# 6

# Eco-friendly Sustainable Development

## THE GLOBAL ENVIRONMENTAL SUSTAINABILITY CHALLENGE

One of the most pertinent challenges for sustainable development in the twenty-first century is the impact of developmental initiatives on the environment. Global warming and climate change are worldwide issues and have far-reaching consequences that will be felt by every human being in times to come. It is a challenge whose outcome will affect the sustainability of the earth and its ecosystem for future generations. In this chapter we will try to understand the problem of environment sustainability, its relationship with development and the possible ways of integrating development and environmental conservation.

A term which is exclusively associated with the environment is greenhouse gas (GHG). GHGs are gases that absorb and emit radiation into the atmosphere. Carbon dioxide, water vapour, methane, nitrous oxide and ozone are some of the primary GHGs in the earth's atmosphere. In our solar system, Venus, Mars and Titan—the largest of the many moons of the planet Saturn—all have greenhouse gases in their atmosphere.

GHGs lead to the phenomenon of greenhouse effect in the earth's atmosphere. As we all know, the sun heats the earth by the process of radiation. About 50 per cent of the energy radiated by the sun is absorbed by the earth's surface while the rest is reflected back into space. This reflected energy is absorbed by the GHGs and then re-emitted in all directions and on to the earth. Thus, the lower atmosphere and the surface get heated much more than they would have been by solar radiation alone. In fact, it has been established that in the absence of greenhouse gases the earth's temperature would have been about –19°C which is about 33°C below the current average surface temperature.[1] At this temperature, most of the oceans would have been frozen, and most of the life forms that inhabit the planet would not have been possible. Thus, per se, the presence of naturally occurring GHGs is a necessity for life to exist.

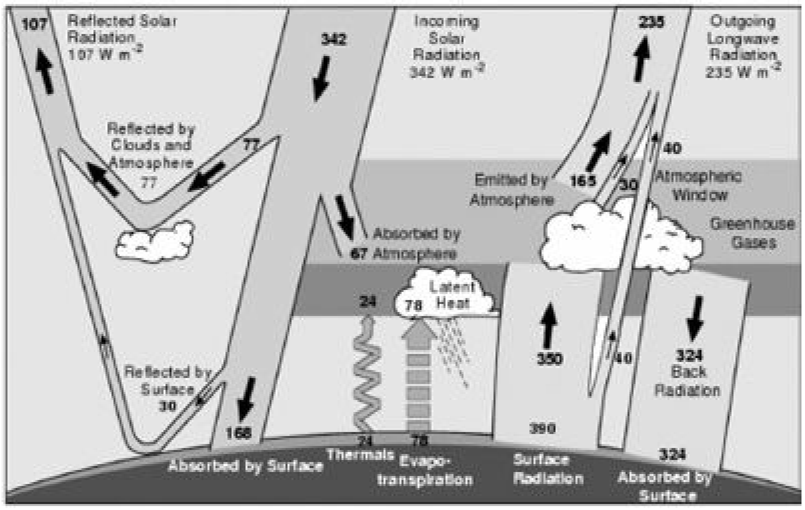


**FIGURE 6.1**: Global heat flows

Source: J.T. Kiehl and K.E. Trenberth, 'Earth's Annual Global Mean Energy Budget', 1997

The earth has both natural sources and sinks for the GHGs, which are delicately balanced. The natural sources of GHGs are volcanic eruptions, decaying vegetation, releases from oceans and land—all due to natural processes. These are balanced by the natural sinks of GHGs like ocean absorption, plants and soil. But it is now evident that human activities since the Industrial Revolution have been systematically altering this thin balance.

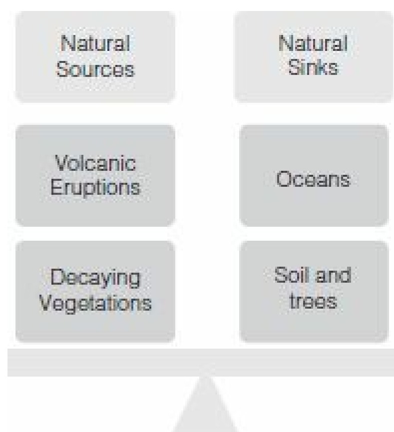


**FIGURE 6.2**: Natural sources and sinks of GHGs

Source: *Climate Change 2007*, IPCC Report 2007

As of 2007, the human-generated, or anthropogenic, annual carbon dioxide emission worldwide stood at roughly 30 billion tons (30 trillion kg) or 30 gigatons,[2] while the total GHG emission (including carbon dioxide) stood at 41 billion tons (measured in carbon dioxide equivalents).[3] Out of this, around half is absorbed by the natural sinks of oceans and soil. This means around 15 gigatons of additional $CO_2$ is released into the atmosphere. Different scientific calculations show that one part per million (1 ppm) roughly corresponds to about 7.8 billion tons of $CO_2$. This means that we are adding about two parts per million of carbon dioxide every year. Such imbalances have been more significant since the Industrial Revolution. Analyses show (see Figure 6.3) that the $CO_2$ concentration has risen from the pre-industrial figure of around 280 ppm in 1750 to about 384 ppm in 2005.

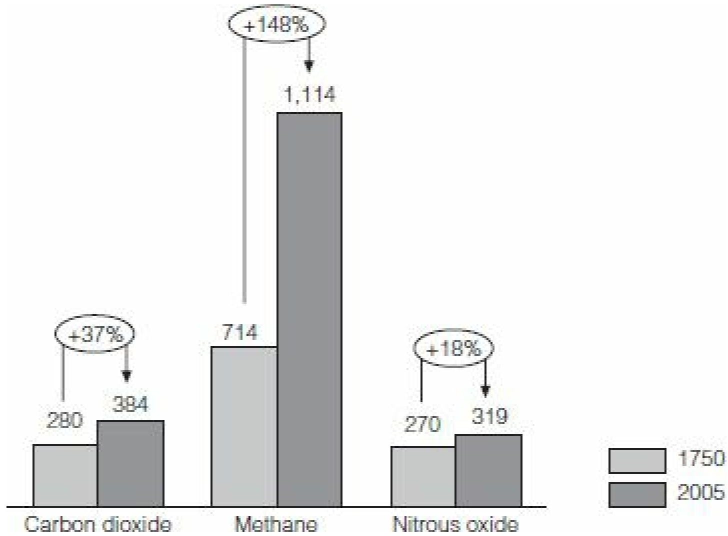


**FIGURE 6.3**: Increasing levels of GHGs

Source: *Climate Change 2007*, IPCC Report 2007

**EMISSIONS FROM SOME DAILY ACTIVITIES**

1 KW-h (kilowatt-hour) of power
= 1.27 kg of $CO_2$
1 kg of coal burnt
= 2.87 kg of $CO_2$
10 km by car
= 2.10 kg of $CO_2$
1 litre of diesel burnt = 2.70 kg of $CO_2$
10 km by two-wheeler = 0.70 kg of $CO_2$

Carbon dioxide is not the only greenhouse gas which has risen significantly. Methane, which is another greenhouse gas with a warming effect four times that of $CO_2$, has risen from a concentration of 714 parts per billion (ppb) to 1,774 ppb in 2005. Another greenhouse gas, nitrous oxide, has risen from a pre-industrial figure of 270 ppb to 319 ppb in 2005.[4] When seen over a large time frame of more than 10,000 years, there is clear proof of a massive surge in the concentration of greenhouse gases in the recent few decades.

Human beings, by the process of biological respiration, release about 900 gm (450 litres) of $CO_2$ into the atmosphere every day.[5] But the net carbon dioxide footprint is many times this figure. An average American releases more than 50 kg of $CO_2$ equivalent emission per day, which is almost sixty times the biological requirement. The average figure for the world is about 12 kg per day, while an average Indian emits about 3.7 kg of $CO_2$ equivalent per day into the atmosphere.[6] It is worth noting here that India is the fourth-largest emitter of GHGs, behind China, the USA and Russia, but its per capita emission is less than one-third the global average. In fact, out of the top ten emitters, India is the only country whose per capita emission is below the world average.

We need to consider why we human beings have become such high-intensity GHG-emitters. Let us take a few examples. The mobility of human beings has gone up exponentially over the last half a century, which is a burden on the usage of fossil fuels.[7] Take air travel, for instance. A return journey from New Delhi to New York burns more than 260,000 kg of fuel. Each kilogram of fuel yields about 3.1 kg of $CO_2$. The release of water vapour into the dry stratospheric conditions and the emission of NOx (nitrogen oxide) add to the GHG effect. The net amount of $CO_2$ equivalent added per person for the return journey would be around 12,000–24,000 kg.[8]

From where does this carbon emission come? As in Figure 6.5, energy supply is the highest contributor and is responsible for around 26 per cent of the overall emissions, largely due to the burning of fossil fuels to generate electricity. Industries have a share of more than 19 per cent of the global emissions, while deforestation contributes another 17 per cent.[9]

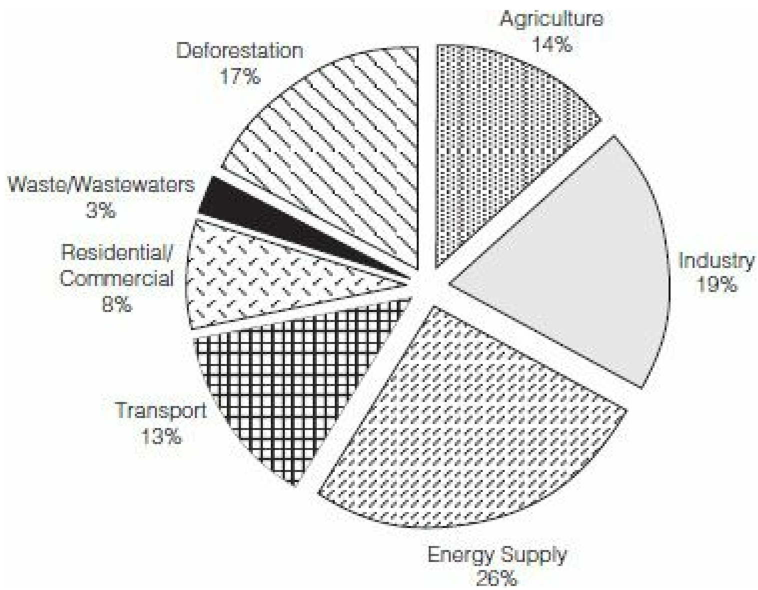


**FIGURE 6.5**: Causes of carbon emission

Agriculture, too, is responsible for about 14 per cent of the global GHG emissions. The entire transport sector put together is responsible for another 13 per cent. The rest of the emission comes from the residential and commercial sectors, waste and wastewaters.[10]

This increase in the concentration of GHGs translates into an increase in radiative forcing (heating power) of +2.3 watts per square metre[11] as estimated by the Inter-governmental Panel for Climate Change (IPCC) in 2007. Besides GHGs, human activities have also led to an increase of aerosol content in the atmosphere, which occurs in the form of sulphates, black carbon, nitrates and dust. The combined effect of this aerosol—both directly and indirectly—is atmospheric cooling at the radiative force of about –1.2 watts per square metre. Putting together all the effects, the net human-generated global warming, as measured in radiative forcing, is about +1.6 watts per square metre. Even if this rate were held constant at the current levels, it would translate into a rise of 0.1°C of temperature every decade during this century.

