforestation, extensive land clearing involves a loss of ecosystem productivity and diversity

Fig. 14.2 Severe gullying and soil loss can follow deforestation and inappropriate cultivation methods

and the destruction of habitat for native flora and fauna. Like the other forms of watershed degradation already discussed, land degradation due to deforestation or land clearing occurs as the direct consequence of poor or inappropriate land-use practices and can be avoided through the application of sound land-use planning and management principles. Good management implies sound overall ecosystem management, a process which requires the striking of a balance between economic objectives for productive land use and ecological objectives for the maintenance of ecosystem quality and diversity. Putting it another way, this kind of approach requires the adoption of an ethic of ecologically sustainable development, which in itself is the essence of the integrated watershed management approach.

Further downslope, as rates and volumes of run-off and quantities of transported sediment increase, larger-scale erosion processes begin to occur (Fig. 14.2).

Gully erosion is essentially a macro-scale version of rill erosion which results in the form of large, incised erosion channels too big to be filled by normal cultivation practices and too wide and deep to be crossed by farm machinery. The classification of gully erosion is usually applied when the depth of the incised channels exceeds 300 mm, although depths of 10 m and more may be experienced under severe erosion conditions (Figs. 14.2, 14.3, and 14.4). Gully erosion involves a number of interacting processes which depend upon climate, soil type, topography and land use. It is initiated in minor drainage lines when normal equilibrium is upset by concentration of water flow or locally decreased resistance of soil to detachment or transport. It develops by two major mechanisms – gully head erosion, which is caused primarily by concentrated flow over the gully head and is the process by which the gully lengthens and moves upslope, and gully side erosion, which can be caused by diffuse over-edge inflow, interflow and groundwater seepage,

Fig. 14.3 Severe gullying may require structural works to reduce flow and trap sediment

Fig. 14.4 Structural gully control works are an effective means for control of sediment movement

undercutting, flow along the gully and raindrop erosion, and is the process by which the gully widens and deepens. As a gully extends upslope the catchment area contributing to head erosion reduces, and uphill movement may eventually stabilize. On the other hand, the rate and amount of over-edge inflow and sub-surface inflow may increase concurrently, enhancing the side erosion process and causing deepening or widening of the gully so long as its capacity to transport eroded material downstream is not exceeded.

Fig. 14.5 Earthworks such as these can reduce runoff and soil loss and retain moisture in situ

Gully erosion can result in the loss of considerable areas of productive cropping or grazing land. It causes significant increases in farming costs, because it makes the operation of farm machinery and the management of livestock more difficult. It also produces serious *off site* effects, resulting from the movement and deposition of sediment, as described below. Because of their size and areal extent, eroded gullies can remove and transport downslope very large quantities of material. If a stream or waterway does not exist downstream to transport this material further down the watershed, a sediment fan will be deposited at its lower end. This can render a substantial area of agricultural land unproductive and may damage farm infrastructure and public facilities such as roads and irrigation or drainage channels. Disturbed flow across the fan deposit may initiate further instability lower down the slope, leading to extended multi-channel or compounded gully development. If the gully discharges into main watershed drainage system, movement of sediment into stream channels will occur, to be eventually deposited further downstream causing river sedimentation or accumulating silt in lakes and artificial reservoirs, with consequential adverse effects on flooding, river and lake productivity and reservoir storage capacity and a general impairment of downstream water quality.

A wide variety of structural and non-structural options is available for the solution of watershed management problems. These may be employed either to control or to rehabilitate land degradation, to control or mitigate the occurrence or effects of water-based natural disasters, or to achieve both concurrently. The more commonly used of these options are briefly described below (Fig. 14.5). More detailed information about them can be obtained from a variety of textbooks and manuals, some of which are listed in the Bibliography which follows this chapter.

Land management measures for the control of land degradation and the mitigation of natural disasters may include a variety of structural and non-structural approaches. The structural approaches comprise a number of small and relatively low-cost mechanical devices whose function is to reduce run-off rates or volumes, to control or retard overland flow or to give protection against erosive or scouring forces. The non-structural measures comprise a variety of farming, cropping and

cultivation techniques whose purposes are to maintain a protective vegetative cover, to increase infiltration and to impede overland flow. For the most effective results, a number of these approaches will generally be used in conjunction, utilizing a combination of structural and non structural measures in an integrated fashion to achieve optimal management results.

