

# **Forestation for combating climate change and its adverse impacts, commercial and environmental opportunities**

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## Definitions, Acronyms and Abbreviations

- **Afforestation:** Planting of new forests on lands which, historically, have not contained forests.
- **Climate change:** The United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.
- **Carbon dioxide equivalents (CO<sub>2</sub>e):** Carbon dioxide equivalency is a quantity that describes, for a given mixture and amount of greenhouse gas, the amount of CO<sub>2</sub> that would have the same global warming process (GWP), when measured over a specified timescale (generally, 100 years).
- **Developing countries:** A nation with a low level of material well-being. Since no single definition of the term developing country is recognized internationally, the levels of development may vary widely within so-called developing countries
- **Desertification:** Diminution or the destruction of the biological potential of the land that can lead ultimately to desert like condition.
- **Ecosystems:** A biological environment consisting of all the organisms living in a particular area, as well as all the nonliving (abiotic), physical components of the environment with which the organisms interact, such as air, soil, water and sunlight.
- **Forest:** A dense growth of trees, plants, and underbrush covering a large area.
- **Fossil fuels:** Fuels formed by natural processes such as anaerobic decomposition of buried dead organisms. The age of the organisms and their resulting fossil fuels is typically millions of years.
- **Global warming:** A continuing rise in the average temperature of Earth's atmosphere and oceans. Global warming is caused by increased concentrations of greenhouse gases in the atmosphere, resulting from human activities such as deforestation and burning of fossil fuels.
- **Greenhouse gas (GHG):** A gas in an atmosphere that absorbs and emits radiation within the thermal infrared range. This process is the fundamental cause of the greenhouse effect. The primary greenhouse gases in the Earth's atmosphere are water vapor, carbon dioxide, methane, nitrous oxide and ozone.
- **Hydrological cycle:** The continuous movement of water on, above and below the surface of the Earth. Water can change states among liquid, vapor and ice at various places in the water cycle, with total amount remaining similar.
- **Kyoto Protocol:** A protocol to UNFCCC, aimed at fighting global warming. The UNFCCC is an international environmental treaty with the goal of achieving the "stabilization of green house concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.

- **Poverty:** A pronounced deprivation of well-being related to lack of material income or consumption, low levels of education and health, vulnerability and exposure to risk, voicelessness and powerlessness.
- **Radiative forcing:** The change in net irradiance at atmospheric boundaries between different layers of the atmosphere, the troposphere and the stratosphere. *Net irradiance* is the difference between the incoming radiation energy and the outgoing radiation energy in a given climate system
- **Reforestation:** Planting of forests on lands which have, historically, previously contained forests but which have been converted to some other use.
- **Renewable energy:** The energy which comes from natural resources such as biomass, sunlight, wind rain, tides and geothermal heat which are renewable (naturally replenished).
- **Saline Agriculture:** A profitable and integrated use of genetic resources (plants, animals, fish, insects and micro-organisms) and improved agricultural practices to obtain better gains from saline land and saline water on a sustained basis.
- **Salt-affected land:** A soil having total salt concentration and/or exchange-able sodium sufficient to interfere with the growth of most of the crop plants.
- **Saline marginal land:** A partially degraded salinized land that, by using conventional agro-technologies, produces far less biomass (crops, grasses, trees, shrubs, etc.) than is possible from the same land if not salinized.
- **Saline wasteland:** A degraded land abandoned by farmers due to acute salinity problem.
- **Sink for GHGs:** Any process, activity or mechanism which removes a greenhouse gas, an aerosol, or a precursor of a greenhouse gas from the atmosphere.
- **Social entrepreneurship:** An enterprise which combines the passion of a social mission with an image of business-like discipline, innovation, and determination and aims for value in the form of large-scale, transformational benefit that accrues either to a significant segment of society or to society at large.
- **Training:** A deliberately planned learning process for improving people's job performance.
- **CO<sub>2</sub>:** Carbon dioxide
- **CDM:** Clean Development Mechanism
- **GHGs:** Green house gases
- **ppm:** Parts per million
- **UNFCCC:** The United Nations Framework Convention on Climate Change

# 1 Summary

Global environment is suffering from several problems. One of the greatest environmental issues is however climate change triggered by global warming. Many factors contribute to global warming and resulting problem of climate change, most important being increased atmospheric concentrations of greenhouse gases (GHGs) predominantly carbon dioxide. Global warming is likely to increase since civilization of the time is obliged to continue relying on fossil fuels as its primary energy source, at least through this century.

Climate change impacts all aspects of world's physical, biological and human systems and hence the human existence itself. Climate change mitigation scenarios involve reductions in the concentrations of greenhouse gases, either by reducing their sources or by increasing their sinks. It is emphasized that changes in land use patterns and management of natural and agricultural ecosystems, combined with commercial opportunities, can play a key role to increase the sink capacity, sequestering large amounts of carbon dioxide. Slowing down deforestation and promoting forestation are in particular useful because of large capacity of trees to sequester carbon dioxide. Moreover, forests do not need to be harvested and replanted each year with machinery that runs on fuel.

Beneficial effects of trees on soil and surrounding environment and human and animal life are adequately proven. They have protective, productive and aesthetic values for us adding beauty across the landscape. Forestation promotes the restoration of watershed areas for the benefit of the water environment, soil protection, flood reduction, conservation of biodiversity and improvement in wildlife habitats. Forest cover also moderates extreme temperatures, decrease evapotranspiration and reverse land degradation and desertification. The effective role played by plants in environmental protection and amelioration has been immensely appreciated and planting campaigns form an integral and effective method amongst various environmental/ ameliorative measures.

