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ARTICLES

Environmental Degradation and Its Correctives in Agriculture Sector*

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Environmental degradation today is a serious challenge to the life forms on the planet earth. It is adversely affecting not only the individuals and human societies in various ways and in different degrees, but is also influencing the changes that are detrimental to the health and growth of all forms of life. The effect is cumulative in its nature and is in an acceleration mode now. Of course, the climate of the earth has never been stable during the history of evolution and the ecosystems and species have evolved within the climatic history (Green *et al*., 2003). The change in modern era, however, has exceeded anything experienced in the past ten thousand years. This accelerated change is threatening a high level erosion of species, which is expected to be between 100 and 1000 times greater than the earlier ones (Pimms *et al*., 1995).

Some of the areas and regions of the world are in virtual whirlpool of fast deteriorating living conditions and there is no place free from the impact of environmental degradation. Climate has changed worldwide over the last century. The average temperature of the earth has risen by 0.6^0 C since 1900. The last decade was the warmest decade globally and 1998 was the warmest year since 1861 (since when temperature had been recorded with adequate global coverage). Because of this global warming, snow cover is decreasing, glaciers are receding, rainfall patterns are changing and extreme weather events have become more frequent. There have been more heat waves and heavy rainfalls. There have been fewer frosts. As the oceans have warmed, sea levels have risen by 10 to 20 centimeters. Even the remote areas away from densely populated industrial centres are not any more insulated from this debilitating impact. Ozone hole, climate changes, global warming, enhanced influence of La Nina and El Nino factors, receding glaciers and changes in precipitation patterns, water and air pollution and soil degradation should be, therefore, of vital concern to the human race at this juncture. Since these negative developments are affecting all the life forms all over the world, it is not a matter of concern for a few societies or individuals only. The whole of human race in every part of this world has to wake up to the ground realities of this fast deteriorating situation.

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Over the past two decades, an enhanced level of awareness has come about these perceptible changes that have occurred in the patterns of typhoons, hurricanes, precipitation intensities and their spatial as well as temporal distribution. Yet, in spite of tremendous technological refinements that have been introduced in climate forecasting models, annual or seasonal rainfall patterns still carry a high degree error in their predictability. Localised, intensive and short duration rainfalls in some places or areas and scant, delayed, unevenly distributed, late arrival and early withdrawal of rains in others have become a matter of serious concern. These unpredictable abnormalities and frequent aberrations bring disasters, loss of life and property. Droughts entailing long duration sufferings, uncertainty in food and fiber production threatening food security in many areas, regions and countries of the world are assuming serious proportions.

Glaciers that are the primary source of clean water for irrigation and life systems and provide stability to the climate pattern, are receding at an alarming rate. For instance, Himalayan glaciers have receded by more than one kilometer over the last 100 years. The sight of mainstreams flowing full to their brims with crystal-clear water in summer is an eye sore to the one who knows that the water flows from the excessive melting of glaciers in the feeding area. In the long run, which is not a very long run, this is going to affect the climate change in turn in an interactive manner and will adversely affect the availability of water.

Climate change is rapidly becoming a significant threat to the bio-diversity. This change may lead to major geographical shifts in natural vegetation zones leading to changes in the distribution of characteristic species of these zones. The climate change, thus adds to the pressure that has already begun by several other routes to affect biodiversity in modern times. Some recent studies have reported a shift in species distribution of plants and animals ranging from grasses to trees and mollusks to mammals. However, for most species, effective migration or adaptation in relatively shorter timeframe is not possible and the time span is often not enough to withstand the impact of environmental change. Thus, a lot many species may not be able to reach places where the climate is suitable for them. Consequently, many plant and animal species may not survive the climate change. It is estimated that a loss up to one-third of the known populations of some of the land plants and animals could occur (Thomas *et al*., 2004).

A high degree of spatial variability in climate change will lead to different species within the same community to respond differently and will impact the existing community structure. For instance, the variable thermal response of species of marine algae to change in sea temperatures and differences in degrees of change in summer and winter will lead to species-specific responses (Hiscock *et al.,* 2004).

Species have to cope with the changing conditions and are likely to face competition from new species spreading into their environment. Native species often struggle to compete with invasive species that may be better adapted to the new conditions. Invasive species can also bring in diseases that the native species may be

poorly equipped to resist. The survival of the native species may depend on their ability to move into new areas as rapidly as their preferred habitats shift geographically. This may particularly put many arctic species in difficulties because their typical habitats may ultimately vanish altogether (Chapin *et al*., 2003).