**RADIATIVE FORCING**

Radiative forcing, often measured in W/m2, is a typically used scale to measure the impact of a particular factor or GHG in heating the atmosphere. IPCC defines radiative force thus:

'Radiative forcing is a measure of the influence a factor has in altering the balance of incoming and outgoing energy in the earth-atmosphere system and is an index of the importance of the factor as a potential climate change mechanism. In this report radiative forcing values are for changes relative to pre-industrial conditions defined at 1750 and are expressed in watts per square meter ($W/m^2$).'

In simple words, radiative forcing is the rate of energy change per unit area.

In terms of the gases, $CO_2$ from fossil fuels is the largest contributor (see Figure 6.4), with a share of about 57 per cent, to the overall GHGs emitted. Another 18 per cent of the GHGs is the $CO_2$ coming out of decomposition of biomass and deforestation. Methane constitutes about 14 per cent of the total emissions and nitrous oxide is another 8 per cent. Both these gases are largely due to the agricultural and domestic sectors.[12]

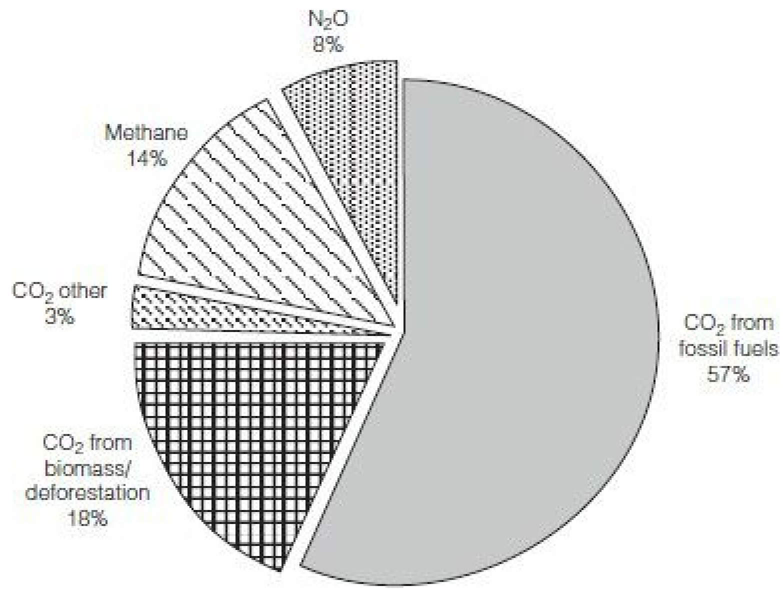


**FIGURE 6.4**: Contributors of human-generated $CO_2$

Source: *Climate Change 2007*, IPCC Report 2007

The effect of global warming caused by GHGs is also seen in the rise of the sea level. Expert agencies report that the global sea level has been rising at an average of 1.8 mm per year since 1961. This rate has now risen to about 3.1 mm per year at the start of this decade. Scientists estimate that the chief contributor to the rise in the level of the sea is the thermal expansion of oceans, accounting for 57 per cent of the rise (see Figure 6.7). Another 28 per cent of the rise is due to the melting of glaciers, and the rest comes from loss of polar ice sheets. This rise is accompanied by a decreasing ice extent. Satellite data shows that the Arctic Sea extent has been shrinking by 2.7 per cent per decade since 1978.[13]

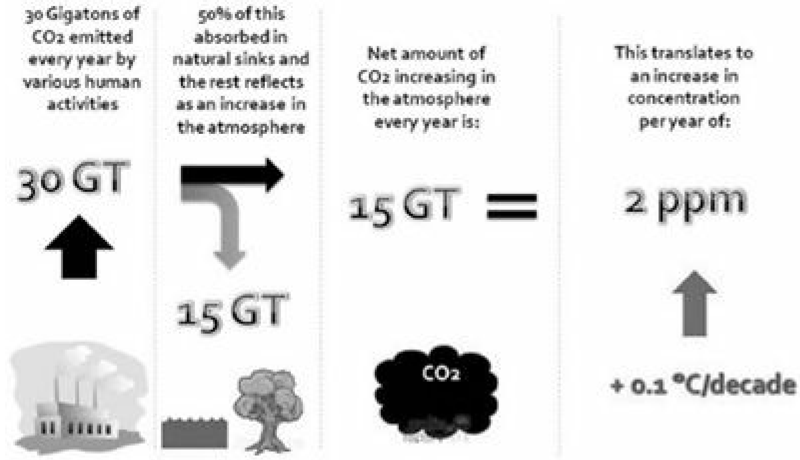


**FIGURE 6.6**: The greenhouse budget

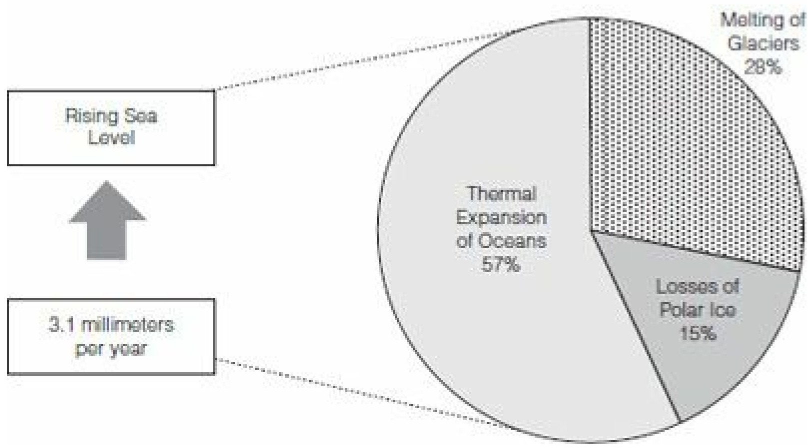


**FIGURE 6.7**: Causes of the rising sea level

The rising sea level is a global threat, especially to low-lying deltas, smaller islands and coastal areas across the world. This is even more critical as today nearly half the world population lives within 200 km of the sea, and this number is expected to double by 2025.

To offset the carbon emission there are many natural sinks of carbon. One sink of $CO_2$ is trees which essentially lock up the $CO_2$ present in the atmosphere as carbon within their trunks and also in the soil. The forests that are still standing have about 4,500 GT (gigatons) of carbon stored in them. By contrast, the total remaining oil has only about 2,400 GT of carbon equivalents. Even the atmosphere on an average has about 3,000 GT of carbon stored in it.[14] But by far, the largest sinks of $CO_2$ are the oceans, which dissolve almost fifty times the $CO_2$ that is present in the atmosphere itself.

The challenge posed by environmental change is indeed real. There may be debates on the intensity of the problem, but the fact that the last decade (2000–09) was the warmest one so far in the recorded history[15] of the world is proof that, while we cannot be sure of the rate of associated threat, one thing is certain—global warming is a significant and clearly visible phenomenon. Any sustainable development system has to be integrally linked to environmental considerations.

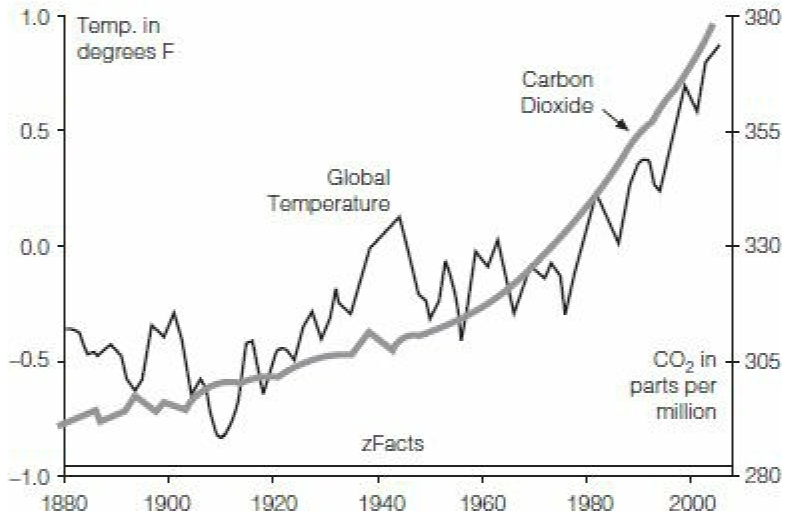


**FIGURE 6.8**: Temperature rise and $CO_2$ emission

Source: *Climate Change 2007*, IPCC Report 2007

Now we will discuss some of the factors which can be instrumental in bringing down the GHG emissions and in realizing a sustainable development system that would have global significance. Later we will discuss some prominent small-scale—often village-level—initiatives from across the world which can be the building blocks for any sustainable development system in the form of a PURA complex.

**METHODS OF REDUCING EMISSIONS**

- Reforestation
- Energy independence
- Renewable sources for power generation
- Use of biofuels
- Reducing waste and converting it into wealth
- Reducing emission by intelligent building

Of course, the GHG emissions from human activities come in many forms and hence the approach to solving the problem also needs to be multi-pronged, covering many areas.