Trees can also help rehabilitate salt-affected land. Vegetation on salt-affected soils tends to reduce salt concentration in the top soil because of increased infiltration and reduced capillary rise of water. In most cases, forage can be produced from salt tolerant trees using land and water unsuitable for conventional crops. The use of fuel-wood from plantings will also save huge quantity of dung, which can enrich agricultural fields. Multiple tree species (and agro-forestry combinations) could be planted so that the converted land would provide multiple benefits to the communities. Some trees are productive, high yielding and of major economic interest. Their plantations are sustainable sources of raw materials necessary for a variety of industries, including energy production.

Forestation efforts, particularly afforestation entail several challenges. A principal challenge is the difficulty of convincing individual landowners to allow their agricultural land to become forested land. The best possibility is using their degraded lands for tree cultivation. Afforestation of degraded waste land would not only sequester carbon dioxide, improve soil and other environmental conditions but would also be source of livelihood. It is emphasized that carbon sequestration potential of soil is much greater on degraded lands than in good land for the reason that degraded lands would have negligible organic carbon to start with.

In the current economic crisis, financial pressures are exacerbating and social problems such as poverty and unemployment needs to be tackled by social entrepreneurship which can then generate their own

revenues to sustain themselves. A case in point is implementation of an out-reach community project, namely “Saline Agriculture Farmer Participatory Development Project in Pakistan” (SAFPDP) by Pakistan Atomic Energy Commission during 2002-08, for rehabilitation of 25000 acres of salt-affected land and resident communities. SAFPDP staff organized awareness seminars, vocational training courses, skill development programs and farmer field schools to educate the farming communities on all aspects of “Saline Agriculture” technology. Saline-waste land was planted with salt-tolerant trees, shrubs and/or grasses for the production of timber, food, forage, fuel, livestock products and fish and saline-marginal land was improved with good agriculture practices. By the conclusion of the project, livestock number and aquaculture enterprises rose, promoting high value agriculture. Yield of field crops also rose sharply. SAFPDP was instrumental in socio-economic uplift and prosperity of rural communities as shown by all social indicators in the project areas. Therefore rather than leaving forestation actions to the government or business sector, the model adopted by PAEC needs to be replicated on larger areas particularly on degraded lands for developing social entrepreneurship.

Pakistan has a lot of private and public land suitable for forestry or agro-forestry, especially in degraded environments. For example, water shed areas needs vigorous reforestation campaigns for conservation, economic, social and environmental reasons etc. The Indus plain needs a large-scale planting of trees for shelterbelts, soil reclamation and other environment benefits. Tree-farming system needs to be properly blended with crops and livestock production. Identification of eligible land for the CDM can be identified using data of Soil Survey of Pakistan.

It must be noted that all types of forestation, good agricultural practices and better animal husbandry can be instrumental in earning carbon credits if due procedures are followed. The carbon credits earned through any such means can be banked or sold to major regulated industrial GHG emitters through CDM compliance or voluntary markets. The main current international agreement on combating climate change (reducing emissions of and atmospheric concentration of greenhouse gases, or emission trading) is the Kyoto Protocol.

Although the CDM should not be expected to solve all problems associated with environmental degradation, it offers an opportunity for developing countries like Pakistan to obtain additional funding for rehabilitation of degraded ecosystems where domestic funding is not available. It can provide opportunity to improve livelihood of poor communities and help develop social entrepreneurship in the country. Increasing the capacity of community for implementation can also be a component of the project.

Climate change progressing with the current trends will increase the frequency of extreme weather events. Natural hazards such as floods, soil erosion and debris flow, avalanches, storms, droughts, desertification and increased salinity will have severe impact on agriculture, forest and water resources and their management. Adaptation strategies are therefore of vital importance for the supply of good-quality fresh water and protection from natural hazards. While mitigation efforts are in place we should also give due emphasis on strategies for adaptation to climate change

## **2 Introduction**

Global environment is suffering from several problems and these problems are in general most severe in developing countries like Pakistan. The problem of Climate change triggered by global warming is one of the greatest environmental issues of our time and is to be tackled on long term basis. Climate change is in-fact a part of larger global change (Alig 2003). An amicable solution of this problem has a direct and/or indirect bearing for the solution of other environmental problems also. This is especially true for developing countries.

Many factors are contributing to climate change. Most important are increased atmospheric concentrations of greenhouse gases (GHGs) predominantly carbon dioxide, originating from use of fossil fuels, since the preindustrial period and burning and clearing of tropical forests and land-use changes. In-fact, land use can be a critical factor in climate change and greenhouse gas production, which includes land-use changes and other human-caused alterations in the natural environment. Global warming is likely to increase since civilization of the time is obliged to continue relying on fossil fuels as its primary energy source at least through this century. So human activities, also called as anthropogenic factors, contribute greatly to global climate change (IPCC 2007).

Forest and agricultural land uses influence the global carbon cycle; forest growth and agricultural productivity are in turn influenced by global climate change. Climate change may alter the productivity of forests, altering resource management and processes of adaptation. Therefore land use patterns and in particular management of natural and agricultural ecosystems can play a key role to help control global carbon emissions. Moreover, our ecosystems must be able to adapt to these changes so that they can retain productivity. Decisions by people will be important in implementing adaptation to climate change and the efficiency of mitigation strategies (e.g., forestation to help mitigate climate change). Human communities need the knowledge and tools to effectively adapt to the impacts of climate change.