A range of non-structural and structural or mechanical means is available for the avoidance of mass movement disasters and the mitigation of their effects. There is a variety of structural or mechanical measures which can be applied to reduce the potential for land instability in areas where occupation cannot be prohibited. These measures might include the following:

- preventing or diverting run-off flows around critical sites
- de-watering sites using drainage systems
- planting trees or shrubs which remove sub-surface water by transpiration
- planting deep-rooted vegetation to bind sub-soil material
- underpinning foundations to stable rock
- battering slopes to stable grades
- constructing retaining walls along the toes of critical slopes

The vulnerability of watersheds to land degradation and water-related natural disasters can be reduced by structural works and land treatment measures. Figure 14.4 is an example of a gully plug to stabilize the small stream. The potential impact of these adverse developments or events can be further reduced by the imposition of land-use controls, designed to manage degradation and minimize exposure to the risk of disasters which cannot be avoided. To achieve this objective, legislative controls which empower the relevant government authorities to direct land-use planning policies and practices related to watershed management should be adopted and implemented. These controls should strive to ensure that an effective and comprehensive legal and administrative system is adopted which addresses the problems of land degradation, environmental protection, and the maintenance of ecosystems and is consistent with the principles of sustainable resource development. Such a system requires an integrated approach to the management and protection of natural resources, including land, water, vegetation and human activity, undertaken on the basis of the total watershed. This approach recognized that changes to the natural environment in the upper watershed will influence conditions in the downstream areas.

7 Efforts Undertaken by the Government to Deal with Land Degradation

Since 1960, the Forest Department had established 766,000 acres of plantations, of which 27 % are designated for fuelwood supply of the country. However, most of these plantations were overcut and depleted due to inadequate management and the lack of people's participation for protection.

The National Commission for Environmental Affairs (NCEA) was established in 1990 to advise the government on environmental policies and acts as National Coordination Body (NCB). NCEA is responsible for observation and monitoring of the environment.

In 1994, the Ministry of Forestry (MOF) launched a "Three Year Greening Project for the Nine Critical Districts" of Sagaing, Magway and Mandalay Divisions in the Dry Zone. This was later extended to 13 districts with the creation of new department namely the Dry Zone Greening Department (DZGD) in 1997.

In April 1995, Myanmar hosted the Asia–Pacific Meeting on the follow-up to the International Convention to Combat Desertification in Yangon. In January 1997, Myanmar acceded to the United Nations Convention to Combat Desertification (UNCCD). Even before Myanmar's accession to UNCCD, measures relating to combating desertification have been taken at the local and national levels.

The most evident efforts are the appearance of the National Commission for Environmental Affairs (NCEA) comprising all ministries and the development of National Action Program (NAP). Myanmar has been a signatory of United Nation Convention to Combat Desertification (UNCCD) since 1997. In Combating desertification and drought, the participation of local communities, rural organizations, national Governments, non – governmental organizations and international and regional organizations is essential. A UNDP/FAO project entitled "**Environmentally Sustainable Food Security and Micro-income Opportunities in the Dry Zone**" has been successfully implemented in three districts of the Dry Zone namely, Chaung-U, Magway and Kyaukpadaung townships with community participation. **Small-scale Afforestation and Reforestation Projects** are also been undertaken jointly with some international NGOs such as Yomiuri, Organization for Industrial, Spiritual and Cultural Advancement-International (OISCA-International), Japan International Forestry Promotion and Cooperation Agency (JIFPRO) and Korean International Cooperation Agency (KOICA).

7.1 The Dry Zone Greening Department

The Dry Zone Greening Department was entrusted with the following objectives:

- To green the Central Dry Zone of Myanmar
- To provide the basic needs for forest products of the rural people
- To enhance knowledge and promote participation of the public on environmental conservation and sustainable development
- To promote the socio-economic status of rural communities
- To improve climatic conditions of the environment for supporting sustainable agriculture
- To prevent desertification

The major tasks to be implemented by the Dry Zone Greening Department include establishment of forest plantations, protection of remaining natural forests, initiating development of wood fuel substitutes and management and development of water resources.

The greening activities of the DZGD have also been accelerated. A comprehensive plan for reforestation of Dry Zone for 30 year-period (2001/2002–2030/2031) has been drafted. The plan is divided into six five year short-term plans.

7.2 Forest Plantation

Human overpopulation is leading to destruction of tropical forest due to widening practices of slash-and-burn and other methods of subsistence farming necessitated by famines in lesser developed countries. As a result of increased population, shifting cultivation, fuelwood extraction and other human activities, very little of the original natural vegetation remains and a degraded form of trees were found in many places of the Dry Zone. In the absence of forest cover on the watersheds, severe floods were sometimes occurred causing great damage on both property and human lives. During 2001 rainy season because of high rainfall and flash floods of the sandy streams, several villages were swept away by severe flood water.

