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Management of the Food Web in Pulicat Lake

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ABSTRACT

Food Web in the Pulicat Lake is constructed for the first time, and is graphically represented, explained and analysed for its complexity. Management of Food Web for the sustainability of the Pulicat Lake ecosystem, impacts of climate change on the lake and its food web are discussed. Construction of food webs in various ecosystems, as an exercise in environmental education, for students, is explained.

Keywords : Pulicat Lake, Food web, Management, Climate change, Detritus, Plankton, Consumers

Introduction

Food, water and air are indispensable for survival, and organisms choose a niche where these basic needs are available in a healthy and abundant measure. "A food web summarises the feeding relations in a community (Molles, Jr., 1999)". Unlike individual food chains, a food web gives a more holistic picture of the ecosystem concerned, like the total biodiversity in the ecosystem, the keystone habitats, keystone prey and keystone predator species, preferred foods, the energy pathways, and the bio amplification of toxic materials at various trophic levels, etc., Food webs are integral parts of any ecosystem, terrestrial or aquatic. "Food web is a more realistic model of an ecosystem" (Bush, 2000). The complexity of a food web is indicative of the richness of the biodiversity, in the ecosystem concerned.

Pulicat Lake Ecosystem

As an ecosystem, Pulicat Lake is a vast but shallow lagoon (13°26' to 13° 43'N latitude & 80° 03' to 80° 81'E longitude), situated extending parallel to the coast of the Bay of Bengal, between the Nellore district of the Andhra Pradesh and the Thiruvallur district of Tamil Nadu. It has been rapidly shrinking, both in its water spread area as well as in its depth, since its origin, about 6,650 to 7,000 yrs. B.P., during the mid- or late- Holocene period. Today, it is reduced to about 35 km in length, from north to south, from its original 60 km until the 17th century, and its width may be about 17 km, at

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its broadest point. Its total water spread area today may be about 300 to 350 sq. Km. Compared to about461 sq.km. earlier, and also its average depth today may be about 0.5 to 0.8 metres, compared to its average depth of 1.5 metres in 1898 and of 3.8 metres, during the Dutch days (17th century). The floor or the substratum of the Pulicat lake is chiefly clayey, due to the deposition of silt, brought in by the monsoon floods.

There is a narrow (200 m) mouth into the lake, from the sea, at the southern end of the lake, at the Pulicat town.

The chief source of the biodiversity and food web in this lake is the tidal flow of sea water which flows upto about 12 km from the lake-mouth, and it brings in oxygen, nutrients, plankton and fish-seed. The other source is the freshwater rivulets, Kalangi and Arni which are monsoonal, and bring in more silt than water, into the lake. The Buckingham Canal which flows through the lake disperses flora and fauna between the several estuaries, backwaters, and lagoons that it is connected with on the Coromandel Coast, but the canal is blocked at several points on its course due to siltation. There are several mudflats in the lake which harbour mud-dwelling (benthic) fauna, and there are two large islands, Venadu and Irakkam, apart from the large Sriharikota Island that separates the lake all along its length, from the Bay of Bengal.

The northern sector or zone of the lake is shallower, more turbid and less saline, suited for wading and swimming birds, but the southern sector or zone of the lake is deeper, less turbid and more saline. In relation to the Northeast monsoon which is more dominant on the Pulicat Lake, there are three clear seasons, Monsoon Season (October to December), Post-Monsoon Season (January to March) and Pre-Monsoon Season (April to September). These seasons have a profound influence on the hydrological and biological parameters in the lake.