Supply, demand, and their effect on prices influence land use and the costs of adaptation and climate change mitigation. Land use may change both as people adapt and as people act to sequester more greenhouse gases by altering land uses (Alig et al. 2004), which is perhaps best possible if and when commercial opportunities with forestation and adoption of good agricultural practices can be maximized. With such changes, revenues can also be generated by earning/selling carbon credits in compliance and voluntary carbon trading markets. This paper briefly discusses all these issues in the context of forestry and environment, the key words of this conference.

## **3 Climate change**

The United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods (UNFCCC, 1994).

Climate change is a significant and lasting change in the statistical distribution of weather patterns over periods ranging from decades to millions of years. It may be a change in average weather conditions or the distribution of events around that average (e.g., more or fewer extreme weather events). The term sometimes is used to refer specifically to climate change caused by human activity, as opposed to changes in climate that may have resulted as part of Earths' natural processes, (Sahney et al., 2010). Used especially in the context of environmental policy climate change is synonymous with anthropogenic global warming.



### **3.1 What triggered climate change?**

Temperature has increased on Earth over the past century. Many scientists believe this is because of an increase in concentration of the main greenhouse gases: carbon dioxide, methane, nitrous oxide, and fluorocarbons. The mechanism of this process is simple. Shorter-wave ultraviolet solar radiation from the sun passes through Earth's atmosphere, and then is absorbed by the surface of the Earth, causing it to warm. Part of the absorbed energy is then re radiated back to the atmosphere as long-wave infrared radiation. Little of this long wave radiation escapes back into space; the radiation cannot pass through the greenhouse gases which naturally blanket the Earth in the atmosphere. The greenhouse gases selectively transmit the infrared waves, trapping some and allowing some to pass through into space. The greenhouse gases absorb these waves and re emits the waves downward. This reduces the heat radiated out to space causing the lower atmosphere to warm.

Since greenhouse gases serve to hold heat in like the glass walls of a greenhouse, this is called the Greenhouse Effect. Greenhouse gas molecules are responsible for the fact that the earth enjoys temperatures suitable for our active and complex biosphere. The earth's "greenhouse effect" is what makes this planet suitable for life as we know it. However, since industrial revolution several anthropogenic factors, i.e. human activities, pump carbon dioxide, and other green house gases into the atmosphere at an increased rate contributing to global warming, which affect the climate.

Most important anthropogenic factors are:

Increase in CO<sub>2</sub> levels due to emissions from fossil fuel combustion

Aerosols

Agricultural patterns

Cement manufacture

Ozone depletion

Animal agriculture

Deforestation

### **3.2 What are the adverse impacts of climate change?**

Climate change is a reality that unfortunately impacts all aspects of the human existence. There is a growing evidence that climate change, particularly increasing temperature, is already having significant impacts on the world's physical, biological and human systems, and it is expected that these impacts will become more severe.

Warmer temperatures are causing changes in the hydrological cycle at regional and global scales, including decreases in the amount of water stored as ice in most of the world's glaciers, ice sheets and sea ice; decreasing snow cover and earlier snow melt; and changes in rainfall patterns. These changes affect the incidence and severity of drought and floods and the availability of water, which in turn present challenges for many aspects of human society and industry (e.g. agriculture, rural economies, water security, food production and security, increased conflict over strained ecosystems and destruction and displacement of many communities that lost their livelihood.). Sea level rise due to losses from ice stores and thermal expansion is another consequence of climate change that will have an increasing impact on human settlements and infrastructure.

Increasing temperatures also affect biological systems. There is evidence of shifts in the range of plant and animal species to higher latitudes and altitudes, changes in species composition and abundance, and changes in the timing of many life-cycle events such as flowering and migration. These changes will affect many of our managed ecosystems (particularly agriculture and forestry) and biodiversity. Many of these impacts, especially when combined, are likely to cause increasing pressure on our resources and industries, and possibly on our social systems and health.

### **3.3 Mitigation strategies**

Climate change mitigation is action to decrease the intensity of radiative forcing in order to reduce the potential effects of global warming (IPCC Glossary Working Group, 2010). Most often, climate change mitigation scenarios involve reductions in the concentrations of greenhouse gases, either by reducing their sources (Molina et al., 2009), or by increasing their sinks. The UN defines mitigation in the context of climate change, as a human intervention to reduce the sources or enhance the sinks of greenhouse gases. Mitigation is distinguished from adaptation to global warming, which involves acting to tolerate the effects of global warming and to find ways to adapt to change that has already occurred and is anticipated to occur in the future (America's Climate Choices, 2010).

#### **3.3.1 Green house gas concentrations and stabilization**

One of the issues often discussed in relation to climate change mitigation is the stabilization of greenhouse gas concentrations in the atmosphere. Stabilization depends both on how quickly GHGs are added to the atmosphere and how fast they are removed. The current GHG level is approximately 390 ppm CO<sub>2</sub>e. UNFCCC has the ultimate objective of preventing "dangerous" anthropogenic interference of the climate system. This requires that GHGs concentrations are stabilized in the atmosphere at a level where ecosystems can adapt naturally to climate change, food is not threatened, and economic development can proceed in a sustainable fashion (Rogner et al. 2007). For this purpose, reducing greenhouse gas (GHG) emissions and stabilizing atmospheric concentrations at 350-450 parts per million CO<sub>2</sub> equivalent (ppm CO<sub>2</sub>e) is essential. Scientists have estimated that lowering concentrations to 350 ppm may enable us to avert tipping points of ocean acidification and the melting of permafrost and arctic ice. Stabilization at 450 ppm is thought to be the threshold to avoid dangerous warming of more than 2 degrees Celsius, which would bring potentially catastrophic impacts for natural and human communities alike.