Forest Department is fully engaged in **Afforestation and Reforestation Program** including planting trees for commercial purposes, industrial wood supply, fuelwood supply and watershed management. In order to promote the environment, forest plantations are being established in the five critical districts (Kyaukse, Myingyan, Nyaung-U, Yamethin and Maiktila). The following is a set of criteria for forest plantations: –

- Only local variety seedlings are to be used in forest plantations
- Only over 70 % survival rate are to be considered for successful plantation
- Forest plantations must supplement 5–10 % of the wood-fuel needs of the Dry Zone

The government has also made continuous efforts to sustain forest productivity in cooperation with FAO, aiming not only to improve environment and food security, but also to efficiently utilize rural energy through establishment of community wood lots. Myanmar Forest Policy (NFP), has identified six imperatives in its text for sustainable forest management (SFM). One of the six imperatives is to satisfy the basic needs of people for timber, firewood, food, shelter and recreation. Moreover, Myanmar's effort to protect and conserve forestlands and resources will result in environmental balance, which, in turn will support the improvement of food production and social setting. The forestry sector of Myanmar is now in the process of developing NFPs for the whole country and for the Central Dry Zone greening within the context of the national sustainable development strategy. In NFP, the existing 50 % coverage of forests over the total land area of the country are to be

maintained, of which 40 % would be designated as Permanent forest Estate (PFE) and the rest, 10 % would be assigned as conversion forests for possible needs for agriculture and other uses for the State.

7.2.1 Decision-Making: Legislation and Regulations

In order to manage lands under forest cover in an integrated approach forest management plans for 62 civil districts covering the whole country were recently reformulated and updated based on SFM principles. With emphasis on environmental conservation and improvement of soil fertility status, a new institution entitled "Dry Zone Greening Department" was recently set up (see Sect. 7.1) to implement the major tasks of protection, reforestation, water resources development and fuel wood substitution in the desert-like dry zone of Central Myanmar.

A major breakthrough in Myanmar Forestry was also made in 1995 by issuing Community Forestry Instructions to promote and encourage people participation and decentralization in forest management in addition to policy, legislative and institutional updating and reforms in the 1990s.

In 1993, Forest Conservation and Management Committees at all administrative levels were formed to implement integrated forestland management to prevent and check land degradation, deforestation as well as to strengthen multi-sectoral planning, decision-making and participation.

The government's endeavors for the promotion of the best possible land use and sustainable management of land resources since UNCED include:

- To facilitate the development of a market-oriented economy, "the Privatization Commission" to oversee and ensure the successful implementation of the privatization process was formed in January 1995.
- In forest sector, the Government is inviting foreign investments in forestry either in joint ventures or 100 % investment, making agreements with Forestry Department.

Forest Law of 1992 has provisions for private sector involvement and investment in establishing forest plantations.

In Myanmar, forestry (about 51 % of the total Land area) and agriculture (about 27 %) are the two main sectors with regards to the management of land and land-based resources. The State, with view of enhancing sustainable agriculture, is reclaiming cultivable wasteland and fallow land into agriculture farmlands, while measures are being undertaken to increase per unit yield. Regarding vast areas of cultivable wasteland (idle land that could be cropped), it is possible to undertake land reclamation encroaching on with forestlands. However, there exists agricultural encroachment into forestland. Some 151,420 ha of permanent agriculture are found to have been cultivated in forestlands. In Myanmar, intrusion of permanent agriculture into forestlands is not a significant issue.

While agricultural land use is still manageable outside forest lands, Forest Department is in the process of increasing the existing permanent forest estate from the present status of about 18 to 40 % as stipulated in Myanmar Forest Policy, 1995.

7.3 Dry Zone Water Supply Program

Water is scarce in the Dry Zone due to low annual rainfall. It is believed that 8,042 villages (2,454 villages in Sagaing Division, 1,469 villages in Magway Division and 4,119 villages in Mandalay Division) are facing water shortage.

Water supply is one of the main activities of rural area development program carried out in the current short-term 5 year (2001/2002–2005/2006) plan. Works for supplying water include ground-water tapping projects and river-water pumping projects for both drinking water and irrigation water supplies. These projects are being carried out collectively by a number of governmental departments.

The Development Affairs Department under the Ministry for Progress of Border Areas and National Races and Development Affairs is undertaking the task of providing adequate water supply in the rural areas. The Ministry has drawn up the 10-year water supply project and has now been implementing to supply water for Sagaing, Magway and Mandalay Divisions.