## REFORESTATION

We had earlier discussed how oceans are a sink for GHGs. But there is a problem. Oceans are essentially liquids that contain dissolved gases. But the capacity of any liquid to absorb gases decreases sharply with a rise in the temperature. Hence, with rising temperatures, oceans are able to absorb less and less GHGs. Forests are the most stable carbon sinks because their ability to absorb—unlike that of oceans—is affected less by heating. Each tree, on an average, removes 20 kg of net $CO_2$ every year by the process of photosynthesis. Besides this, each tree provides shade and protection from the wind which, by conservation of energy, can indirectly cause reduction in the emission of

$CO_2$ equal to fifteen times its absorption by the tree itself. Of course, this value varies from tree to tree, and tropical trees are far more effective in absorbing $CO_2$. Every acre of trees is thus capable of removing $CO_2$ generated by burning 3,700 litres of gasoline in a year and providing oxygen to about twenty-two human adults.

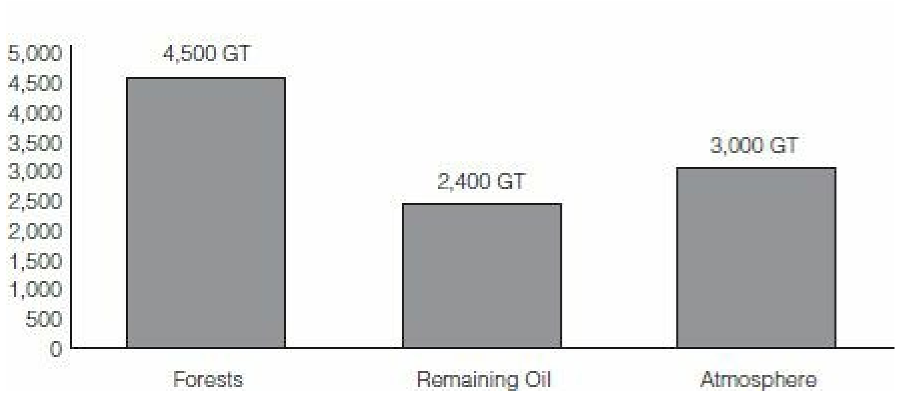


**FIGURE 6.9**: $CO_2$ stored in forests, oil and the atmosphere

Source: Video titled 'A Convenient Truth', FAO

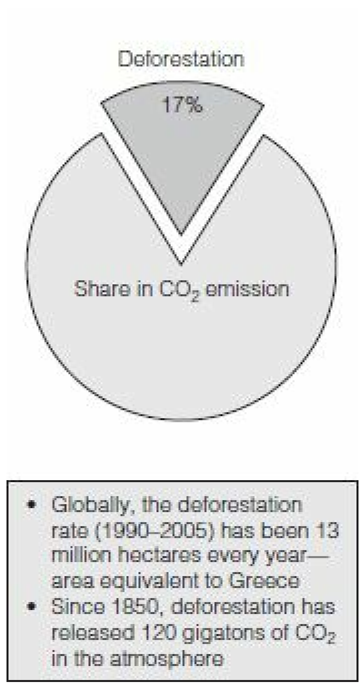


**FIGURE 6.10**: The results of deforestation

Source: Video titled 'A Convenient Truth', FAO

However, when forests are cleared, they release the carbon back into the atmosphere in the form of $CO_2$, methane and other gases.

In fact, deforestation accounts for 17.4 per cent of $CO_2$ emissions and is a larger source than the entire global transport sector. Eight thousand years ago, nearly 50 per cent of the earth's surface was covered with forests. Over the years, deforestation has brought it down to 30 per cent now.[16]

Today, we are destroying forests at the rate of 13 million hectares every year, which means we are annually removing forest cover equivalent to the size of Greece.[17] Most of the deforestation has occurred in the least developed regions of the world, especially in the equatorial forests of Amazon, Africa and Indonesia. During the period 1990–2005, there has been a decrease of more than 5 million hectares in Central and South American forests and about 4 million hectares in Africa.[18]

This trend can be reversed by a thrust on reclaiming the lost forests by replacing the lost trees and creating new ones.

The Indian government has promoted the plantation of new trees under the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA), which mandates 100 days of guaranteed employment to every rural family. Similar efforts are being made by many state governments across the country.

India has a unique strength in the 130 million young school-going children. If each student were assigned the responsibility of planting and taking care of ten trees, we could plant more than a billion trees in the country during the next ten to twelve years. Schools need to participate actively in such environment-friendly ventures.

An important aspect in this context would be the choice of trees for replanting. In such initiatives, we should focus more on fruit-bearing trees or trees with medicinal value. Further research should be conducted in the development of fast-growing varieties which are more resistant to climate changes and pests.

**MGNREGA AND TREE PLANTATION**

Tree plantation is one of the activities promoted by the MGNREGA, a flagship programme of the Indian government. This was successfully carried out in Bihar under the leadership of a civil servant, S.M. Raju. Every village council has now been given a target of planting 50,000 saplings. A group of four families has to plant 200 seedlings and to protect them for three years till the plants grow sturdier. Depending on the survival of the trees, funds are released. One proof of the success of this initiative was clearly seen on 30 August 2009, when 300,000 villagers from over 7,500 villages in northern Bihar were engaged in a mass tree-planting ceremony, which had the potential for breaking the record for the highest number of trees planted by a group in one day.

*Source*: A BBC report

## ENERGY INDEPENDENCE

Energy is the lifeline for modern societies. But today, India has 17 per cent of the world's population and just over 1 per cent of the world's known oil and natural gas resources, including the petroleum and natural gas reserves in the Krishna–Godavari (KG) basin and the Barmer (Rajasthan) region.[19] We might be able to extend the use of our coal reserves for some time but that too at a high cost and by facing environmental challenges. The climate of the globe, as a whole, is changing.

**GLOBAL ENERGY VISION 2030**

Global Energy Vision 2030 has to be three-dimensional. First, it has to ensure that quality energy is made affordable and accessible for all. Second, it must ensure that dependence on depleting fossil fuels is minimized, thereby giving stability to the energy supply. Third, it has to be balanced against the environment aspect, by stressing the development of greenery, thereby adding cleanliness to our energy. The energy independence vision has to be global in its implementation and a priority for all nations.

Five objectives for achieving Global Energy Vision 2030:

1. Improving energy efficiency in industrial, transport, residential and commercial sectors and reducing by 50 per cent the growth rate of energy demand.
2. Dependence on fossil fuels as the primary energy source to be brought down to under 50 per cent.
3. Replacing petroleum as a primary fuel source for transport by renewable fuels that emit less carbon or are completely carbon-neutral.
4. Enforcing methods for development of green energy through a seamless flow of ideas and technologies with international collaboration.
5. Reducing the net emission per unit of energy consumption to 25 per cent of the current rate.

We will first discuss energy security, which rests on two principles. The first is, using the least amount of energy to provide services and cutting down energy losses. The second is, securing access to all sources of energy including coal, oil and gas supplies, before the end of the fossil fuels era, which is approaching fast. Simultaneously, we should access various technologies to provide a diverse supply of reliable, affordable and environmentally sustainable energy.

Energy security, which means ensuring that our country can supply energy to all its citizens at affordable costs at all times, is thus a very important and significant need, and an essential step on the path to progress. But it must be considered as a transition strategy, to enable us to achieve our real goal—energy independence—an economy that will function effectively with total freedom from oil, gas and coal imports.

Hence, our highest priority has to be achieving energy independence. We must make a tremendous effort to attain this within the next twenty-one years, which means, by the year 2030. For carrying out this mission, a proper policy must be formulated, funds guaranteed and leadership entrusted without delay, as a public–private partnership, to our younger generation—now in their thirties—as a lifetime mission in a renewed drive for nation-building.

Let me now explain the pattern of energy consumption in India. We have to look critically at the need for energy independence in different ways in its two major sectors: the generation and the transportation of electric power. At present, we have an installed capacity of about 180,000 MW (megawatts)* of electricity, which is 3 per cent of the world capacity.[20]

A forecast of our energy requirement by 2030—when our population may be 1.4 billion people—indicates that the demand from the power sector will increase from the existing 180,000 MW to about 400,000 MW. This comes to a growth rate of 5 per cent per annum.

In India, electric power is at present generated from four basic energy sources: fossil fuels such as oil, natural gas and coal; hydroelectricity; nuclear power; and the renewable energy sources—biofuels, solar, biomass, the wind and the oceans.

Fortunately for India, 89 per cent of the inputs for power generation today is available indigenously: coal, 55 per cent; hydroelectricity, 21 per cent; nuclear power, 3 per cent; and renewable, 11 per cent. The solar energy segment contributes just 0.2 per cent to our energy production.

It can be seen that only 11 per cent of electric power generation is dependent on oil and natural gas, most of which is imported at an enormous cost. Only 1 per cent of oil (about 2–3 million tons) is being used every year for producing electricity. However, power generation to the extent of 10 per cent is dependent on high-cost gas supplies. With the recent discoveries of oil and natural gas, this will come down, but only marginally. India is making efforts to access natural gas from other countries.

Let us discuss coal, another fossil fuel. Even though India has abundant quantities of coal, it is constrained by regional locations, a high ash content that affects the thermal efficiency of our power plants, besides which there are also environmental concerns. Thus, a movement towards energy independence would demand accelerated work in the production of energy from the coal sector through integrated gasification and a combined cycle route.

In 2030, the total energy requirement of the nation is expected to be 400,000 MW. By that time, if we were to follow the present route, the power generated from coal-based power plants would increase from the existing 80,000 MW to 200,000 MW. This would demand a significant build-up of thermal power stations and a large-scale expansion of coal fields, leading, naturally, to much higher levels of pollution.

The hydel capacity generated through normal water sources and by the interlinking of rivers is expected to contribute an additional 50,000 MW. Numerous large-scale solar energy farms with a capacity of hundreds of megawatts could together contribute around 55,000 MW. The nuclear power plants should have a target of 50,000 MW of power. At least 64,000 MW of electrical power should come from wind energy. The balance 51,000 MW has to be generated through conventional thermal plants, through coal and gas, and renewable sources of energy such as biomass, through burning municipal solid waste and solar thermal power. The most significant aspect, however, is that the power generated through renewable energy technologies has to be increased to 28 per cent from the present 5 per cent.