UNFCCC (1992) requires from member states to limit its anthropogenic emissions of greenhouse gases and protect and enhance its greenhouse gas sinks and reservoirs". Many factors are contributing to climate change, from fossil fuel use to the burning and clearing of tropical forests. We need a comprehensive approach to reduce the impacts of all these factors – an approach that decreases emissions across all sectors and enhances the adaptive capacity of all nations. Examples include using fossil fuels more efficiently for industrial processes or electricity generation, switching to renewable energy (solar energy or wind power), improving industrial processes etc. the insulation of buildings, and expanding forests, better agriculture and other "sinks" to remove greater amounts of carbon dioxide from the atmosphere (Glossary of climate change acronyms, 1977). The "sink" was defined as "any process, activity or mechanism which removes a greenhouse gas, an aerosol, or a precursor of a greenhouse gas from the atmosphere".

#### **3.3.2 Methods and means**

There could be many mitigation actions but not all are created equal in terms of their ability to reduce GHG emissions. Climate change concerns and the need to reduce carbon emissions are

driving increasing growth in the renewable energy industries (International Energy Agency, 2008). The wind, sun and biomass are three main renewable energy sources. Among low-carbon energy sources nuclear power is unique since it brings with it important waste disposal, safety and security risks (Koplow, 2011). Moreover nuclear power plants have unfavorable economics compared to other sources of energy. Scientists have advanced a plan to power 100% of the world's energy with wind, hydroelectric and solar power by the year 2030.

### **3.3.3 Carbon intensity of fossil fuels**

Natural gas (predominantly methane) produces lower greenhouses gases per energy unit gained than oil, which in turn produces less than coal, principally because coal has a larger ratio of carbon to hydrogen. The combustion of natural gas emits almost 30 percent lower carbon dioxide than oil, and just under 45 percent lower carbon dioxide than coal. In addition, there are also other environmental benefits (Michael, 2010). Thus the increased use of natural gas in the place of other, dirtier fossil fuels can serve to lessen the emission of greenhouse gases in the United States.

### **3.3.4 Energy efficiency and conservation**

Both energy efficiency and conservation are important in environmental and economic terms. Efficient energy use, sometimes simply called "energy efficiency", is the goal of efforts to reduce the amount of energy required in various industrial processes to provide products and services. Other examples could be insulating a home or a building to use less heating and cooling energy to achieve and maintain a comfortable temperature and installing fluorescent lights (e.g. a spiral-type integrated compact fluorescent lamp) reduces the amount of energy required to attain the same level of illumination compared to using traditional incandescent light bulbs (Anonymous, 2007). Energy conservation is broader than energy efficiency in that it encompasses using less energy to achieve a lesser energy service, for example through behavioral change, as well as encompassing energy efficiency. Examples of conservation without efficiency improvements would be heating a room less in winter, driving less, working in a less brightly lit room or adopting green building designs.

### **3.3.5 Kyoto Protocol**

The main current international agreement on combating climate change is the Kyoto Protocol, which came into force on 16 February 2005. The Kyoto Protocol is an amendment to UNFCCC. Countries that have ratified this protocol have committed to reduce their emissions of carbon dioxide and five other greenhouse gases, or engage in emission trading if they maintain or increase emissions of these gases.

The first phase of the Kyoto Protocol expires in 2012 (Adam, 2009 A). The United Nations Climate Change Conference in Copenhagen in December 2009 was the next in an annual series of UN meetings that followed the 1992 Earth Summit in Rio. In 1997, the talks led to the Kyoto Protocol, Copenhagen was considered the world's chance to agree a successor to Kyoto that would bring about meaningful carbon cuts (Adam, 2009 B).

### **3.3.6 Developing countries**

In order to reconcile economic development with mitigating carbon emissions, developing countries need particular support, both financial and technical. One of the means of achieving this is the Kyoto Protocol's "Clean Development Mechanism" (CDM). The World Bank's Prototype Carbon Fund is a public-private-partnership that operates within the CDM. In July 2005 the U.S., China, India, Australia, as well as Japan and South Korea, agreed to the Asia-Pacific-Partnership for Clean Development and Climate. The pact aims to encourage technological development that may mitigate global warming, without coordinated emissions

targets. The highest goal of the pact is to find and promote new technology that aid both growth and a cleaner environment simultaneously, a need particularly beneficial for developing countries.

### **3.3.7 Carbon emissions trading**

The European Union Emission Trading Scheme (EU ETS) is the largest multi-national, greenhouse gas emissions trading scheme in the world. It commenced operation on 1 January 2005, and all 25 member states of the European Union participate in the scheme which has created a new market in carbon dioxide allowances estimated at 35 billion Euros (US\$43 billion) per year.

## **4 Greenhouse gas remediation**

CO<sub>2</sub> is not the only GHG relevant to mitigation, and governments have acted to regulate the emissions of other GHGs emitted by human activities (anthropogenic GHG). The emissions caps agreed to by most developed countries under the Kyoto Protocol regulate the emissions of almost all the anthropogenic GHGs (Grubb, 2003). These gases are CO<sub>2</sub>, methane (chemical formula: CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), the hydrofluorocarbons (abbreviated HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF<sub>6</sub>). Stabilizing the atmospheric concentrations of the different anthropogenic GHGs requires an understanding of their different physical properties.