7.4 Other Programs and Projects

Some technical assistance projects are being provided by ICIMOD. In Myanmar as in all developing countries mountain ecosystems are susceptible to soil erosion, landslides and rapid loss of habitat and genetic diversity. Unemployment, poverty, poor health and poor sanitation also prevail among mountain dwellers. Most mountain areas are experiencing environmental degradation. Proper management of mountain resources and socio-economic development of people need immediate action. It should aim at preventing soil erosion, increasing the amount of tree and plant life, and maintaining the ecological balance in mountains. For local communities and indigenous people, education, health care and energy should be provided. The people also need more opportunities to earn livelihood from such activities as tourism, fisheries, environmentally sound mining, cottage industries, and processing of medical plants.

Myanmar's major mountainous areas as part of Hindu Kush-Himalayas are found in Chin, Kachin and Shan States. Myanmar has been the member country of International Mountain Development (ICIMOD) since the early 1990s. Biodiversity study in Pi-daung Nature Reserve in Upper Most Myanmar of the Kachin State is being undertaken jointly by Myanmar and ICMOD. An experiment on slope land agriculture technique is also underway in Northern Shan State, which is financed by ICIMOD. Furthermore, a project proposal for the management of

mountain biodiversity in the Hindu Kush-Himalayan Region has been submitted to the Myanmar Government by ICIMOD. In sum, Myanmar is placing emphasis on the sustainable development of mountainous areas in close cooperation with ICIMOD.

7.4.1 Biodiversity

Myanmar has been divided into nine bio units, each representing a different agro/eco-climatic zone. The country is endowed with a diversity of flora and fauna. It has been identified that there are about 7,000 plant species, more than 300 mammals and 400 reptiles, and 1,000 birds species. The major development in biodiversity conservation is the promulgation of the "Protection of Wildlife, Wild Plants and Natural Areas Law" in 1994. The wildlife legislation as against in contrast to the old one has assumed the modern approaches in biodiversity conservation. The Law has greatly enlarged the scope of protection accorded to the animals. Among them, birds and mammals are prominently included. The 1994 wildlife legislation declares complete protection for 39 mammals, 50 birds and 9 reptiles species, normal protection for 12 mammals, 43 birds and 6 reptiles species; and seasonally protected species including 2 mammals and 13 birds.

8 Practical Methodologies for Combating Land Degradation

At present, the extent and locations of land degradation in Myanmar are mainly derived from aerial photograph interpretation and reconnaissance soil survey using topographic maps. From these maps, the severity of water erosion was deduced. No comprehensive studies concerning the severity and extent of various forms of land degradation have been conducted because there has been no specific demand by any users for land degradation data in detail. Moreover, there are no means and financial resources to conduct a specialized study of land degradation at a national scale by the Land Use Division (LUD). In spite of this, LUD conducted a thorough examination of land degradation in the surveyed area during its normal detailed planning and classification of various degrees of land degradation according to international standards.

Current land management policies focus on:

- Reclamation of cultivable wastelands.
- Construction of dams for irrigation.
- Environmental protection and conservation.
- Vertical expansion of agriculture.
- Production of agro-forestry/community forestry.
- Creation of income-generation opportunities.
- Restoration of degraded forestlands for soil improvement.

Table 14.2 Extent of water erosion within the dry zone of Myanmar

Type of water erosion	Extent (%)
Slight rill erosion	7.2
Slight to moderate rill erosion	38.2
Severe sheet and sheet erosion	26.2
Topsoil completely removed	0.4

Note: Total water erosion affected area = 72 % approximately

8.1 Mapping of Degraded Land, Availability, Scales and Methods Used

At present, mapping is carried out by the LUD. The three types of major maps produced are: agro-ecological zone maps, soil maps and soil erosion maps at the national level. Soil maps based on land topography are produced at the state/division level. Mapping is based on 16:1 scale, which is used by the Department of Settlement and Land Record, and 1:1, 1:2 and 1:4 scales for military maps. Data on the shifting cultivation area are produced using the Forest Inventory Maps generated by the Forest Department, Ministry of Forestry.

Types of water erosion and their affected areas (Table 14.2) are deduced from medium-scale soil survey maps produced by LUD and the Myanmar Agriculture Service (MAS), Ministry of Agriculture and Irrigation (MOAI). Geographic information systems (GIS) have been used recently for the production of soil maps to clearly explore soil degradation condition in central dry zone areas. The usage is unsophisticated due to lack of software as well as human resources and financial aid.