As stated earlier, climate change is also expected to increase the frequency of extreme climatic events. In some regions heavy rains, floods and hurricanes may occur more often, while other areas may suffer droughts and desertification. As the pack ice that covers much of the arctic ocean is melting and is shrinking in mountain ranges such as Andes and Himalayas, global warming is accelerating. A warming of 5^0 C can eliminate 20 per cent of the coastal wetlands by the year 2080 (IPPC Report, 2002). If glaciers and icecaps continue to melt at the present rate, the sea level will gradually rise, coastal flooding will become more frequent and certain low-lying coastal regions and small island states may become permanently submerged. An indication of global warming is available in Siberia. Forests here are beginning to spread across the Tundras as the summers have become warmer and growing season has lengthened. The annual growing season in Finland has lengthened by several days over the last thirty years.

The widespread melting of permafrost could mean that more fresh water enters the North Atlantic via the rivers that flow into Arctic Ocean. If in the process the salinity of the North Atlantic falls below certain level, the Gulf Stream could slow, stop or even change its course. Such a change could bring about a potentially disastrous cooling in the climate of North Europe instead of warming. Thus, there are several uncertainties. Enhanced carbon dioxide (CO_2) concentration and subsequent acidification of ocean waters are likely to affect the process of calcification by which key marine species including corals will be affected adversely. Our understanding of the impact of ocean acidification and its interaction with climate change is currently very poor and it is difficult to predict how the marine system will respond to the combination of these drivers of change (The Royal Society, 2005).

Due to the fast increasing population, especially in the developing countries and least developed countries, demand for food and fiber and other necessities and amenities of life is increasing fast. In many countries, food security is at a critical stage and is being threatened by non-availability of food, fiber, industrial goods and services is being increased through intensive cultivation and chemicals based production systems. This is leading to over-exploitation of scarce natural resources in different countries, especially the cultivated and arable land and water. The ever enhancing level of production of industrial goods and services is considered to be the major source of environmental degradation through the emission of greenhouse gases (GHG), especially the carbon dioxide, methane and nitrous oxide. Efforts are afoot and systems are in place such as the Kyoto Protocol, European Union Emission Trading Scheme (EU ETS), the United Kingdom's ETS, Chicago Climate Exchange (CCX) in USA, Regional Greenhouse Gas Initiative (RGGI) in North-Eastern United

States, New South Wales carbon market (NSW) in Australia for the sale and purchase of carbon credits in order to put a check on the emission of greenhouse gases. Quite a few corporates, especially the power companies and private players, brokers and agents are operating in the spot and forward markets for trading in carbon credits. Under the Cap-and-Trade regime, European Union Allowances (EUAs) have been allocated in the First Phase in order to control CO_2 emissions from various enterprises. In the Phase II, the caps are going to be at much lower level of emissions. Market in carbon trading has developed quite fast. Carbon Credit Markets operate like share markets and stock exchanges in respect of spot purchases and future hedging. The value of global carbon market was more than US$10 billion in 2005 and is expected to be between US $25 to 30 billion in 2006. Average price of the 79 million tonnes of carbon credit traded in the first quarter of 2006 is reported to be US $11.45 per tCO_2 (Capoor and Ambrosi, 2006). In view of the stricter regimes expected to be imposed in the industrially developed countries in respect of carbon emission, the market in carbon trading is expected to be quite flourishing in future. However, improvements in production technology and cleaner fuel substitutions that will reduce or minimise the carbon emission might have a depressing effect on the carbon trading market, especially in the futures trading. Therefore, it is difficult to project the trends of this market as yet. It is, however, encouraging to note that the financial market is linking up itself with carbon trading market, with the banks showing interest in investments in Clean Development Mechanism (CDM). Advances are being offered for Certified Emission Reductions (CERs). Recently the World Bank has entered into two agreements with a Chinese company to buy carbon credit (emission reduction credits) at a rate of Euros 6 per tonne of carbondioxide (t CO2e) for seven years.