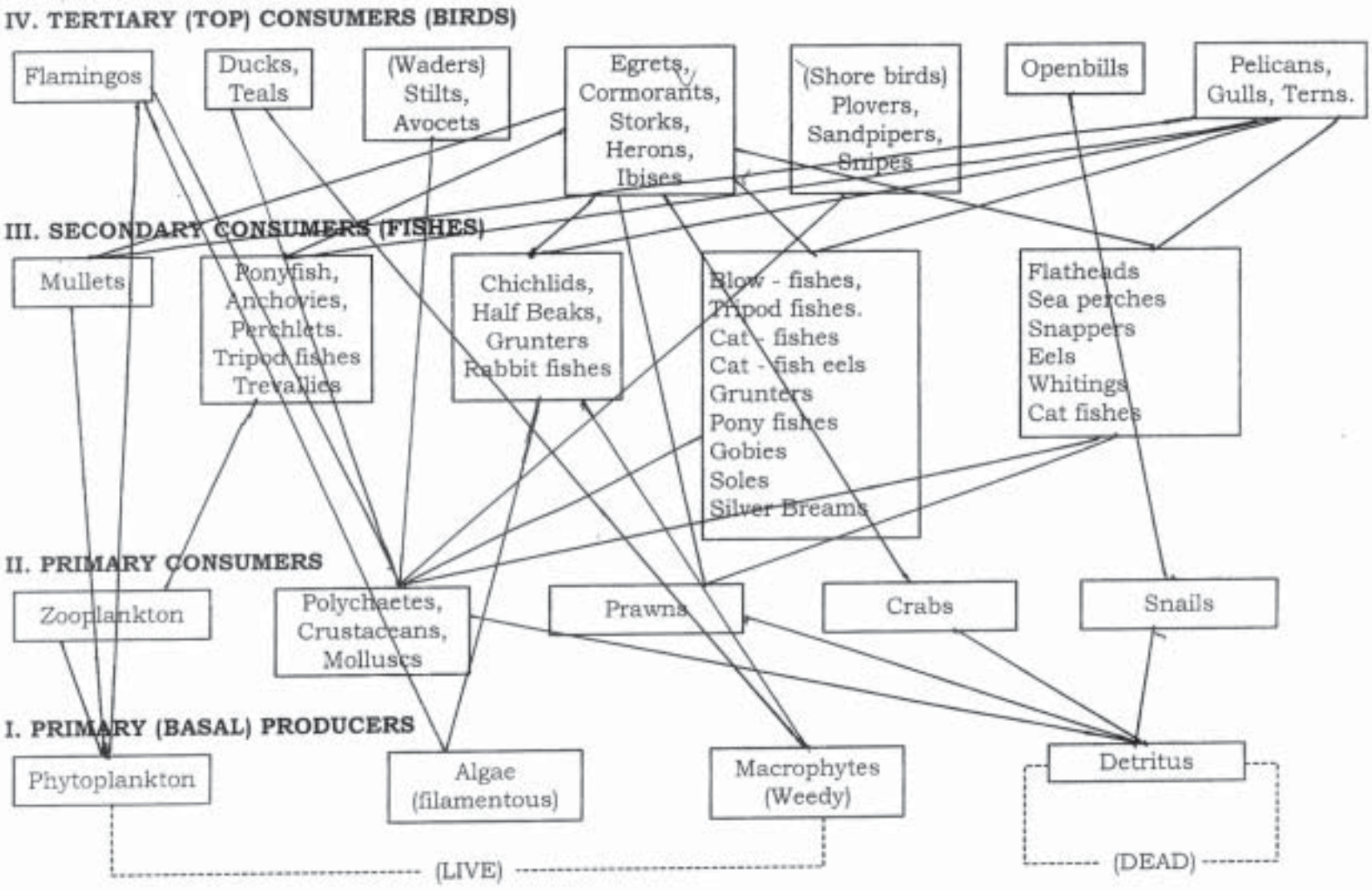
With bright sunlight (solar energy) for most days in the year, except on a few monsoon days, the rich and diverse phytoplankton multiplies within the lake itself and yielded a high primary productivity of about 3,467.5 kg/ha, during the years 1969-1972 (Kaliyamurthy, 1978). Also, based on the benthic productivity Raman, *et. al.*, (1975a) classified Pulicat Lake as "Mesotrophic".

Food Web in Pulicat Lake

The following Food Web for the Pulicat Lake is worked out from the published work and also from direct observations made for over 45 years, since 1962, on this lake.

Chacko, *et. al.*, (1953), in their foundation paper, have listed the plankton exhaustively and have analysed the stomach contents of 24 fishes from this lake and have described their feeding habits. Later, the scientists of the Central Inland Fisheries Research Institute have described the food of individual fishes like the *Gerres* species (Rao, 1968), *Sillago sihama* (Krishnamurthy, 1969), *Etroplus suratensis* (Prasadam, 1971) and *Ambassis gymnocephalus* (Raman, *et. al.*, 1975b). Kaliyamurthy and Rao (1972) have analysed the food of 37 species of fishes from the Pulicat Lake, during 1967 – 1968, and observed that detrivores constitute major groups (37.84%), followed by carnivores (24.32%), plankton feeders

FOOD WEB IN PULICAT LAKE
(Diagramatic and Tentative)



(21.62%) and herbivores (16.22%). Krishnamurthy (1971) and Raman, *et.al.*, (1975b) have described the plankton and the benthic fauna of this lake. Kaliyamurthy (1975) described the plankton ecology in the lake.