8.2 Prediction and Modeling for Land Degradation Development

Slope maps, which are essential for erosion mapping and land capability mapping, have never been produced in Myanmar for so large an area. The methodology has been contributed by the Watershed Management for Three Critical Areas Project. After the slope maps have been produced for the entire project area at 1:633,600 scale, algorithms to produce erosion susceptibility data are formulated using FAO procedures. Management practices that conserve soil moisture or increase soil water holding capacity of the soils employ soil conservation techniques. For the time being, LUD is conducting measurement of the erosion rate on an experimental basis mainly in the central dry zone areas. Treatments include bare soil plots, contour plantation plots, plantation plots along the slope and natural vegetation plots. Soil loss findings from the tested plots are given in Table 14.3.

Table 14.3 Rate of soil erosion under different levels of soil cover

Testing period (During wet season)	Bare soil (no grass)	Plantation plots along contour	Plantation plots along slope	Natural vegetation	Rainfall amount per rainfall event
26 June to 7 October	0.63 t/ha	0.21 t/ha	0.22 t/ha	0.18 t/ha	3.8–2 mm 17 rainy days with total rainfall of 200 mm

Data from Land Use Division, Ministry of Agriculture and Irrigation (U Kyaw Yee, personal communication 2011)

9 Challenges

There is widespread land degradation as population increase. Demands for new and inappropriate land uses and husbandry practices are on the increase. A proper land use policy is the key to control land degradation due to improper land use and to ensure a sustainable use of land according to their productive capabilities and constraints. Up to now such a policy is lacking.

Efforts to combat desertification and arrest and reverse land degradation are still in progress in Myanmar. There are still many things that we don't know about the degradation of productive lands and the expansion of desertified land. We would like to achieve control technologies to reduce the rate of land degradation/desertification. From the scientific and technological point of view, we have low understanding of technologies on control of DDLD due to the needs for diverse levels of education as well as the lack of sufficiently proactive machinery and insufficient conversation between decision makers, scientists and media.

The main challenges to sustainable agriculture and rural development in Myanmar, could be (a) shortage of competent human resources in research and development activities, (b) lack of financial and or physical access of the farmers to the available inputs, (c) development and transfer of appropriate and sustainable agro-technology which are environmentally friendly, and (d) lack of marketing system that guarantee a fair share of benefit for all parties involved in the system. For the time being, only outdated aerial photograph interpretation and soil survey data (semi-detailed and topographic) are available, thus there is a need for improved methods to identify and collect more accurate information concerning the severity and extent of land degradation in Myanmar. Myanmar needs international cooperation and coordination among the network's countries for the establishment of a land degradation database, which will be of great benefit to land development.

To prevent land degradation, reliable and up-to-date information on the potential and constraints of the various agro-ecological zones and the production potential of each of them based upon systematic and quantitative land suitability and productivity assessments are required. A general national soil maps was made in the 1960s, but since then only little progress was made towards the creation of a national soil/land data base, due to financial and technical reasons.

Young staff members urgently need training, as experienced soil scientists are getting to or are past retirement age. Myanmar needs technical and financial assistance in this particular field. To increase awareness and participation of private sector in promoting sustainable agriculture, the government has initiated a number of activities, through farmers' meeting, pamphlets, radio broadcast, television, and field days. But much more needs to be done and help from the donor community including NGOs, will be needed over the next 10–15 years.

10 Conclusions

Land degradation has been a severe threat to sustainable agriculture and forest development for 50 years. Land degradation due to wind and water erosion, salinization and alkalinization is of particular concern. According to the current land utilization, about 11 million ha or 16 % of the total land area is under cultivation. Since a total of about 18 million ha is estimated as suitable for agricultural purposes, some 7 Mha of new land can be brought under crop cultivation and livestock farming. In bringing new land under agricultural use, it is important that scientific techniques for land evaluation and land-use planning are used to ensure the suitability and optimum use of land. In agricultural planning, land evaluation sets up a link between the basic survey of resources and the making of decisions on land use. As part of the land-use planning process, the Land Resources Information System is vital to ensure that environmentally valuable lands are not encroached upon and that adverse environmental impacts can be avoided.

To ensure conservation of the resource base, effective programs should be designed to address the following constraints in agriculture:

- Low productivity due to agro-climatic conditions;
- Low productivity due to water shortage;
- Low productivity due to soil degradation, irrigation-induced water-logging and salinity in the dry zone.

A number of agricultural research stations and centers are presently carrying out research on plant varieties, cropping patterns, irrigation techniques, water storage techniques and soil analysis. The programs and activities of these centers should be reviewed to ascertain their effectiveness and to assist in the formulation of new programs that can address key productivity constraints

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