We also depend on crude oil to the extent of 192 million tons every year, of which about 83 per cent is imported and used almost entirely by sector.[21] The resources known at present and the future exploration of oil and gas may give mixed results. The import cost of oil and natural gas for 2009 was almost Rs 400,000 crore ($80 billion).[22] Petroleum prices are highly volatile and steadily rising, going as high as $147 per barrel in 2008.

Electricity production is the single largest source of man-made GHGs with a share of 25.9 per cent in the overall emission of $CO_2$. This is largely due to the fact that more than 41 per cent of overall world electricity[23] depends on coal-based plants, which are highly polluting. This trend is yet to start reversing with many countries still rapidly putting up coal-based plants.

## RENEWABLE SOURCES FOR POWER GENERATION

Against this background, any move towards sustainability would be fruitless without altering our methods of generating electricity. One of the ways out of this problem is to focus on green and non-emission processes of electricity generation, at both the local and central levels. We shall discuss some of these ideas.

### *Solar energy*

At sea level on a clear day, any part of the surface of the earth which is perpendicular to the sun's rays receives about 1,000 watts of solar energy per square metre. The total solar energy absorbed by the earth's atmosphere, the oceans and the land masses is approximately 3,850,000 exajoules (EJ) per year. Thus the solar energy absorbed by the earth in one hour is more than what the entire human population uses in one year.[24]

Such a huge source of energy holds tremendous possibilities for mankind. Solar energy, in particular, has the potential for massive application in the agricultural sector, where farmers need electricity exclusively in the daytime. This could be a primary demand-driver for solar energy. Shortages of water—both for drinking and farming operations—can be met by large-scale desalination of sea water and pumping it inland, using solar energy supplemented by biofuels wherever necessary.

### *Wind energy*

Experts have estimated that the potential of wind energy in India is around 45,000 MW.[25] Intense research and development is required for reducing the investment per MW through improved designing and the application of newer technologies. The generation cost at present is between Rs 2.50 to Rs 3.50 per unit, depending on the site, and should be brought down to Re 1.00. Autonomous wind-generating units can be established in islands and remote areas if the site has wind potential. Feasibility studies have to be conducted to determine the economic size of wind energy plants, which can be used for lifting water from a 30-metre depth and can serve the needs of farmers with small holdings in a region with an average wind speed of 8 to 10 km per hour.

Such integrated actions will enable the realization of 64,000 MW of wind power against the present ceiling.

### *Energy in the transportation sector*

The transportation sector in India is the fastest-growing consumer of energy. As discussed earlier, the import cost for India in 2009 of oil and natural gas was almost more than $80 billion, which is much more than the budget allocation for any other sector in the same period, as compared in Figure 6.11. Moreover, every time we import petroleum products we indirectly import GHGs, as each litre of petrol burnt produces about 2.7 kg of $CO_2$.

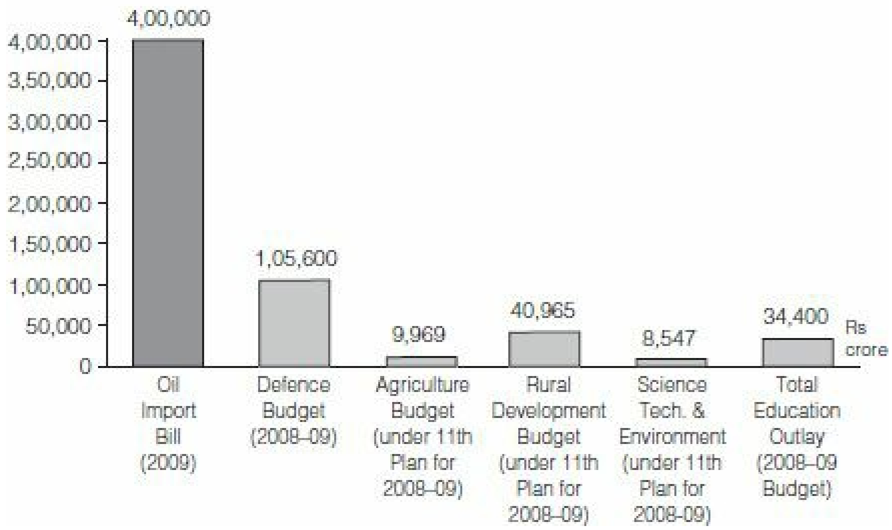


**FIGURE 6.11**: Oil import budget versus other allocations for India (figures are in Rs crore; 1 crore = 10 million)

Source: Indian Budget 2008–09, Indian Economic Survey

This has to be carefully addressed as a large fraction of our net imports consists of only petroleum and hence, major fluctuations in the international prices of oil and gas have the potential to destabilize our balance of payments situation. This highlights the need to explore the next-generation alternative fuels which are economical, fast to produce and safe to use. In the future, India has to take immense strides to achieve energy independence, which means satisfying its energy requirements by a combination of unconventional energy sources like wind, solar, nuclear, tidal and geothermal. One very promising clean fuel is in the form of biodiesel from a variety of agricultural initiatives. This form of energy can be the answer to the energy needs of the 1.6 billion people worldwide who lack access to electricity, and about 2.5 billion people who rely on traditional biomass fuels to supply their energy needs.

**PETROLEUM IMPORT AND ECONOMIES OF THE WORLD**

Petroleum import is a major burden on most of the developing and underdeveloped economies of the world. Of the fifty poorest nations of the world, thirty-eight are net importers of petroleum, and out of these, twenty-five are totally dependent on imports to meet with their requirements. This means that their already-fragile economies are made even more vulnerable by fluctuations in oil prices. A United Nations report highlights the fact that some of these nations were spending six times more on fuel than they do on health. A sustainable development system—whether on a national or an international scale—cannot be realized without achieving energy independence.

Initially, biofuels were obtained from edible crops like corn and gave rise to apprehensions of biofuels creating a gap in the food supply. But now, there are a number of advanced ‘second-generation’ biofuels that are made from inedible plant material. What is most significant is the fact that, lately, many special energy crops are coming up which can be grown in poor soil conditions, with less water requirements. Hence, they will not enter into a ‘resource competition’ with the much-needed food crops.

# USE OF BIOFUELS

In June 2006 we held the Conference on Biodiesel: Towards Energy Independence in Rashtrapati Nilayam, Hyderabad, in which various stakeholders—farmers, entrepreneurs, marketing agencies, researchers, policy-makers and NGOs—actively participated. The conference suggested the following actions to be taken up in mission mode:

1. Achieving the production of 60 million tons of biodiesel per annum by 2030 (this would be 20 per cent of the anticipated oil consumption in 2030).
2. As a first step towards reaching this target, drawing up a coordinated plan for achieving a 6-million-ton production by 2010, which would be 5 per cent of the present import of oil.
3. Improving, through research, the productivity of seed and extraction techniques and expanding the area under crops capable of yielding biodiesel in order to obtain 30 million tons of oil by 2020, and 60 million tons by 2030.

There are many kinds of biofuels.

## *Jatropha*

One such type is the biodiesel obtained from Jatropha, whose success I have seen near a cluster of villages in Allahabad district in north India. The Jatropha plant, which can be grown in non-arable and fallow lands, has the unique property of transforming alkaline land into cultivable soil. Also, where land has to be reclaimed from the sea, it has been done in less than two years' time with the Jatropha plant. Another property, unique to this plant, is that after it is cultivated it takes only two years to bear fruit. When the seeds are crushed, the resulting oil from them can be processed to produce a high-quality diesel oil with less carbon content than fossil fuels. It is estimated that each hectare under Jatropha plantation can yield 2,500 plants and offset 20 tons of $CO_2$ per year for forty years. Moreover, there is the economic gain from the sale of the biodiesel.

The biggest advantage of Jatropha lies in the fact that it can be used to reclaim wastelands with little input and yet give good results. India has about 33 million hectares of wasteland allotted to tree plantation. This land can be gainfully used to produce biodiesel and create energy independence. Let us see how.

**ECO-PRENEUR WITH A BIOFUEL MISSION**

The country has been engaged in cultivating Jatropha for the last decade, but the real momentum for it began only in 2005. Based on the present estimates, as of June 2008, over 560,000 hectares are under Jatropha cultivation. Out of this, nearly 84,000 hectares are in the state of Chhattisgarh and 10,400 hectares in Allahabad (Uttar Pradesh), where the impetus has been provided by Dr D.N. Tiwari, a former member of the Planning Commission, Government of India. Under his leadership, an NGO has been working near Allahabad and has converted 735 hectares of wasteland (infertile, marginal and abandoned land) into Jatropha-producing land, capable of earning Rs 50,000 per hectare.

Originally, this land, which was alkaline in nature, was given to the farmers of Allahabad district. Many of the farmers started using the mud from the land for producing bricks. Others gave it up and went to the cities for work. When the special characteristics of Jatropha were realized through the work of Dr Tiwari, the villagers undertook its cultivation on that land. Since then, these villagers have realized energy independence through the use of biofuel. They do not use kerosene for cooking, or petrol and diesel for running their generators and vehicles. Not using kerosene has resulted in better health for women in rural areas. Jatropha is also planted on fertile land as a shield against heat for the banana plantations during summer.

Owing to the planting of Jatropha, the soil from being alkaline has become neutral, and it has reduced environmental pollution.

Seeing the success of 735 farmers, over 10,000 farmers have taken to planting Jatropha in the Allahabad region. In addition to the upgrading of soil, the Jatropha plantation has enabled water retention and an enhancement of the water table in the neighbouring areas. Dr Tiwari and his team are now engaged in research and development to make Jatropha a more feasible source of biodiesel. This includes increasing the yield from seed to 35 per cent (oil content); the use of oil cakes; and using the residue as fertilizer and pesticide.

On an average, one hectare of land under Jatropha plantation gives about 5 tons of Jatropha seeds a year, from the third year after planting. This can generate about 0.75 to 2 tons of biodiesel depending on the conditions. If we take a rough average of about 1.4 tons per hectare, then the wastelands of the nation have the potential to generate more than 43 tons of diesel oil every year, which roughly matches our current demand. With improving technology, this quantity can only move upwards and biodiesel can be the mission for energy independence and economic returns. Can we employ our wastelands to meet our energy demands?

The government of Chhattisgarh in central India is actively pursuing a biodiesel mission based on Jatropha. The state has already planted 160,000 hectares with Jatropha and, with further cultivation it hopes to extract 2,000,000 tonnes of biodiesel annually. Interestingly, one of the users of biodiesel is the chief minister of the state himself.