Sanjeeva Raj (2006) has been studying the macro fauna of the Pulicat Lake, observing the food and feeding habits of them, for over 45 years, since 1962. Jacobsen and Sanjeeva Raj (2009) have been studying the distribution, food and feeding of nearly 80 to 100 thousand water birds, belonging to 80 species, during the years 1999 to 2004, on this lake.

These and other research papers, quoted in the text, have helped the construction of this Food web for the Pulicat Lake. Very few ecosystems in India have been worked out for such food webs, graphically. Other scientists may evolve a slightly different pattern of food web for the Pulicat Lake. Very few ecosystems in India have been worked out for such food webs, graphically. Other scientists may evolve a slightly different pattern of food web for the Pulicat Lake, than what is given herein, because of their different perceptions. Students may be taught the methodology to construct simpler food chains first, and later, the complex food webs, for various ecosystems in their neighbourhood.

Explanation of the Food Web

Water sources

Morphologically, Pulicat Lake is a balanced and healthy ecosystem, with an inlet from the sea that flushes the lake, atleast to about 12 km distance with saline waters, rich in nutrients, oxygen, phyto and zooplankton and seed (larvae and juveniles) of almost all the marine species, in the Bay of Bengal. This is the chief source of sustenance for the food chains and the food web in the Pulicat Lake.

The other sources of inflow of water are the two monsoonal rivultes, Kalangi and Arni. These rivulets bring in more monsoonal silt, than freshwater micro or macro organisms which can not afford to tolerate the predominantly saline waters in this lagoon. The Buckingham Canal that flows through the Pulicat Lake may also bring in flora and fauna from the various estuaries, backwaters and lagoons with which it is connected on the Coromandel Coast, provided it flows continuously without obstruction at several points on its course, due to siltation.

Primary (Basal) Producers

Being a very shallow lake (0.5 to 0.8 metres of average depth), with siltyor clayey substratum, where decomposition of dead algal and other vegetable matter, epifauna and infauna of benthos takes place, detritus information is a continual process in this lake, so that detrivores tend to be more common and populous at all trophic levels, in the food web of this lake.

During 1951-1952, phytoplankton and zooplankton was rich, with 53 species of phytoplankers and 29 species of zooplankters (Chacko et al., 1953). Gradually, it has been declining due to chemical pollution from the south, and today, plankton in Pulicat Lake may be just half that original level. However, Kalyamurthy (1978) observed that

phytoplankters seem to multiply within the lake itself, to result in a high primary production of 3,467.5 kg/ha. Kaliyamurthy (1974) has described the plankton qualitatively and its ecology and Raman, *et.al.,* (1975) have quantified the plankton densities in the lake.

Benthos is equally rich in this lake, as analysed by Krishnamurthy (1971) and by Ramna, *et al.,* (1975a), so that based on the benthic productivity, the latter classify this lake, as "Mesotraphic".

Aquatic macroflora (algae) also of this lake are described by Chacko, *et al.,* (1953). Macrophytes like Halophila avails and *Syringodium isoetifolium* are more common in the central zone, around the Kuruvithittu mudflat, along with some patches of the mangrove, Avidennia marina, on the mudflat itself.

Primary Consumers

The diverse and rich benthic invertebrate fauna in Pulicat Lake, are detrivorous primary consumers, excepting the pelagic zooplankton which feeds on phytoplankton, Isopods, amphipods, juvenile and sub-adult pernaeid prawns, species of the lamellibranch Modiola and crabs are all epifauna, but polychactes and some specifies of the lamellibranches like Meretrix and Anadora are infauna, buried in sediments, and are all detrovies. Species of Cerithidea are most abundant ecological indicators in inter-tidal brackishwaters, where detritus is abundant. The Edible Oysters, on the other hand, are filter-feeders in shallow waters, filtering large quantities of detritus, suspended in water.