However, these efforts so far have remained focused primarily on industrial emissions. Due attention has not been paid to the agriculture sector on this aspect as yet. Concerted effort to increasing agricultural production and food security is putting tremendous strain on environmental elements. Ever increasing use of fertilisers, pesticides and other chemicals are polluting the environment to a level of deep concern throughout the world. For instance in the United Kingdom, the Royal Commission on Environment has reported that every year, farmers spray some 30,000 tonnes of pesticides over Britain's broad acres. Over a million people are put at risk by this spray, drifting into their homes from the fields. The rest of the population consumes the poisons in their food. Recent official measurements found traces of 80 different pesticides in the edible agricultural products ranging from apples to butter, bread, chocolates to chicken nuggets. Fifty of these pesticides have been identified by the international authorities, including the World Health Organisation, as acute poisons, suspected causes of cancer and likely hormone disrupters believed to have weird 'gender bender' effects on both humans and wildlife. Arable crops are sprayed on an average five times before being harvested.

Potatoes are astonishingly sprayed 13 times. Fruits are doused even more frequently – 13 applications on an average, with some apples receiving a mindblowing 18 doses.

After examining medical studies and actually finding out about people who claimed to have been affected by drifting spray, the commission concluded that the victims were 'genuinely ill' and that there was a 'plausible link' between pesticide exposure and disease. The Royal Commission cited official studies that suggested that such exposure could cause Parkinson's Disease, and expressed particular concern that it might lead to cancer and disabling 'multi-system disorders' like chronic fatigue syndrome.

Most of the intensively cultivated irrigated areas of the world are suffering from technology fatigue that is leading to declining factor productivity. In order to maintain the same level of output, more and more intensive use of chemicals (fertilisers and pesticides) is being resorted to. For instance, take the case of Punjab province in India. The state forms only 1.5 per cent of the geographical area of the country, but contributes between 40 to 49 per cent of rice and 50 to over 70 per cent of wheat to the central foodgrain stocks of the country (Department of Agriculture, Punjab). It amounts to a contribution of over 20 million tonnes of foodgrain annually for more than three and a half decades. More important, 90 per cent of the interstate movement of foodgrains has been of the grains from Punjab. One can well imagine what would have been the fate of the country on the food front and food security, if this much of annual supply of foodgrain had not been contributed by this tiny-big state. Punjab genuinely takes pride in this achievement, but seldom realises the unduly very heavy social cost the state is paying for it, in monetary as well as physical terms. Also, it is a question of sustainability in physical sense which can be viewed in terms of utilisation of the most scarce resource(s) and productivity of the resource-use along with negative externalities on agro-ecology and environment at large. In the case of resource use, the main question mark is on the utilisation of underground water. The water balance in the state is getting seriously disturbed through excessive withdrawal of underground water. Over the last decade, 75 to 80 per cent of the water requirements of crops in the state have been met through tubewells. Consequently, water table is receding at a rate of over 70 centimeters per year (PAU estimates). Today, hand pumps in the central Punjab districts have become items of museum. About thirty per cent of the centrifugal pumps have gone dysfunctional and have been replaced with submersible pumps. Depending upon the depth of water table and size of the pump, a submersible pump costs between Rs.50,000 to Rs. 80,000 in the central Punjab. More important, submersible pumps dry out the centrifugal pumps located in their vicinity, affecting the farmers around, specially the small farmers, adversely. The small farmers around do not have the resources to replace their pumps with submersibles. It is estimated that if the conditions remain as they are, at the present rate of withdrawal of water from the aquifer, in the next about ten years, there will be no areas in the central Punjab with water table less than 25 metres deep and all the pump sets will have to be replaced

with submersibles. At the present rate of withdrawal of underground water, the situation is, therefore unsustainable. The water, which is the most scarce production resource in the state, is *de facto*, being **mined** because the withdrawal exceeds the recharge.

This situation has developed primarily because with the construction of Bhakhra dam, free flow of water and floods in the river basin that lies in the central Punjab, have been controlled, canals have been lined and whatever excess water flows from the dam to the areas below has been canalised through constructing earthen banks *(Dhusi Bandhs)* of the river. Thus, water has been excessively diverted from the river basin and crop production has to depend up to about 80 per cent of its irrigation requirements on the underground water. Thus, the situation is not only unsustainable, but more so it poses serious environmental challenges. There is a danger of underground brackish water from the South-western districts invading into the central districts, rendering the underground aquifer brackish in these areas also.