### *Algae oil*

One clean fuel is in the form of biodiesel from algae. Recently, I visited Eastern Kentucky University in the USA where they have set up the Center for Renewable and Alternative Fuel Technologies to carry out research for making algae fuel production commercially viable. Algae can be easily grown in low-lying, shallow areas near the sea. It is later used to extract algae oil which can act as a supplement to the conventional petroleum derivatives. Algae oil is far superior in terms of yield per hectare. Compared to conventional biofuel crops like corn—which generates about 172 litres per hectare—algae oil can generate more than a hundred times that yield. The challenge is to develop better technologies which can bring down the cost of generating algae oil. Also, the sequestration process of algae means that, for every 100 kg of algae produced, almost 180 kg of $CO_2$ is absorbed from the atmosphere, during which process about 22 litres of algae oil is also produced.[26] The residual algae mass can be used as an organic fertilizer that can economize the process.

At the international aerospace exhibition, ILA 2010 in Berlin, the world’s first algae-oil-powered aircraft, a Diamond DA42 powered by two Austro Engine AE300, was exhibited. The test showed that with minor modifications to the engines, a biofuel-powered flight is possible. In fact, the reports further highlighted that due to the higher energy content in the algae oil, the fuel consumption was actually lower than that of the standard JET-A1 fuel. The amount of $CO_2$ released during the flight was equal to that amount of $CO_2$ absorbed by the algae during its growth—leading to a carbon-neutral flight. For the entire transport industry, this is indeed a promising development.[27]

### *Other biofuels*

Biofuels are being generated from various sources around the world. They include a wide variety of edible and non-edible crops like maize, soyabean, potato, wheat, rice, sunflower, sugar beet, willow and sugar cane.

Coco biofuel is also one of the highest-yielding land-based varieties, with an output of up to 700 gallons per hectare. It is a promising option for the coastal and island areas and their PURA complexes.

## REDUCING WASTE AND CONVERTING IT INTO WEALTH

### *Generating electricity through municipal waste*

Residential and commercial areas contribute about 8 per cent to the total GHGs, a large part of which is due to untreated waste. Increased urbanization has further led to another serious problem—that of the accumulation of municipal solid waste. The efficient and environmentally clean disposal of this waste has always been a major technological challenge. Although it is a threat to the environment, mounting garbage is also a rich source of energy. The potential for converting this waste into usable energy—which would, at the same time, eliminate a major source of urban pollution—was realized by one of our innovative organizations, the Technology Information, Forecasting and Assessment Council (TIFAC) of the Department of Science and Technology. The department helped by developing a completely indigenous solution for the processing of waste into fuel which could, in turn, be used for generating electricity through mini plants.

Two entrepreneurs in Andhra Pradesh have adopted and refined the technology and established two independent plants in Hyderabad and Vijayawada, generating over 12 MW of electricity which is being supplied to the state grid. India needs thousands of mini power plants using municipal waste in small towns and urban areas. The banking sector, with the collaboration of small-and medium-sized enterprises, can provide the thrust for promoting such power plants in major municipalities.

Recently, I was introduced to the Plasma Enhanced Melter (PEM), which offers a revolutionary method of dealing with two pressing needs of today's society: disposal and treatment of waste, and clean sources of energy. The PEM can convert almost any kind of waste material into 'syngas'—composed of 40–45 per cent hydrogen and 30–35 per cent $CO_2$—that can be used to power a turbine generator. The PEM is superior to competing methods because of its economic and environmental advantages and its potential to be used across a wide range of applications.

### *Converting fly ash into a wealth-generator*

The use of coal for generating power results in an increased quantum of fly ash production, which has reached about 100 million tons per year. All-out efforts are needed to utilize this fly ash, not only out of environmental considerations, but also to avoid using land for dumping it. It is reported that when fly ash is mixed with soil, the agricultural increase of grains is around 15 per cent, that of green vegetables 35 per cent, and root vegetables 50 per cent, without any risk of toxicity. Fly ash can become a wealth-generator by using it for agriculture and producing 'green' building materials. Its usage can also be an employment-generator and, at full utilization, it can provide a business volume of over Rs 4,000 crore ($8 billion) per year.

## REDUCING EMISSION BY INTELLIGENT BUILDING

The emerging trends of intelligent and 'green' building entail the use of modern technology, smart materials and eco-friendly designs. The building environment and comfort conditions could be monitored and altered to suit specific requirements, using new processing tools like neural networks and fuzzy logic. The future holds a lot of promise as new concepts in nano technology, smart materials and design software will open fresh avenues and unleash an era of efficient and sustainable buildings.

### DEVELOPMENT AND ENVIRONMENT: ARE THEY COMPATIBLE?

There have been significant discussions on how development can be compatible with non-linear developmental goals. Development is closely linked with energy consumption, and increase in the demand for energy is both a prerequisite for development and a consequence of it. Mechanization is required for rapid development, which is an additional burden on energy needs. Moreover, development, in the end, leads to better incomes for people who then have more purchasing power and consequently, there is a further increase in the demand for energy. As long as our primary energy continues to be supplied largely by fossil fuels and their derivatives, development will come at the cost of the environment.

**GREEN BELT MOVEMENT**

Professor Wangari Maathai is passionate about environment and biodiversity, and is actively contributing to the sustainable development and growth of planet Earth. Wangari Muta Maathai was born in Nyeri, Kenya, in 1940. She is the first woman in east and central Africa to earn a doctorate degree and to become chair of the Department of Veterinary Anatomy and an associate professor. Wangari Maathai was active in the National Council of Women of Kenya and was its chairperson from 1981 to 1987. While she was on the council, she introduced the idea of community-planting of trees and has continued to develop it into a broad-based, grass-roots organization whose main focus is the planting of trees by women's groups in order improve the quality of their lives and to conserve the environment. This led to the birth of the Green Belt Movement, through which Professor Maathai has evolved a movement with 600 community networks across Kenya and in twenty countries, resulting in the plantation of 40 million trees.

She and her movement have received numerous awards, most notably the 2004 Nobel Peace Prize.

Professor Maathai gives a new meaning to the important act of planting a tree by extending it to life itself, when she says, 'The planting of trees is the planting of ideas.' She highlights the qualities of patience and commitment in planning and realizing a future, which is what we learn when we plant trees and wait for them to yield fruit. India honoured her contribution to the furthering of the relationship between India and Kenya, and awarded her with the Jawaharlal Nehru Award for International Understanding (2005).

She concluded her Nobel Lecture in 2004 thus: 'As I conclude, I reflect on my childhood experience when I would visit a stream next to our home to fetch water for my mother. I would drink water straight from the stream … I saw thousands of tadpoles: black, energetic and wriggling through the clear water against the background of the brown earth. This is the world I inherited from my parents.'

The new generation development models of PURA, with sustainability as a focus, have to evolve mitigating strategies to avoid falling into the vicious development–environmental degradation trap as shown in Figure 6.12. They have to use technology and innovation as a bridge between the environment and ecology.

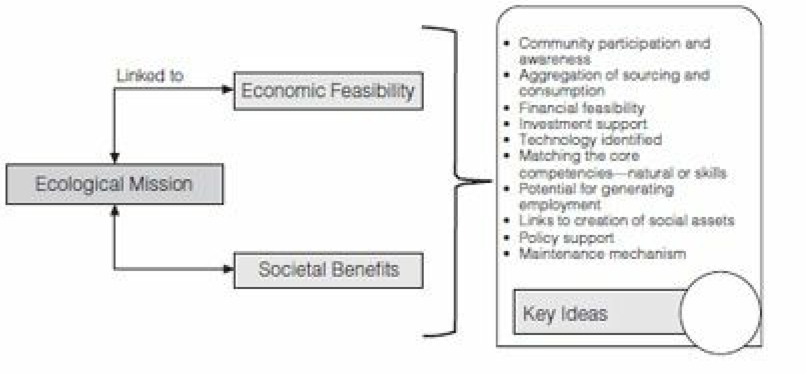


**FIGURE 6.12**: Building ecological missions

## AN ENVIRONMENTALLY CONSCIOUS SOCIETY

First and foremost, it is important to create a society which is sensitive and committed to the cause of environmental conservation and enhancement. For this purpose, it is necessary to make environment a part of the education system and engage the youth in the mission for conserving the environment. There are more than 550 million youths in the nation, and if each youth could be motivated to plant and nurture ten trees, then we could achieve a cumulative target of planting more than a billion trees for the nation.

It is also important to link environmental conservation with economic and social benefits. If people can be persuaded that their wealth and health are inseparably associated with their care of the environment, a significantly eco-conscious society can evolve. This is proved in the case of the Mudiali Fisherman's Cooperative Society that shows how successful and sustainable initiatives can be undertaken, which are also environmentally beneficial.

### LINKING ECOLOGY AND ECONOMICS

The Mudiali Fisherman's Cooperative Society is located on about 80 hectares of wetlands leased from the Kolkata Port Trust (KPT), in a densely populated area about 10 km south-west of the heart of Kolkata (West Bengal).

The local people, largely fishermen, leased this unused marshy wetland, cleared it of not only natural weeds and debris, but also of anti-social elements, and used it for wastewater fisheries. In the process, it cleansed the water by natural means and converted the area into a nature park, which has become quite a popular attraction in the city of Kolkata.

The park accepts the domestic sewage and industrial waste-laden water as input, and employs a series of cleansing processes to remove the heavy metal from the wastewater. This water, laden with organic material, is used to breed quality fish and manufacture fish food, thereby significantly improving the income levels of the fishermen. The park, which sees thousands of visitors every day, is also an income-generating source for the women of the households that run small restaurants and other enterprises in the park.

While this experiment is relatively smaller, it is a great inspiration in the way a community, through its innovative spirit and entrepreneurship, has linked an environmental mission with economic goals, and demonstrated how wastewater can act as a significant source of income.

## ECO-PRENEURS AND INNOVATION

The new generation of sustainable development can give rise to a new form of entrepreneurship that would be a bridge between environment and business—eco-preneurship, which would generate green jobs.