Because of its predominance, carbon sequestration has been proposed as a method of reducing the amount of radiative forcing. Carbon sequestration is a term that describes processes that remove carbon from the atmosphere. A variety of means of artificially capturing and storing carbon, as well as of enhancing natural sequestration processes, are being explored. At the moment, photosynthesis by higher and lower plants is the only process considered as a main natural process to act as a sink by removing carbon dioxide from the atmosphere.

Plants take up carbon dioxide from the air and return oxygen in the process of photosynthesis. The carbon is stored in leaves, branches, stems, and roots. It is widely recognized that anthropogenic land uses and land use changes can alter the magnitude and rate of natural exchanges of greenhouse gases. Due to the dominating influence of natural forests, the issue of carbon sinks in relation to land-use, land-use change and forestation of all type of land is of particular interest- that is to capitalize on the remarkably efficient capacity of trees to remove carbon from the atmosphere.

## **5 Forestation can best combat climate change**

Although the primary source of anthropogenic carbon dioxide emissions is the use of fossil fuels, deforestation, i.e. removal of a forest or stand of trees where the land is thereafter converted to a non-forest use, contributes significantly to net increase of atmospheric carbon dioxide. For example almost 20% (8 GtCO<sub>2</sub>/year) of total greenhouse-gas emissions were from deforestation in 2007. Therefore, slowing down deforestation and promote forestation is a critical step of an overall strategy to address both global warming and climate change. (Alig et al., 2005). It must be emphasized that forests do not need to be harvested and replanted each year with machinery that runs on fuel.

To increase the capacity of forests to sequester and store carbon we need to maintain and enhance forestland base. Moreover what is good for forest health is good for carbon sequestration. Creating ideal conditions for growing trees also creates ideal opportunities for carbon sequestration. Whether we are interested in wood production or carbon sequestration,

the forest-management approaches are similar. That means increasing leaf area, maintaining forest health, accelerating growth, and thinning forests to remove the less vigorous trees, leaving the rapidly growing trees.

The climate-helping character of young forests should be a boon to society. Replanting the land with fast-growing, young trees quickly restores the forest canopy which continues the process of sequestering carbon. Two elements of strategies that could increase carbon sequestration potential are species selection and density management. While current research is aimed at maximizing the volumes of the commercial harvest, some results have shown that significant biomass gains can be achieved by modifying planting or spacing regimes. In addition to species selection and density management, increased planting instead of natural regeneration and seeding after harvesting can also increase carbon sequestration.

### **5.1 Forestation and soil health**

Forests are known to maintain soil fertility by adding organic matter to the soil, biological nitrogen fixation, and ensuring increased availability of essential nutrients by solubilization of phosphorus through mycorrhiza or bacterial activity and solubilization of other essential macro and micro nutrients. Addition of organic matter improves the physical properties of the soil (water retention, permeability and aggregate stability). Forest cover reduces the negative effects of the nutrients leaching and minimizes on top soil the erosive action of wind and rain. Forest cover also moderates extreme temperatures and decrease evapotranspiration from the system. All these factors ultimately result in increased biological productivity of soil.

### **5.2 Forestation types, reforestation and afforestation**

Two important areas of activity in forestation are reforestation and afforestation:

Reforestation can be equally or more profitable than before, with current trends of atmospheric warming and increased concentration of CO<sub>2</sub>. The National Climate Change Assessment in the late 1990s found that net economic impacts of climate change across forestry and agriculture were positive in a temperate zone (Alig et al. 2002; Irland et al. 2001), probably due to increased warmth. Proper maintenance as well as the restoration of damaged and degraded forest ecosystems can play a protective role and cushion the effects of climate change. Forestation promotes the restoration of degraded forests, particularly in floodplains and upper watershed areas for the benefit of the water environment, flood reduction, conservation of biodiversity and soil protection.

Afforestation efforts entail several challenges. A principal challenge is the difficulty of convincing individual landowners to allow their marginal agricultural and other land to become forested land. Therefore, afforestation is likely to proceed slowly at first, as programs and policies are implemented, financing mechanisms are established, landowners and others learn about opportunities, technical advice is provided, rules for carbon accounting are developed and seedlings are made available.

### **5.3 Why afforestation is preferable on degraded waste land in combating climate change?**

Afforestation is best known as a potential solution for mitigating climate change. Farmers are interested in incomes over short times and therefore they would grow crops if they can. Only degraded waste land could be the option for afforestation in most cases and that too if commercial opportunities are associated with it. Afforestation can help combat not just climate change but also improve wildlife habitat and water quality (Alig 2008). Valuing the ecosystem service of carbon sequestration in the marketplace could create incentive for private forest

owners to maintain or increase their forested acreage. Therefore focusing on achieving goals which go beyond just carbon sequestration, such as income generation, land management and environmental goals is likely to be the most successful approach to afforestation over the longer term.

Afforestation of degraded waste land would not only sequester carbon, improve soil and other environmental conditions but would also be source of livelihood where poorest of the poor live. It is emphasized that carbon sequestration potential of soil is much greater in degraded lands than in good land for the reason that degraded lands would have negligible organic carbon to start with. Ornstein et al (2009) investigated the possibility of using the Sahara and the Australian Outback as areas for afforestation. The Sahara and Australian Outback are extremely dry and arid areas; therefore the forests would have to be irrigated. The possible water supplies considered were the groundwater, biogeophysically-induced precipitation once the trees are established, and desalinated water. In this context they identified challenges to implement such a plan and argued that the costs involved with afforestation of subtropical deserts need to be weighed against potential costs of recovering from the impacts of global warming such as drought and flooding.