Power is another scarce resource with the state. Lifting of underground water accounts for more than 95 per cent of the power consumption in the farm sector. The agriculture sector consumed 25.418 billion units of electricity costing Rs.7,628.1 crore net to the state over the last four years and the state had to buy electricity from outside costing Rs.7,310.98 crore. This year the state will be purchasing electricity from outside worth over Rs. 3,300 crore and subsidy to agriculture in going to exceed Rs. 2100 crore, because the power supply to the farm sector is now free. This situation is also not sustainable in the state which is not very comfortable on financial resources. More important is the fact that free supply leads to over overuse and misuse of both power as well as water which are the two most scarce resources in the state and the state cannot afford that on a sustainable basis.

In respect of the adverse impact of growing paddy in June to August on the ecology of the state, it leads to the disquieting levels of soil, water and air pollution. During the months of June to middle of September, with temperatures ranging around 40^0C, relative humidity above 95 per cent and scheduled as well as unscheduled long and extensive cuts in electricity supply, environment of the state becomes totally unlivable. Also in the months of October-November, in spite of the government ban, the farmers burn paddy stubbles that pollute the environment extensively, which creates serious breathing problems for the people. It has happened twice that in the end of October the smoke emerging out of burning paddy stubbles got trapped under the clouds in the absence of blowing winds. Fortunately, the rain and winds cleared it. Had it continued for a couple of hours more, there could have occurred serious casualties.

For the state of Punjab, and for that matter Haryana, Western Uttar Pradesh and many other states of the country two main issues need to be tackled with urgency. The first issue is that of depleting water resources and the second is environmental degradation. Both of these issues are closely related ones, particularly in the context of growing of paddy, which is a very higher water consuming crop. Growing of

paddy leads to excessive withdrawal of underground water resulting in imbalance in the sense of withdrawal of water exceeding its recharge. For instance, the Central Board on underground water has reported that in central districts of Punjab the underground water being withdrawn as a per cent of recharge exceeds almost everywhere. For instance, this percentage is 350 in Jalandhar East block, 317 in Nakodar, 217 in Jalandhar West, 205 in Moga I, 187 in Moga II, 180 in Ahmadgarh, 169 in Sangrur and the lowest is Mahal Kalan at 119. Thus, almost nowhere in the central districts the water balance is positive. This situation is unsustainable.

The second issue of environmental degradation is not only in terms of high temperature, high humidity, soil and water pollution, more importantly it is in terms of the emission of greenhouse gases (GHG), primarily carbondioxide, methane and nitrous oxide, that are emitted into the environment from the paddy fields. Paddy growing in standing water is in fact the most unsuitable crop for Punjab and other such areas. Yet, it is becoming difficult to remove this crop from the cropping patterns because of (1) lack of more remunerative or even equally remunerative alternative crops that have lower level or even same level of production risks and price uncertainty compared with paddy crop. Perishability, production risks and lack of effective market clearance are the main constraints to the replacing the rice crop. Further, free water and electric power, prompt market clearance, often with relaxed quality specifications, are the factors that keep the farmer from shifting the area from under rice. Right pricing of the irrigation water and power and equally efficient market clearance for alternative crops can easily tilt the balance against paddy crop; (2) Food security of the country is another serious concern. The wheat crop is not that much of a problem in respect of water consumption in the state. It is therefore essential that technology must be developed such that ponding of paddy fields is avoided that would lead to reduction or even elimination of emission of greenhouse gases and check degradation of soils, reduce water consumption and put a stop to degradation of environment.

On the issue of greenhouse gases, rice plant has intercellular spaces that conducts these gases to be emitted into the atmosphere. The anaerobic bacteria, under the anaerobic conditions created around the rhyzosphere of the plant by the constantly standing water, produce these gases. The plant also absorbs and conducts oxygen from the atmosphere to the root zone for the anaerobic bacteria that work on organic matter under standing water. It is estimated that rice crop growing in standing water over a period of ninety days produces more than 0.45 tonnes of methane, which is emitted into the air. Accounting for all greenhouse gases, one hectare of rice crop over its growing period emits an equivalent of about 20 tonnes of carbondioxide. If this emission, through avoiding the ponding of water in the rice field, is checked and certified, this can earn carbon credits (etCO2) which can be traded in the carbon markets of the world. One hectare of rice, if replaced with other crops or even rice that is grown without standing water has the potential of earning carbon credits worth more than Rs. 10,000 in three months of its growing period. If rice can be cultivated

under anaerobic conditions, this can revolutionise the rice cultivation without impairing the food security of the country and having a solitary positive effect on environment and reduction in demand for irrigation water.