The PURA complexes—especially those located in regions with forest cover and unspoiled natural conditions—can find the possibility for such eco-preneurship opportunities. These may be run independently, such as an ecotourism centre; or they could be a part of an existing model like the value addition of green energy sources to enterprises, solar cookers to homes, water conservation and treatment measures; or the installation of bio-gasifiers in the animal husbandry sector to cut down on the methane emissions that are dangerous for livestock. Let us understand this with a real life example from Siwa in Egypt.

Siwa is an oasis in the western desert of Egypt (about 550 km from Cairo, the capital of the nation). It is an isolated settlement of Berbers and has a dense landscape of trees, natural springs and salt lakes. It is an important stopping place for caravans travelling in the desert from the Nile Valley towards Libya. It is home to the Oracle of Amon and it is also believed to have been visited by Alexander the Great. Thus, Siwa has significance as a trading point and also possesses heritage value. It has a small population of about 25,000 people and, given its core competencies, it had the potential for a sustainable development system with a multi-pronged integrated development focus.

**THE ECO-PRENEUR WITH A TREE MISSION**

In May 2010, while in Gujarat, I met with Premjibhai who has made a remarkable contribution to tree-planting in certain areas of Gujarat. Starting his mission in 1987, he would set out every morning with a small spade in hand and a bagful of seeds, which he would plant on the bunds of fields. Later, at the age of fifty-five, he bought a motorcycle and added mobility to his mission. He began approaching individuals and institutions for voluntary service and motivated them to engage in ecological restoration. He also brought schoolchildren into the fold of the mission by contacting local schools. He travelled more than 140,000 km during his first five years on the motorcycle. Later, he and his team invented a unique petrol-driven mechanical blower that could be mounted on the back of a jeep and which could blow the seeds to a distance of 15 metres.

In 2009, using this invention, he ‘broadcast’ 10 tons of tamarind seeds in the villages around Ahmedabad. It is estimated that about 45 billion seeds have been distributed by him. Even if 0.25 per cent of them survived, Premjibhai is responsible for planting more than 10 million trees. This is equivalent to nearly 200 million kg of $CO_2$ removed every year which, in a typical carbon market, would be worth about Rs 20 crore per year.

It was only in 1977 that the Government of Egypt established some physical connectivity to the place by providing roads from other parts of Egypt. In 1998, Environmental Quality International (EQI), the Cairo-based environmental service and consulting firm, began to invest in the area of Siwa Oasis, by implementing the Siwa Sustainable Development Initiative (SSDI). This project was done in partnership with the Canadian International Development Agency (CIDA), which supported it under its initiative for generating employment, and the International Finance Corporation (IFC), which provided the necessary financial assistance.

The objectives of the SSDI were to make Siwa Oasis a natural heritage site; to preserve and enhance the fragile ecosystem of the Oasis; to generate employment for the local people; and, at the same time, to establish a business utilizing the core competencies of the Siwa region. The initiatives chosen for implementation included temporary lodging facilities; women’s artisanship development initiative; sustainable agriculture; renewable energy for the region; organic farming and other development projects for the community.

The materials used for constructing are entirely traditional, comprising palm beams and olive wood. In this way, it preserves the culture and the environment and also establishes an attraction value proposition for its customers. Under the renewable energy initiative, the SSDI is implementing twenty-five bio-digesters that will absorb methane, which has very high radiative force, and use the resulting gases as fuel. Another area that it is promoting is organic farming and the capacity-building of farmers in this domain, and helping them connect with high-value markets. The net effect of its efforts is that value-added jobs have been generated for local families. While earlier, few income-generating activities were available except during the three-month season of cultivating dates and olives, there is year-round income generation since the SSDI started its operations. Till date, UNDP reports, it has brought social and economic advantages to more than 600 families in the Siwa region. At the same time, it has preserved the ecology of the Oasis, leading to sustainable development.

A sustainable development model such as this has significant scope in desert regions where oasis-based PURAs can be established, which will protect the environment and the unique culture of the place. Eco-friendly income-generating activities can be extended to other areas as well. Take for example, the case of eco-and medical tourism. These combined with tourism promotion activities as a part of the PURA mission will have a three-fold impact. First, the enterprises will be created around the philosophy of protecting the environment and culture. Second, as a collateral benefit, the local areas will have access to quality health care. Third, with the increase in enterprises, there will be quality jobs ranging from doctors and nurses to guides and hospitality, and jobs in other service sectors.[28]

## BIODIVERSITY AS A GENERATOR OF WEALTH FOR THE NATION

India occupies only 2.4 per cent of the world's total land area, but its contribution to the world biodiversity is 8 per cent of the total number of species. India has ten distinct biodiversity zones with varying terrain, rainfall patterns and climatic conditions. Biogeographically, India is situated at the junction of three of the eight terrestrial eco-zones—the Afrotropic, the Indo-Malayan and the Palearctic. Hence, it has the characteristics of all of them. India is one of the twelve countries in the world with mega diversity. It has about 11.7 per cent of the world pisces (fish) and about 12.6 per cent of the world's bird species.[29]

India ranks seventh in the world as far as the number and variety of species in animal husbandry and agriculture are concerned. There are 166 types of crops and 320 types of wild and domesticated animals. More than 19 per cent of our land area is covered with forests, but the area of dense forests has to increase to 30 per cent.* This forest cover can be divided into sixteen major groups comprising 221 types. Our wetlands—while occupying only 3 per cent of the area—are home to about 320 species of birds and 150 species of amphibians. Similarly, we have a wide diversity of plants and animals in our mangroves, coral islands and islands. Indian deserts have more than 1,200 species of animals. The question we need to ask ourselves is, how can this biodiversity be preserved, enhanced and become a source of strength for the nation?

The biodiversity of the nation can be a core competency which can be used as the basis for undertaking a three-pronged mission of ecological conservation, societal empowerment and economic development.

Let us now analyse some of the areas where our biodiversity can help us attain this.

## EXOTIC FOOD PRODUCTS

Mankind, during the long course of its history, has used approximately 80,000 edible plants, of which only about 150 have ever been cultivated on a large scale. Today, about ten to twenty species provide 80–90 per cent of the food requirements of the world. Most of the plants being used as a source of nutrition and food in the tribal areas of the nation are not known to the outside world. For example, such food varieties are *Ceropegia bulbosa* in central India; *Meliosma pinnata* in the northeast; *Cicer microphyllum* in Kashmir. Many of these may have special nutritional value or exotic flavours. Tapioca is a very important food item in the southern states. We should embark on a mission to collate and research the various forms of such traditional food varieties. This would help promote rural enterprises, which would be vertically integrated and could export processed and value-added traditional foods as exotic food products. This could be done through biodiversity-based PURAs.

One prominent initiative in this aspect was conducted by the Field Research Laboratory, Leh, of the Defence Research and Development Organization (DRDO). This laboratory experimented with a little-known Himalayan shrub, Seabuckthorn; botanical name, *Hippophae rhamnoides Linn.* The shrub bears berries only for around five weeks a year, which contain eight vitamins, twenty-four minerals and eighteen amino acids and antioxidants. The laboratory has made a pioneering contribution by converting them into packaged juice for commercial sales throughout the year. Thus, through the confluence of research, traditional national wealth and entrepreneurship, it is possible to create economic value based on biodiversity.

These examples can find replication in many regions of the nation.

## TRADITIONAL MEDICINES

Today, as much as 70 per cent medicines are derived from natural products.[30] Around 20,000 plant species are believed to be used for medical purposes. In India too, 95 per cent of formulations in the traditional systems of Unani, Ayurveda and Siddha are plant-based.

India has 49,000 species of flowering and non-flowering plants, which represent 12 per cent of the world’s flora.[31] There is a pressing need to carry out research to find the medicinal value of this wealth of biodiversity. I was reading about *Taxus baccata*, a sub-Himalayan tree which was once believed to be of no value. Recent research has proven it to be an effective medicine in certain types of cancer.

Similarly, when my team and I met with cancer researchers from the James Graham Brown Cancer Center of the University of Louisville, Kentucky, USA, in April 2010, we were pleasantly surprised to find that they are carrying out research on developing a low-cost vaccine for cervical cancer based on a protein obtained from tobacco leaves. The same tobacco—which is the commonest cause of cancer, especially of the lungs—can, through science, be a cure for another type of cancer. The traditional Indian *neem* tree has been used in various applications such as antiseptic, anti-fungal, anti-parasitic, anti-inflammatory, and even as an organic pesticide.

When I visited the Chitrakoot PURA in Madhya Pradesh in 2006, I saw a herbal garden with over 400 Ayurvedic herbs at its health centre called 'Arogyadham'. This herbal garden is vertically integrated with an Ayurvedic pharmacy laboratory called 'Rasshala'. The medicines formulated here are standardized and sold in the market and, at the same time, the local people are educated in the use of these medicines. Thus, biodiversity, when nurtured and researched, can be used simultaneously for economic advantage and societal welfare.

Through PURA's sustainable development systems we can consider establishing, across the nation, centres with global standards for researching and marketing biodiversity. These can capitalize on the floral wealth in the ten biodiversity zones of the nation and manage them in an efficient, entrepreneurial manner.

## MEDICAL AND ECO-TOURISM

India's medical tourism sector is expected to experience an annual growth rate of 30 per cent, and the value of medical tourism in India, to go as high as $2 billion a year by 2012.[32] There are many advantages for medical tourists: reduced costs, availability of the latest medical technologies and a growing compliance with international quality standards.

With the tremendous medicinal wealth still untapped in our forests, the confluence of modern science and traditional methods, and the growing acceptance of alternative therapies, the mission can think of evolving eco-medico-centres which would give patients from all around the world a unique mixture of advanced Indian medicinal treatment in a green, clean environment and specially protected zones. These centres could be located in tribal areas and the tribal youths can be stakeholders in the mission, thereby offering them quality entrepreneurial opportunities that would not harm nature or the environment. Moreover, the availability of health-care facilities in remote regions would give social benefits to the local people and also spawn more green employment with the creation of markets for ecotourism and traditional forest products.

### EVOLUTION OF ECO-FRIENDLY, ECONOMICALLY SOUND SYSTEMS

The Irula tribe is found in the states of south India, particularly the Kancheepuram district of Tamil Nadu. They used to live deep in the forests but deforestation has forced them to migrate to villages. These tribal people feed on forest products like fruits and tubers and also on small animals like lizards and jungle cats. For many generations, they have been traditionally engaged in catching and selling snakes and trading in skins and other parts of snakes. However, in 1976, the government banned snake skin trade, which put a stop to the primary economic activity of the Irula tribe.