#### **5.4 Environmental/commercial opportunities associated with forestation**

Beneficial effects of trees on soil and surrounding environment and human and animal life are adequately proven. They have protective, productive and aesthetic values for us adding beauty across the landscape. The effective role played by plants in environmental protection and amelioration has been immensely appreciated and planting campaigns form an integral and effective method amongst various environmental/ ameliorative measures. Experts therefore say that more than 25% of landscape of the country should be covered with trees for environmental, conservation and economic reasons. In our country, area covered by trees is just 4-5%. This too is mostly located in the northern area. Reduced forest cover in northern areas due to deforestation is responsible for several ailments in watershed areas which are economic, social and environmental etc. The gigantic Indus plain in essence is devoid of trees and is intensively used for crop production. Only a few 'Kikar' and 'Shisham' trees are dotted here and there. Therefore, this plain does not have a tree cover to ameliorate hot winds blowing from south-west to north-east and to resist cyclonic winds and flow of dust. Moreover, our deserts are expanding because of reckless removal of vegetation for forage and fuel needs.

##### **5.4.1 Trees for environmental /aesthetic benefits**

Environmental planning and implementation costs cannot be reckoned merely on economic basis. The assessment should include external cost such as damage to the environment. It should consider aesthetic effects derived from conserving environment. The Indus plain needs a large-scale planting of trees for shelterbelts, soil reclamation and other environment benefits. Tree farming system should be properly blended with crops and livestock production. Microenvironment at farm-level has to be maintained in this way. Moreover, our deserts are expanding because of reckless removal of vegetation for forage and fuel needs.

##### **5.4.2 Trees as a Pollution Scavenger**

Trees act as natural filters as they remove (scavenge) pollutants from the atmosphere and thus improve the air quality by absorbing hazardous gases, particles and soot from the smoke. Global temperature is increasing because of green house effect; CO<sub>2</sub> is one of the major components of green house gases. To prevent global warming, trees need to be planted in billions as they absorb CO<sub>2</sub>. Plantations act as pollution sinks in two ways – as air filters and as air ventilators. Trees cause air current and eddies that help to ventilate an area that might

otherwise have very still air. The forest soil with its microbes and vegetative cover also acts as natural filters by absorbing noxious materials.

A dense stand of plantation is helpful in absorbing and reducing noise and in mitigating effects of noise. Its significance may be gauged from the fact that noise increases blood pressure, pulse rate and affects the frame of mind leading to depression and dulling of one's spirits, resulting in excessive fatigue, headaches and loss of hearing. A dense stand of plants with its flowers and foliage is ideal for mental recreation. In its quiet solitude, man finds peace and solace and the continuously changing views inside a plantation may divert him from the tension of daily life.

### **5.4.3 Protective role of trees on land**

We all know how trees can produce a pleasing microenvironment. Dense vegetation due to its sheltering and blanketing effect interrupts incoming light reflects it and reduces extremes of soil temperature by its canopy action and interaction of surface litter layers. Diurnal fluctuations in temperature also significantly reduce under dense plant cover. Due to higher evapo-transpiration, plantations increase atmospheric humidity and reduce temperature and air movement. Large plantations make conditions more favorable for obtaining rainfall. The effect on microclimate and moisture regime in turn affects soil, the amount and type of plant life in different soil layers and depth of rooting. The overall impact of trees on soil is healthy: more productive soil that is more resilient, less subject to degradation processes, environmentally sustainable natural or agro-ecosystems.

#### **5.4.3.1 Reduced floods and water erosion**

The plants reduce the force of raindrops and splashes and ultimate effect is reduced soil erosion. The soils under plantations have greater porosity, encourage absorption and infiltration of water and thus help recharge aquifers. Dense vegetation effectively checks excessive runoff, thus it may have a marked effect in the manner water is released from catchments and thus tampering the floods. Reduced sediment from catchment area under dense vegetation enhances watershed health, protects waterways and dams from silting in.

#### **5.4.3.2 Reduced desertification and wind erosion**

A thick stand of vegetation controls wind erosion and desertification. Soil is protected from blowing winds mainly because of binding action of roots and reduction in wind velocity by mechanical barrier of plant canopies. Rather a dense stand of trees serves to remove and settle wind borne dust. The leaves, branches and stems act as mechanical barriers and when dust laden wind blows into the vegetation, it loses much of its velocity resulting in the precipitation of much of its dust. Depending upon the plant species, one-hectare plantation has been reported to collect 36-68 tons of dust in a year. Filtering of dust by plants removes water condensation nuclear particles and reduces fog which contains gases injurious for life. However, the need for agricultural land to feed growing populations makes it unlikely that high-quality land will be used for planting trees.

#### **5.4.3.3 Rehabilitation of salt-affected land**

Trees can help rehabilitate salt-affected land. Vegetation on salt-affected soils tend to reduce salt concentration in the top soil because of increased infiltration and reduced capillary rise of water. This would allow farmers to grow field crops for immediate economic returns thus

allowing farmers to get short-term economic benefits also from saline wasteland with the help of trees. Such planting is cheaper and lasting and is preferred to various expensive engineering methods. In some cases, forage can be produced from salt tolerant trees using land and water unsuitable for conventional crops. Trees as compact plantations established on salt-affected soils and/or irrigated with saline water would allow better land and fresh water to be reserved for field crops. The use of fuel-wood from plantings will also save huge quantity of dung, which can enrich agricultural fields.