Agricultural technologists of the Department of Agriculture, Punjab have developed one such technique of rice cultivation under anaerobic conditions, which has been authenticated through average of 12 experiments conducted by the Punjab Agricultural University. This technique saves water by about 40 per cent, increases yield by about 6 to 8 per cent, improves the quality due to drier micro-climate, and improves the soil quality. The technique is catching up with the farmers, but very slowly and hesitantly. Punjab Agricultural University is expected to approve of this technique from the next season. Once the PAU formally approves and recommends this technique, this can revolutionise rice cultivation in the irrigated areas of the state. The technique will help not only Punjab, but also other areas of the country and even the world where rice is grown in ponded fields through artificial irrigation. If farmers can be encouraged through some incentives out of the money earned from carbon credits through project mode in the carbon futures market, this system can pick up very fast. It is estimated that Punjab can earn something like Rs. 20,000 crores in ten years through these carbon credit if all the rice area can be brought under anaerobic conditions. At least one-half of this money can be transferred to the farmers.

The technique is very simple. The land is prepared as is done for any other crop like wheat or maize. Ridges and furrow are drawn two feet apart with a *ridger*. Water is applied in the furrows (water should not flow over the bunds). Paddy nursery is transplanted four inches above the bottom of the furrow on both sides of the ridges with plant to plant distance of six inches. Water is kept standing in the furrows for five to six days. Then water is applied once a week. If there is rain, irrigation may not be required. Under such anaerobic conditions, the emission of greenhouse gases is reduced to almost nil. Yet, this carbon credit earning technique needs to certified through accredited agencies after authenticated research results that may be brought out by the Punjab Agricultural University or any other research institute of the National Agricultural Research system (NARS).

On the issue of use of chemicals (fertilisers and pesticides), use of bio-fertilisers and bio-pesticides and organic farming are the options. Productivity and production might get a set back for a couple of years, but experience shows that soon the productivity picks up. For instance, Cuba presents a workable model on this aspect, where booming requirements of protective foods are being met through organoponicos on small plots of land allotted to the individual farmers. Cuba is filled with more than 7,000 urban allotments or "organoponicos", which fill perhaps as many as 81,000 acres. They have been established on tiny plots of land in the centre of tower-block estates or between the crumbling colonial homes that fill Havana. More than 200 gardens in Havana supply its citizens with more than 90 per cent of their fruits and vegetables.

Such farms barely existed in the late 1980s. Back then, Cuba's economy was extraordinarily reliant on subsidies from its political elder brother, the Soviet Union. It's agriculture was designed with one aim in mind – namely to produce as much sugar as possible, which the Soviets bought at more than five times the market price, in addition to purchasing 95 per cent of its citrus crop and 73 per cent of its nickel. In exchange, the Soviets provided Cuba with 63 per cent of its food imports and 90 per cent of its petrol. Such a relationship made Cuba extraordinarily vulnerable.

With the collapse of the Soviet Union, such subsidies halted almost overnight. Suddenly, the future looked bleak. By necessity, this meant a back-to-basics approach; with no Soviet oil for tractors or fertilisers, it turned to oxen and natural compost and the production of natural pesticides and beneficial insects. It is estimated that more than 200 locally based centers specialising in biopesticides annually produce 200 tonnes of verticillium to control whitefly, and 800 tonnes of beaveria sprays to control beetles. Cut banana stems baited with honey to attract ants are placed in sweet potato fields, which have led to control of sweet potato weevil. There are 170 vermi-compost centres, the annual production of which has grown to 9,300 tonnes (Andrew Buncombe, The Independent, U.K.).

Crop rotations, green manuring, intercropping and soil conservation have all been incorporated into polyculture farming (Report by Jules Pretty). Remarkably, this organic revolution has worked. The proof of this is that annual calorie intake per head in Cuba now stands at about 2,600 a day. UNFAO estimates that the percentage of population considered undernourished fell from 8 per cent in 1990-92 to about 3 per cent in 2000-02. Cuba's infant mortality rate is lower than that of the US, while at 77 years, the life expectancy is the same.

Thus, alternatives to the use of chemicals (fertilisers and pesticides) exist and can be innovatively developed to avoid the impending environmental disaster. Crop patterns can be changed such that productivity of most scarce resources (land and water) improves and farm incomes are enhanced without negative externalities of environmental degradation and threat to food security. The Universities and research institutes of NARS have a challenge before them in this respect, which can be met with vision and grit.

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