However, the core skill of the Irulas—dexterity in catching snakes—could still be useful in an ecologically beneficial way. The Irulas, with the help of the leadership provided by Dr Romulus Whitaker—an American who has settled in India—went about setting up a cooperative society of their own. In 1978, two years after the ban was imposed on snake skin trade, they got approval to set up the Irula Snake Catchers' Industrial Cooperative Society with an initial membership of twenty-six participants.

The fundamental goal of this cooperative was to transform the traditional skill of the Irulas into an economically productive and environmentally sustainable activity, with the help of technology, investments and access to a new market. Thus the focus of the Irula Cooperative was on value addition to the skill of snake-catching by entering into the market of venom sales (primarily used for medicinal purposes), sale of live snakes, removal of rodents and gathering medicinal herbs and honey.

Every member of the cooperative society is provided with better and modern equipment for making snake-catching safer. Typically, each member can earn Rs 3,000 to Rs 4,000 per month by selling live snakes. To encourage environment-friendliness, the society pays Rs 100 to Rs 1,000 for different varieties of live snakes. Their venom is extracted, stored at 10°C, and then the snakes are let out again into the open forests. Thus, the process of snake-catching and venom extraction has been made sustainable.

With its profits, the cooperative society is able to pay a 14 per cent dividend to all its members against their share capital; make allowances for education and medical expenses; give interest-free credit for housing; pay insurance against snake-biting incidents; and provide free transport for delivering live snakes.

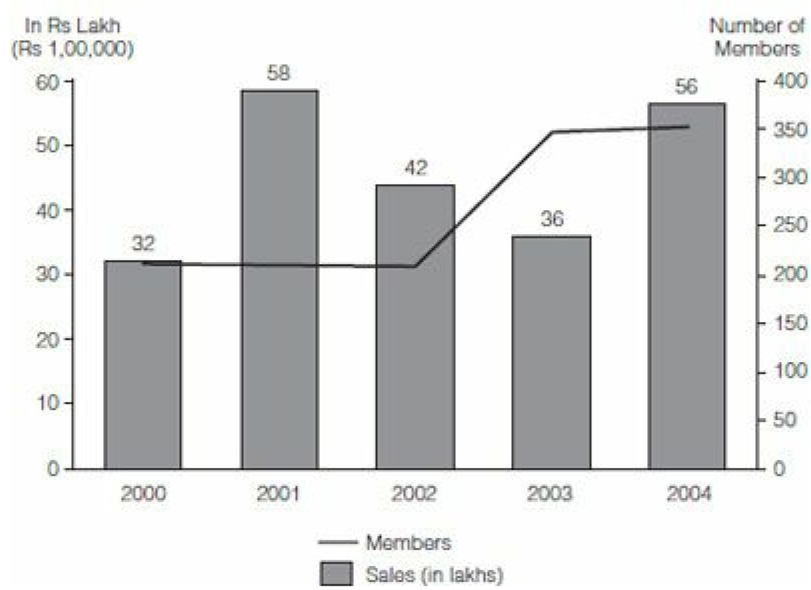


**FIGURE 6.13**: Performance of the Irula Cooperative Society

Source: National Cooperative Union of India (NCUI) Publication

By this innovative business technique, the Irulas have been able to continue using their traditional skills and, at the same time, earn greater economic profits and exercise ecological sustainability. In fact, since live snakes are a source of income, the members of the society have an incentive for protecting and preserving the dwindling snake population.

Although the Irula Snake Catchers' Industrial Cooperative Society is a small initiative, it sends out a great message for the building of ecologically sustainable development systems. Innovative thinking that adds fresh dimensions can be the meeting point of development, tradition and ecology.[33]

## BUILDING VERTICALLY INTEGRATED ECO-PRENEURSHIP FOR CREATING VALUE

We have already stressed in the previous chapters the need to build vertical integration in development systems to make them robust and to augment the returns. It is equally applicable when we talk of the environmental sustainability of PURA's sustainable development models.

I have come to know about the United Nations Environment Programme's (UNEP) Rural Energy Enterprise Development (REED) Programme, which is offering incubation services to clean energy enterprises in Brazil, China and five African countries. Since its beginning in 2000, it has funded more than forty enterprises that are now returning capital to an investment fund, which is then reinvested in new enterprises. In addition to the returns on the investment, these enterprises have also led to economic and ecological development and the provision of environment-friendly activities to the poorest sections of society in the world. One such enterprise incubated and later analysed by REED was Tanzania's Biomass Energy Technology Limited (BETL), which works in collaboration with Tanga Cement Company Limited (TCCL).

BETL sources and supplies biomass and agricultural wastes which are used to provide heat for TCCL's cement kilns. This translates into a saving of 15 per cent on the 44,000 tons of heavy fuel oil that TCCL uses every year; a reduction in greenhouse emissions; and a generation of 42 per cent of profit margin for BETL, which delivers about 1,200 tons of biomass every month.

Lower down the sourcing chain, for sourcing its material, BETL employs women in urban areas who work individually and earn about US$60 (about Rs 3,000) per month by collecting forty bags of charcoal residue a day. Thus, the environment effort of these eco-preneurial women is aggregated by BETL, and by using technology is converted by TCCL into an economically feasible activity. Moreover, the benefits are flowing down to the bottom of the sourcing chain, which is an incentive. The investment is, of course, shared by TCCL and BETL, but most of the fixed equipment pre-existed in the form of cement kilns.[34] Let us further elaborate on linking environment and social assets.

## LINKING ENVIRONMENT TO THE CREATION OF SOCIAL ASSETS

A unique biogas development model has emerged in Nepal out of its Biogas Support Programme, co-founded by the Government of Nepal, the Netherlands Development Organization (SNV), the German Development Bank (KfW), and financially assisted by the World Bank. It has installed over 120,000 biogas plants in Nepal that are providing 3 per cent of Nepal's households with low-pollution fuel for lighting and cooking. Moreover, since more than 70 per cent of these biogas plants are connected to human sanitation places, it has also led to improved hygiene conditions. This programme was the first of its kind to be set up under the Kyoto Protocol's clean development mechanism, and each of the biogas plants is equivalent to 4.6 tons of $CO_2$ per year, making it an economical and beneficial entity. This example was replicated in Vietnam for its animal husbandry section, where more than 25,000 biogas plants have been built, benefiting more than 100,000 people. The biogas is used as domestic fuel while the bio-slurry residue is useful as a crop fertilizer and fish food. Thus, innovative technology and aggregation of consumer demand have led to the development of a large-scale socio-eco enterprise model.[35]

India has more cattle than any other country, and these biogas models, which can directly yield benefits to local households, hold great potential for implementation. Figure 6.14 shows different fuels with their relative qualities in the Indian context. It shows that biogas—which can be generated entirely domestically—is superior in its thermal efficiency* and also in its heat content (calorific value).†

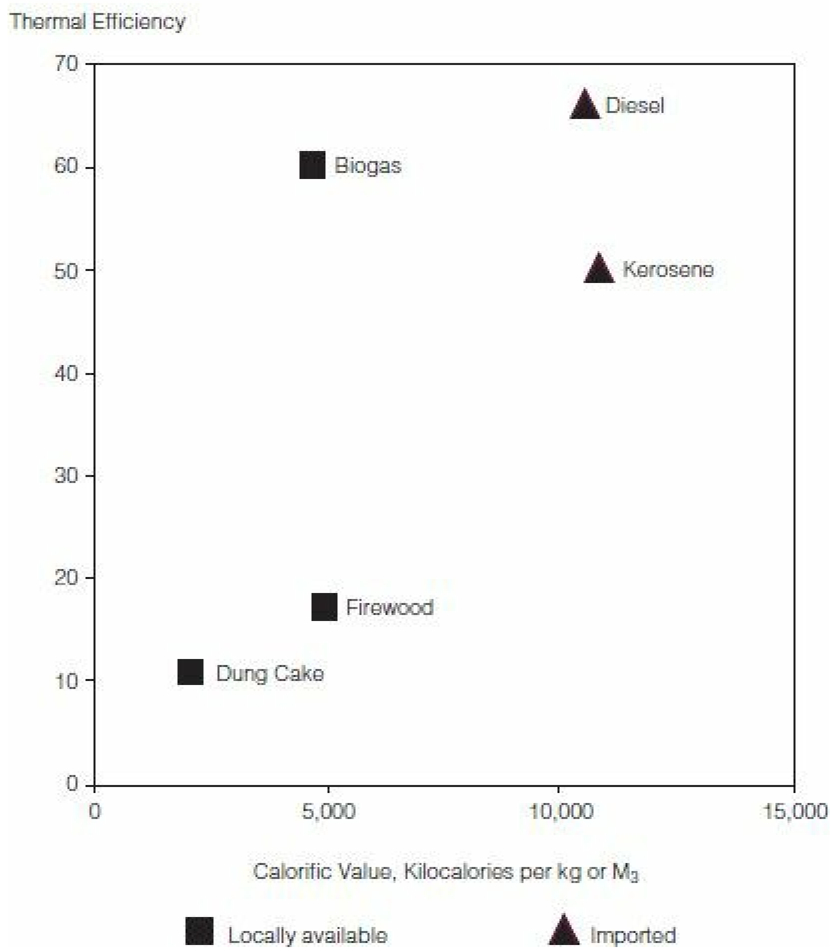


**FIGURE 6.14**: Thermal efficiency versus calorific value for different fuels

Moreover, the biogas that is generated will be of great benefit for the women of the household. It will not only save them time—which they would have otherwise spent in collecting firewood—but also ensure them better health as they will be saved from inhaling toxic fumes caused by burning firewood. Every year, about 200,000 women in the nation die due to respiratory problems arising largely out of unhealthy cooking practices. Biogas initiatives can be a saviour for them. Moreover, since biogas converts methane to $CO_2$ it is also environment-friendly, because, although both are GHGs, methane is thirty-one times more effective than $CO_2$ as a GHG. Let us now add another dimension where the community has been empowered in all aspects for energy independence. This will be the evolutionary, closed-loop sustainable system and an important lesson for PURA implementation.