#### **5.4.4 Trees for Economic Benefits**

Increasing carbon storage in forests can also go hand-in-hand with other forest management goals, such as providing products of economic value and maintaining biodiversity. When we subject a piece of land to reforestation or afforestation, or when a crop land is converted to forest land, it doesn't have to be a monoculture. Multiple tree species (and agro-forestry combinations) could be planted so that the converted land would provide multiple benefits to the communities. Raising livestock, mushrooms and honey bees, seri and lac culture etc. are some examples of multiple benefits.

##### **5.4.4.1 Industrial forestry**

Some trees are productive, high yielding and of major economic interest. Their plantations are sustainable sources of raw materials necessary for a variety of industries, e.g., pulp or paper, panel products, match manufacturing, sports goods, plywood, fiberboard, saw wood, fuel-wood, charcoal, constructional and furniture timber. Such benefits have given rise to the concept of "industrial forestry which stands for application of technology to improve productivity and minimize environmental impact.

Industrial forestry primarily aims at harvesting and replanting of timber but also includes conservation and recreation purposes. The forest manager is also responsible for the application of other land controls, including the protection of wildlife and the implementation of programs to protect the forest from weeds, insects, fungal diseases and fire. The primary interest in industrial forestry is however to produce plants best-suited to produce large volumes of raw material for industrial use. Plantations are also increasingly used for producing energy by gasification or for producing costly compounds e.g. by pyrolysis etc. Most of the industrial plantations involve a large landowner, raising crops usually of one or two desirable tree species, with economic value rather than for subsistence.

##### **5.4.4.2 Social entrepreneurship**

A social enterprise targets its programs at the "underserved, neglected, or highly disadvantaged population that lacks the financial means or political clout to achieve the transformative benefit on its own. In the current economic crisis, financial pressures are exacerbating and social problems such as poverty and unemployment needs to be tackled with this approach. Social entrepreneurs manage donor contributions in an effective manner, investing in social ventures which can then generate their own revenues to sustain themselves.

##### **5.4.4.3 A case in point: "Saline agriculture Farmer Participatory Development Project in Pakistan"**

Pakistani scientists have done pioneering research to develop technologies to live with salinity for economically utilizing saline environments and/or brackish ground water. However a large



scale adoption of these technologies by end-users had yet to be seen. The reasons for this observation were that these technologies were developed at government owned R&D institutions and even extension department was not aware of them. Realizing the need to educate the end-users, Pakistan Atomic Energy Commission implemented an out-reach community project, namely “Saline Agriculture Farmer Participatory Development Project in Pakistan” (SAFPDP) as a pilot activity during 2002-08 in some parts of Pakistan. On conclusion of the project, PAEC published a technical report highlighting salient points and achievements of the project (Aslam et. al. 2009). The following account is based on contents of the report.

SAFPDP staff organized awareness seminars, vocational training courses, skill development programs and farmer field schools to educate the farming communities on all aspects of “Saline Agriculture” technology. Training/skill development programs included participatory nursery raising, planting techniques on salt-affected soils, appropriate agronomic and irrigation practices for economic utilization of salt-affected soils and brackish ground water, use of amendments like gypsum and mineral acids for the improvement of salt-affected soils and brackish waters, grafting techniques and plant production technologies, use of friendly insects for pest control, use of salt-tolerant plants, animal health care, vaccinations against animal diseases and preparation of urea-molasses feed blocks, honey bee keeping and saline aquaculture. Knowledge sharing was also done with farmers, extension workers and interested persons elsewhere, through brochures, newsletters, print and electronic media and a website, [www.sem.org.pk](http://www.sem.org.pk). The farmers were provided farm machinery, seeds/saplings of salt-tolerant plants, fish seed, feed blocks and animal vaccines and other agricultural inputs either free of cost or on highly subsidized rates.

Saline-waste land was planted with salt-tolerant trees, shrubs and/or grasses for the production of timber, food, forage, fuel, livestock products and fish. Most importantly, livestock number and aquaculture enterprises rose sharply, promoting high value agriculture. Yield of field crops also rose sharply. SAFDPD also acted as a conduit for relevant departments in introducing bio-gas technology and improving water channels and streets/roads in the project area. With “Saline Agriculture” interventions, plant production and thus, farmer incomes increased substantially, contributing to wards food security and poverty alleviation at the project sites. Physical and chemical properties of soil i.e. soil quality improved and hence also capability and capital value of land were increased greatly. SAFDPD was instrumental in socio-economic uplift and prosperity of rural communities as shown by all social indicators in the project areas. SAFDPD also had a very good fall out effect in areas adjacent to the project sites. It is emphasized that “saline Agriculture” could be a potential strategy for revegetation and thus sequestering CO<sub>2</sub> in the atmosphere in degraded salt-affected areas, and thus tackling in one go, land degradation and human-induced climate change.



Fig. 1 *Acacia ampliceps* can be successfully grown on saline waste



Fig 2. *A. ampliceps* grown on saline-waste land support goat herds

#### 5.4.4.4 Forestation for social entrepreneurship

Because of the financial burden to start with, and bureaucratic hurdles, large scale forestation in public sector is unlikely to be realized in the near future. Industrial planting is feasible only with large profit margins and with social interests generally compromised. Rather than leaving forestation actions to the government or business sector, the model adopted by PAEC needs to be replicated on larger areas particularly on degraded lands for developing social entrepreneurship. This is likely to solve the problem by changing the system, spreading the solution, and persuading entire societies to take new leaps on a landscape level. The need for forestation is understandable and ethical, and therefore can engage widespread support, recruiting maximum number of local people implementing it with passion. Social entrepreneurship would rely less heavily dependent on donor funds because it would create social programs that are meant to be self-sustaining.