Secondary Consumers

Fishers are the most common secondary consumers in aquatic ecosystems. In a lagoon like the Pulicat Lake, with the inflow of sea water and fresh water, a wide variety of fishes of marine, freshwater and brackishwater origins coexist, with wide seasonal flunctuations in their diversity and populations. They are diverse in their dietary habits also, detrivores, phyto-or zooplankton feeders, macrophyte and algal feeders and carnivores, etc.,

Fish, in turn, contribute as the food of not only aquatic birds, which are the tertiary or top consumers, but also for humans, so that they are exploited and depleted lopsidedly by fishermen, jeopardising the balance of the food web, as well as of the ecosystem, as a whole.

Phytoplankton feeding mullets are the most abundant fishes in this lake. Diversity-wise, detrivorous fishes form the major category. Next to them are carnivores, feeding on amphipods, prawns and polychaetes. For a better management of the food resources available in this lake, it has been recommended (Kaliyamurthy, 1978), that more herbivorous fish need to be promoted in this lake.

Tertiary Consumers

Birds, unlike all other animals, are the most independent indicators of the optimum ecological conditions needed for their survival, chief among them is food. Water birds are known to migrate thousands of miles (or kilometres), even across the Himalayas, deserts, oceans, mountains and forests, to reach their

annual wintering grounds, mainly for food. In both their feeding and breeding grounds, they sojourn on wetlands where they are assured of adequate food without which they may even forgo breeding itself.

Pulicat Lake attracts nearly 80 to 100 thousand water birds belonging to 80 species (Jacobsen and Sanjeeva Raj, 2009), every winter, some from Ladakh, Tibet and China. It is significant that the near-threatened species like the Spot billed Pelican, Painted Stork, White Ibis, breed in the vicinity of the Pulicat Lake. Lesser Flamingos, Darters and Marbled Teals, also near-threatened species, arrive in small numbers, but do not breed here. However, the Greater Flamingo, about 15,000 of them spend the winter on this lake. Is there enough food for all these birds?

Diet-wise, these birds are highly varying, from phytoplankton, algal and benthic organism-feeders like flamingos, to macrophyte-feeders like ducks and teals, benthic feeding waders like stilts and avocets, openbills feeding on snails, piscivorous birds like pelicans, egrets, cormorants gulls terns, and painted storks, etc.,

There are eleven raptor species recorded on this lake (Jacobsen and Sanjeeva Raj, 2009), but they are not predators on any of these water birds.

We should not however forget humans who can feed on all these different trophic levels. The key role of humans as omnivorous consumers, exploiters and even as unfortunate victims of bioamplified toxins, along the various trophic levels, and above all, their role even as managers of ecosystems, is crucial for the sustainability of ecosystems.

Analysis of the Food Web in Pulicat Lake

Following the ecologist stiling (2002), the relative complexity of the food web in the Pulicat Lake also can be measured by its Chain-length, Connectance and Linkage density.

Chain Length is the average number of links between various trophic levels. In the food web of the Pulicat Lake, we have four trophic levels, with three links between them, and therefore, the chain length is three, which indicates - a complex food web.

Connectance is the value of the actual number of links, divided by potential number of links.

$$Connectance = \frac{actual\ number\ of\ links}{potential\ number\ of\ links}$$

Potential number (N) of links is $N = n\frac{(n-1)}{2}$, where n is the number of species in the whole food web, i.e., 21.

$$\text{Therefore, } N = 21\frac{(21-1)}{2} = 210$$

There are 32 links and therefore, the Connectance is 32 / 210 = 0.153.

Linkage density is the number of links, per species. Here, the number of links is 32 and the number of species is 21, and hence Linkage density = 32/21 = 1.523.

These three measures of complexity of a food web will be more meaningful, when we compare them with food webs from other similar aquatic ecosystems.

The pyramid of the food web in Pulicat Lake is an "inverted pyramid" (Stiling, 2002, p.340).

Also, in the food web of Pulicat Lake, items like detritus, polychaetes, amphipods and penaeid prawns may be considered as 'keystone prey' and carnivorous fish may be considered as 'Keystone predators'.

Management of the Pulicat Lake Ecosystem, in relation to its Food Web

Food webs are crucial not only for the health of the ecosystems concerned but also for the 'wise use' of them for sustaining the human communities, dependent on them. Management of ecosystems has to be approached from various levels, starting with the habitats and infrastructural resources, leading upto the highest trophic level, in the food web.