DECENTRALIZED ENERGY INDEPENDENCE AND PARTICIPATIVE MODELS

The path to development can be realized as an integrated mission with environmental sustenance. In

Mali, a remarkable innovation, using Jatropha to power the local energy needs, has been made by a local NGO called Mali-Folkecenter (MFC) Nyetaa, with support from the UNEP, the UNDP and the Global Village Energy Partnership (GVEP). An interesting idea was launched to convert the villages into an 'energy service centre' capitalizing on Jatropha oil. Planting unused land with Jatropha, the villagers used the oil as fuel for powering activities like grinding and battery-charging, and provided energy-intensive services to villages and even running motor cars. This successful idea is now implemented in the village of Garalo in southern Mali where 1,000 hectares of Jatropha plantation will run a 300 KW power plant that will provide 10,000 people with quality energy. The land for Jatropha cultivation is distributed across the fields of the villagers.[36] The project now aspires to provide clean, green, carbon-free electricity to 100,000 people in some of Mali's poorest and most isolated communities—across sixty-five villages in Sikasso and Koulikoro. The project will establish and maintain fifty Jatropha plantations and sixty-five energy service centres: fifteen solar-powered and fifty fuelled with Jatropha oil. To achieve this, 20 hectare plantations of Jatropha will be set up in each of the sixty-five villages and locals will be trained to work as technicians to manage the energy service centres. The Mali Folk Center project is an example of how clean green power can bring development to the remotest regions of the world. What is the cost of the project? About $2 million spread across five years, which is $4 per beneficiary per year.[37]

A similar initiative was carried out in the village of Ranidhera, Chhattisgarh, by a private company, Winrock International, in 2005. Ranidhera is a four-hour drive from Raipur, the capital of the state, and although high-tension wires run above the village, supplying power to the cities, Ranidhera itself was without power. It has a population of about 600, largely tribal, people. The Ranidhera Jatropha mission began with garnering community participation in planting Jatropha on available barren land in the village and along the bunds between the fields. The village members planted and nurtured over 25,000 saplings. A unit of three special generators has been set up, which run on straight biodiesel (without processing) produced from the oil extracted from Jatropha seeds. This was established with the help of the British High Commission and the Indian government.

**ENVIRONMENTAL MISSIONS IN PERIYAR PURA**

Periyar PURA is operated by the Periyar Maniammai University, Thanjavur, in the state of Tamil Nadu. Large areas of the university campus itself have been planted with Jatropha trees, and the university is working on spreading the message of biodiesel and other green initiatives across the PURA region. The university operates many centres out of which three are directly linked with environment-friendly activity and research. They are:

**1. Periyar Research Organization for Biotechnic and Ecosystem (PROBE)**
This is an outreach wing started in the year 1996 with a prime focus on rural development through afforestation and biotechnology-based activities for the development of wastelands. PROBE has developed agro-modules in this locality for imparting hands-on training in various agro techniques in order to generate employment opportunities for the local people.

**2. Periyar Centre for Environmental Energy Management (PCEM)**
This centre was set up in collaboration with Cape Breton University (formerly, University College of Cape Breton), Nova Scotia, and the College of the North Atlantic (CNA), Newfoundland, Canada. It conducts training programmes in analysis and treatment of wastewater, remediation technologies and renewable energy technologies. The centre is currently involved in a project on the 'Generation of Power from Municipal Solid Waste in Thanjavur' in joint technical collaboration with RWTH University, Aachen, Germany.

**3. Periyar Renewable Energy Training Institute (PRETI)**

PRETI is a joint venture with the Ministry of Non-conventional Energy Sources (MNES), Government of India. It offers training courses in the use of renewable energy and energy conservation to suit the needs of various groups, for a duration of one day to one month. The courses are available to self-help women's groups, unemployed youths, panchayat presidents, council members, government officials, students, faculty members and others interested in using renewable energy.

The idea behind this initiative was to create a local sustainable power project running on green fuel. A Village Energy Committee (VEC) consisting of the villagers was set up, and they were trained in basic operations for the running, accounting and administration of the power plant. Electricity is distributed using a wire network and street lights, too, have been installed. The VEC decides on the tariff and the timing for making the power available.

The villagers can deposit Jatropha seeds with the VEC and against it they can receive subsidies in the power tariffs. Under this small but interesting innovation, each of the 110 households has been given decentralized power points that supply four hours of power every evening, for two lights at about $1 per month. The VEC has managed to supply power without any unscheduled outages or breakdowns.[38]

The example of Ranidhera is being replicated across Chhattisgarh. Dr D.N. Tiwari, vice chairman of the State Planning Commission, told me that more than ninety villages were now green energy-independent, meaning that they are not only self-sufficient in their energy requirements, but that they are also green in the form of the energy they use. Biofuel has been a successful tool in achieving this ambition. In fact, there is an excess production of Jatropha seeds, which is sold in the external market and the benefits given back to the local people. Last year, 100,000 tons of Jatropha were sold as export, bringing in revenue for the rural population.

Thus, a local resource in the form of barren land has led to energy independence. The story of Garalo and Ranidhera highlights four key lessons. First, that technology can play a role in transforming barren land into a social asset in the form of power. Second, that a one-time initial investment—in this case, diesel generators properly constructed—can create self-sustaining systems. Third, that it is important to empower local people with skills and decision-making authority in order to ensure long-term usability, and to imbue them with a spirit of ownership in the asset being created. Fourth, that aggregation gives power to development systems, but it has to be linked to perceivable benefits. In the case of Ranidhera, the aggregation was done in the form of planting and cultivating Jatropha. Moreover, the benefit of participating in the cooperative venture is manifest in the form of four hours of power and subsidies in the power tariff for the seeds supplied.

Energy independence can be linked to economic and social goals and be driven in a decentralized manner by the community. This could be a model for national implementation. In fact, depending on local conditions, biofuels can be obtained from Jatropha, algae, sunflower and coconuts, which would help harness competency for energy-generation.

## SIMPLIFIED ENVIRO-ECONOMIC MODELS

The Kyoto Protocol, which led to the introduction of carbon credits and carbon markets, was a remarkable initiative for incentivizing 'clean development' which is environmentally sustainable. It was the first time in a real sense that a benefit that could translate directly into monetary gain was associated with the effective implementation of initiatives for saving the planet and its environment.[39]

**THE KYOTO PROTOCOL AND CARBON CREDITS**

The Kyoto Protocol, which came into force on 16 February 2005, was one of the first initiatives for following the course of eco-friendly development on a global scale. Under the Protocol, thirty-seven industrialized nations (called Annexure I countries) committed themselves to a reduction of the four greenhouse gases—carbon dioxide, methane, sulphur hexa-fluorides and nitrous oxide—and the two groups—hydrofluorocarbons and perfluorocarbons—produced. All the other member nations (including India) were to give a general commitment, though not as rigorous as the one given by the industrialized nations. The Annexure I countries agreed to reduce their collective emissions by 5.2 per cent from the 1990 level. The Kyoto Protocol was signed by 187 countries on November 2009. India is a member of the treaty while the United States has a status of 'signed but not intending to ratify' the treaty.

The Protocol allows for several 'flexible mechanisms', such as trading of emissions; the Clean Development Mechanism (CDM) and the Joint Implementation (JI), to allow Annexure I countries to meet with their GHG emission limitations by purchasing GHG emission reduction credits from elsewhere: through financial exchanges; projects that reduce emissions in non-Annexure I countries; from other Annexure I countries; or from Annexure I countries with excess allowance.

Under the International Emissions Trading (IET), countries were allowed to trade in the international carbon credit market to cover their shortfall in the stipulated amount of emission. Countries with surplus units were allowed to sell them to those which were exceeding their emission norms. This gave rise to a new 'carbon currency' called carbon credits. One carbon credit is equal to one ton (1,000 kg) of carbon dioxide or carbon dioxide-equivalent gases. While the concept of carbon credit trading is still nascent, even in a turbulent state, such platforms for the promotion of a clean environment are going to hold more significance with time.

PURA's sustainable development system would have to draw on the emphasis laid by international initiatives on clean development, accept it readily and take it in a simpler form down to the rural level. For this, it is essential to develop derivative financial measures based on the carbon credit system. This will help in the promotion of environment-friendly initiatives and green enterprises to find space in the development profile of rural complexes. In a simple model, let us define the value of environmental contribution as a quantity $P_E$. This quantity can be directly associated to certain activities which lead to the emission or absorption of $CO_2$ and other GHGs emissions (weighted according to their heating power).

For example, let us suppose a tree that absorbs about 20 kg of $CO_2$ per year (net) is assigned a value of 1 $P_E$. In the same way, using the same measurement, different activities associated with an enterprise or initiative within the PURA complex can be assigned $P_E$ equivalent values. Some of these are as depicted in Table 6.1. Hence, any initiative which saves 10 kg of coal from being burnt every day and replaces it with clean fuel is approximately worth +511 $P_E$ annually. This value would be significant in deciding what kind of viability gap funding or priority lending should be given to a particular enterprise which is planned for setting up in the PURA complex.

**TABLE 6.1**: Sample Tree Equivalent Table

| Typical Activity | Approximate Absorption (+ive) Value or Emission (–ive) | Associated $P_E$ |
|---|---|---|

| | | |
|---|---|---|
| 1 tree | +20 kg (annual) | +1 (annual) |
| Burning 10 litres of diesel | –27 kg | –1.35 |
| Planting biofuel source equivalent to production of 10 litres of fuel supplement | +27 kg | +1.35 |
| Burning 10 kg of coal | –28 kg | –1.40 |
| Cultivating 1 hectare of Jatropha (average yield) | +20,000 kg (annual) | +1,000 (annual) |

## CONCLUSION

This chapter has highlighted how development and environment can move together and often in an interdependent way. We studied, through examples, how successfully environment-friendly initiatives have been carried out—often in conditions of poor access, low skills and low income—by activating the people and endowing them with knowledge and skill empowerment. These systems can lead to the creation of what is called the 'Rural Green-Collared Job' and a cadre of rural skilled and semi-skilled workers and entrepreneurs who use green practices to create wealth. The rural youths of the next generation in the PURA system will have to be trained to practise this green-collar outlook—with an amalgamation of technology, innovation, aggregation and resource management.