### 6 Valuing carbon sequestration in the marketplace

All types of forestation, good agricultural practices and better animal husbandry can be instrumental in earning carbon credits if due procedures are followed.

#### 6.1 Forest ecosystems

Active forest development/management can increase carbon sequestration, especially when the carbon forests capture is put into long-term storage such as in wood products like lumber for building/ construction etc. Therefore forest-based efforts to sequester greenhouse gases could serve as a bridge to a broader implementation of substantial greenhouse emission reductions (Alig et al., 2005). If carbon sequestration were valued in the marketplace as part of a GHG offset program, the economic value of sequestered carbon on public or private lands could be substantial, relative to timber harvest revenues (Depro et al. 2008). Surely society's welfare can be enhanced by involving them with ownerships for forestation at a landscape level and help them with decision support by public agencies.

#### 6.2 Agro-ecosystems

Although not to the extent possible with forest ecosystems, the potential of large agricultural soil carbon sinks could also be realized as a climate change mitigation strategy. This can happen by including conservation practices on croplands (i.e., reduced or no tillage and reduced fallow land), pasture management, conversion of marginal croplands to perennial grass and

conservation of wetlands and riparian areas. With this approach, growers could not only earn carbon credits from agricultural soil but would also potentially lower input costs resulting from lower fuel use, as well as more efficient use of fertilizers. Nevertheless landowners must be provided information about the comparative advantage of sequestering carbon and other greenhouse gases (GHG) in forest practices (e.g., afforestation) as compared to those in agriculture.

Better livestock management techniques also offer opportunities for significant reductions in GHG emissions. Methane (which is 23 times more potent of a greenhouse gas versus carbon dioxide) is produced by livestock via flatulence and eructation. In terms of prevention, vaccines have been introduced in Australia to reduce methane released by livestock via flatulence and eructation (Committee on Science, Engineering, and Public Policy (1992)). A world-wide adoption of such vaccines may drastically reduce methane release from livestock with significant reduction in GHG contributions towards global warming. Alternatively people will need to stop raising livestock and turn vegetarian if the world is to conquer climate change. The carbon credits earned through any such means can be banked or sold to major regulated industrial GHG emitters through CDM compliance or voluntary markets.

### **6.3 Identifying eligible land for the CDM**

Water shed areas needs vigorous reforestation campaigns for conservation, economic, social and environmental reasons etc. The Indus plain needs a large-scale planting of trees for shelterbelts, soil reclamation and other environment benefits. Tree farming system should be properly blended with crops and livestock production. Microenvironment at farm-level has to be maintained in this way. However, the need for agricultural land to feed growing populations makes it unlikely that high-quality land will be used for planting trees. Nevertheless, Pakistan has a lot of private and public land suitable for forestry or agro-forestry, especially in degraded environments. Identification of eligible land for the CDM can be identified using data of Soil Survey of Pakistan. District governments may be represented during site selection. This may ensure the commitment of local government to support project preparation and implementation, including the creation of enabling conditions at the local level.

### **6.4 Planning CDM projects with social entrepreneurships**

As mentioned earlier, afforestation on degraded waste land is preferable for carbon sequestration and meeting environmental and commercial needs. Social needs can be advanced with implementation of such projects by social entrepreneurs. Increasing the capacity of community for implementation would be a component of the project. Specific community capacity needs include short and long term training including specialization in the areas of agro-forestry, high-risk areas of soil erosion, environmental management and program awareness to farmers, foresters and agricultural extension workers, and the establishment of community tree nurseries. The project must also have a goal to improving the ecology, promoting the rural economy and increasing farmers' income. Under such projects, the forests will also improve the aesthetics and the rural environment, increase forest resources and vegetation coverage and guarantee agricultural production providing people with fuel wood and cash crops earn carbon credits and increase the capital value of otherwise unproductive land.

## **7 Strategies for adaptation to climate change**

Despite mitigation efforts there is no tangible decrease in emission of greenhouse gases at global level as a whole. Climate change progressing with the current trends will increase the frequency of extreme weather events. Natural hazards such as floods, soil erosion and debris flow, avalanches, storms, droughts, desertification and increased salinity will have severe

impact on agriculture, forest and water resources and their management. We are already witnessing severe heat waves, cyclonic and erratic patterns of rainfall and flash floods. Adaptation strategies are therefore of vital importance for the supply of good-quality fresh water and protection from natural hazards. While mitigation efforts are in place we should also give due emphasis on strategies for adaptation to climate change. Well adapted forest and agricultural sectors could not only limit adverse effects of climate change (Alig et al. 2004) but would also benefit growth of plants at least in some places because of elevated levels of temperature and CO<sub>2</sub>. Acquired ability for maintaining natural and agro-ecosystems will ensure that humans and other species can remain as resilient as possible to the impacts of climate change.

## **8 Concluding comment**

Although the CDM should not be expected to solve all problems associated with environmental degradation, it offers an opportunity for developing countries like Pakistan to obtain additional funding for rehabilitation of degraded ecosystems in mountains, plains, deserts and coastal areas where domestic funding is not available. It also offers opportunity to improve livelihood of poor communities and help develop social entrepreneurs in the country. The CDM should be recognized both in the agriculture and forest sectors for the opportunities it provides to stakeholders to participate in large- and small-scale projects and giving incentives and encouraging private landholders to practice sustainable agriculture and forestry voluntarily. There is also much room for improving animal husbandry to increase production of milk and meat etc. and earning carbon credits. While mitigation efforts are in place we should also develop appropriate programs for adaptation to climate change.

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