So far as the Pulicat Lake is concerned, management of the lake-mouth is crucial for the health and prosperity of the whole lake ecosystem. The wider and the deeper the lake-mouth is and the longer it opens into the sea, during the year, the more will be the vital inputs from the sea, like nutrients, oxygen, plankton and fish-seed, which are the very basis of life and food chains in this lake. Keeping the lake-mouth open right round the year, and opening up extra mouths in the north, will surely enhance the productivity and food chains, in this lake.

Even drainage from the monsoonal rivulets and from the Buckingham Canal is sources of freshwater and brackish water, with the flora and fauna drifted into the lake. However, monsoonal siltation has to be checked. The floor or the bottom of the lake should be developed as a sandy-muddy one, rather than as a mere sandy or mere clayey one. Sand and clay (50:50) is known to promote benthic vegetation and primary consumers, as infauna and epifauna of benthos, in the substratum.

Edible Oysters, *Crassostrea madrasensis* (Preston) which was proved to be the keystone species in Pulicat Lake (Sanjeeva Raj, et. al., 2002), in attracting and harbouring nearly 83 species of biodiversity, creating new food chains should be promoted, on a priority basis.

Despite the high primary production of 3,467.5 kg/ha (Kaliyamurthy, 1978) in the Pulicat Lake, during 1969-72, the fish yield was only 3.459 kg/ha which amounts to only 0.1% of the gross primary production, which is far below. Hence, he recommended that more herbivorous fish must be introduced into this lake, in order to consume the whole phytoplankton and vegetable matter in the lake. Herbivores like *Etroplus suratensis* (Banded etroplus), *Chanos chanos* (Milk fish), *Siganus* species (Rabbit fishes), *Hemiramphus gaimardi* (Half beak) and above all, Oreochromis mossambica (Tilapia) could be introduced into this lake.

Over-exploitation of the fishery-resources and pollution of the lake should be under constant check. The preferred food fishes of the migrant birds could be stocked in this lake, soon after the migrant birds arrive.

More vegetation could be promoted in this lake, both as a source of direct food for consumers as well as for detritus formation.

Mangroves flourished once upon a time, on the Pulicat Lake, when its biodiversity, food chains and food we b could have been equally rich. According to the geologists Farooqui and Vaz (2000), even about 6,650 to 7,000 yrs, B.P., there were luxurious mangroves, chiefly of the family Rhizophoraceae, on the north-western shores of the original Pulicat Lake. By about 4,640 yrs. B.P. they seemed to have shifted eastwards, by about 18 km, due to the massive marine regression. Much later, by about 1450 to 1800 A.D., these mangroves extended southwards, as Caratini (1994) obtained fossil pollen grains of mangroves from the three-four metre deep sediments in the lake, opposite the Pulicat Town.

Jayasundaramma et al., (1987) have recorded nearly ten species of mangroves on the bank sof the Buckingham Canal in the South Andhra Pradesh, on the eastern bank of the Pulicat Lake, and Excoecaria agallocha was found to be the most dominant species, represented by 80% of the mangrove population. Suryanarayana et al., (1998) recorded four species of mangroves on the Sriharikota Island. Today, low and sprase bushes of Avicennia marina are common, down south, at Ennore, as well as on the Kuruvithittu Mudflat, at the border of the Tamil Nadu and Andhra Prdesh, in the Pulicat Lake.

The biodiversity and food chains were prosperous in the Pulicat Lake, during earlier days, perhaps due to the fertilizing of the waters by the mangrove leaves and due to the extra habitats that the mangrove root system and the trunks provided. If mangroves are restored to their original native soil of the Pulicat Lake, the biodiversity and food chains may be promoted, once again.

Impacts of Climate Change on the Biodiversity and the Food Web, in Pulicat Lake

Climate change has its own specific impacts on the biodiversity, food chains and the food web of the Pulicat Lake. These impacts were already felt, but rather sporadically, since the past 30 years. They have shown up through two major manifestations, through drought, and through cyclonic storms and floods.

Drought

Raman et al., (1977) have studied the impacts of the severe drought of 1975 on the Pulicat Lake ecosystem, with the following sequence of events:-

The lake-mouth was completely closed by the formation of a high and wide sand bar, for eight months. Since the tidal flush was totally lost, the lake started shrinking in its water spread area and also in its depth. Water receded far away from the flashing villages where their boats were berthed, and fishermen could not navigate both because of the dry lake-bed as well as because of the loss of optimum depth for navigation. The water temperatures were uniformly high all over the lake (35*C), with incredibly high salinities of 70-80%. And the dissolved oxygen in water was very low (2.1 to 3.2 ppm). As a

consequence, plankton was very poor due to neither fresh ingression from the sea nor its failure to multiply within the lake. Fishery productivity went down by 23% and there was a heavy mortality of even larger finfish and shell-fish in the lake. The ultimate victims of the manifestation of climate change were the local fishermen who could neither navigate in the lake nor had an fish-catches. They were impoverished and got heavily indebted to the money lenders and wee desperately in search of alternate livelihoods, in the nearby towns.

Cyclonic Storms and Floods

Sanjeeva Raj (1985) described the impacts of the 'Sriharikota Cyclone' of 1984 that had its 'eye' right on the northern part of the Sriharikota Island, and created cataclysmic changes on the lake ecosystem, never heard of, by even the oldest fishermen on this lake. The following sequence of events took place:-

For four consecutive days and nights, from the 10th till the 14th November 1984, with very low barometric pressure of about 984.1 mb, and with high wind-speeds of 170-200 km/hr, it rained continuously flooding the lake to about 12 feet above its normal level. The gushing waters burst open seven more new mouths for the southern sector of the lake into the sea, so that not only the lake waters but also, all its biodiversity and fisheries were flushed out, far into the sea, to almost 200 km, away, up to Pondicherry in the south. Due to the severe churning of waters by the cyclonic fury, the whole floor of the lake was totally changed, some areas got deepened, and some areas got sandy mounds formed, by the sand that was blown off by the cyclonic winds from the seaside sand bar. Monsoonal freshwater in the lake could not sustain the marine plankton, fishes and prawn, and hence for nearly six months after the cyclone, the fisheries were non-existent in the lake. Fishermen lost all their craft and gear, blown away by the cyclonic storm. As with drought, even with the cyclones and floods, fishermen suffered loss of livelihoods, more severely than through drought, because fishermen lost even their means to livelihoods, namely their boats, nets and houses too. The fury of the cyclonic winds killed nearly 400 Spot-billed Pelicans of the Nelapattu Bird Sanctuary, a near-threaten species, uniquely protected in this sanctuary. About 600 Greater Flamingos also were battered to death (Anon, 1984), and several smaller birds also were destroyed. Strange fish like the Lesser Trunk Fish (*Ranzania laevis*), from its native habitat in the Gulf of Mannar, was blown, as a straggler into the Pulicat Lake (Sanjeeva Raj, 1985). Fortunately however, no invasive alien species (IAS) seem to have been drifted into the lake. The Buckingham Canal got silted up at various points along its course, so that ancient navigation on it had to be abandoned since this super cyclone, and biodiversity dispersal through this canal was also affected.

Cyclones of lower intensity are annual features (Sanjeeva Raj, 1992 and 1995), on the east coast of India, including the Pulicat Lake, during the Northeast monsoon (October-December), and they bring about temporary and recoverable disruptions in the biodiversity composition, food chains and the food web in the lake. Sometimes, cyclones enhance the fishery and avian productivity on this lake, so that fishermen and farmers welcome these annual cyclones.

Although the Climate change and its impacts on the coastal lagoons in India, including the Pulicat Lake, are inevitable, yet they can be faced more positively, if the connections of these lagoons to the sea are patent, ie., open optimally, neither the impacts of droughts nor the impacts of floods could be of long-standing and severe magnitudes. Their biodiversity wealth, natural food chains and the food webs could be sustained. Hence, the mouths of these lagoons and estuaries on the east coast of India should be kept open artificially, at the beginning of every monsoon, in case they are closed, naturally.

Food Webs, as an Exercise in Environmental Education

It is a joy to watch ecosystems teeming with life. Humanity, bereft of all biodiversity, according to behavioural scientists, may suffer an emotional shock of loneliness and monotony, on this planet. Complex food webs in an ecosystem are indicative of rich biodiversity and balanced ecosystems. Students and naturalists should learn to analyse and graphically represent food chains and food webs in ecosystems, to manage them sustainably.

Methodology

To determine the food of any organism, direct observation of 'who eats whom' in an eco system, is an unquestionable evidence. Photographing predators capturing their prey or holding the prey, also is a good evidence of their precise food. Left-over remains of partly consumed food or regurgitated food are other sources of information.

Indirectly, one can pinpoint the feeding site of predators and search for their probable food items. However, conventionally, analysis of crop or stomach – or gut-contents of animals, soon after their feeding, gives a clear picture of the food consumed, and even the relative qualitative and quantitative information on food, and also its diurnal and seasonal fluctuations. However, it is most important to observe that sacrificing protected or endangered animals is a serious violation of the wildlife protection laws. In wildlife biological studies, scat or faeces examination of predators for hair, feathers, bones horns and claws, and similarly, examining for seeds, plant tissues or bark in the herbivore dung is a conventional approach to detect and quantity the food consumed.

Graphic representation of a food web is rather complicated to begin with, but construction of simple food chains may be easy to start with, and then they may superimpose the various individual food chains of an ecosystem to arrive at a rough picture of the food web. Usually, published information on the food of various animals helps greatly in the construction of food chains and food webs. It is easier to start at the top (predators) and go down to the lowest producers, in constructing a food chain or food web.

Working out a food web is not a mere academic exercise, but is more a management necessity. It is imperative for the managers of ecosystems, wherein naturalists and students can help them to construct the food webs of the eco system concerned, for maintaining the eco balance and sustainability of the ecosystems and to save them from the vagaries of the impending climate change.

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Awareness towards global warming among higher secondary students of Coimbatore district

T. Prasanyaa*

ABSTRACT

The present study is an attempt to find the awareness on Global Warming among Higher Secondary Students of Coimbatore District, Tamil Nadu, India. The information was gathered through a questionnaire constructed for this purpose. The questionnaire consists of 40 questions related to awareness on Global Warming. A survey was conducted among 200 respondents using the questionnaire. The data collected were grouped and analysed using mean, SD, 't'test. Findings revealed that the Higher Secondary Students of the Coimbatore district have significant awareness on Global Warming. The result of the survey showed that the environmental awareness must still be more promoted.

Keywords : Global Warming, Awareness, Survey, Environment

Introduction

In the past 200 years, the world's population has increased dramatically by over six times, from just 1 billion in 1800 to a mammoth 6 billion by 1999. This has resulted in overcrowding and stress on all the world's resources. Accordingly, in the last few decades, environmental problems have been approached from not only technical and economical dimensions but also in societal dimensions (Tuna, 2004). Technological solutions and economic measures for meeting the environmental crisis faced by countries, including developing countries, can be successfully introduced only if the public perception and demand is taken in to consideration. This was confirmed in several studies in both developing and developed countries (Zhenmin and Xiaohua, 2002; Tikka and Tynys, 2000). Hence, it is the duty of teachers to include the awareness, knowledge and participation of the students towards Global Warming (Ellen and Doris, 2001).

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Need For The Study

In recent years, population has tremendously increased on earth. People depend on the environment for their basic needs and exploitation gradually degrades the environment. People destroy forest areas for sophisticated lifestyle and also use chemicals such as Chloro Fluoro Carbons (CFC) and aerosols to increase the life's comforts which are hazardous to the environment that leads to Global Warming (Edward Boyes and Martin Stain street, 1997). The authors feel that, the awareness and positive attitude towards Environment must be spread among people through Environmental Education in order to effect a positive change towards environment. Environmental Education refers to an organized curriculum to teach how natural environment functions and how we can manage our ecosystems through modifications in our lifestyles for a sustainable and healthy environment. The term is often used to imply education within the school system, from primary to post-secondary levels. However, it is sometimes used more broadly to include all efforts to educate the public through several means including print materials, websites, media campaigns, etc., Hence the present study is aimed to focus on the "Awareness towards Global Warming among the Higher Secondary Students".

Statement Of The Problem

The key to successful environmental education is in the hands of teachers and students in the classroom. If the students do not have the attitude and awareness towards environmental education and environmental contexts, it is difficult to protect the environment from various consequences (Hager, Sarah and Staraka, 2007). Hence, the study was chosen.

Operational Definitions

Awareness: It is the process of knowing about environment, environmental pollution and environmental conservation.

Higher Secondary: Education offered to XI and XII Standards for the age group of 16 to 17 at schools in Tamil Nadu and Pondicherry, India.

Higher Secondary Students: The students who are studying XI and XII standards.

Global Warming: "Increase in average temperature of the earth's surface due to green house effect.

Objectives Of The Study

The present study has the following Objectives

1. To find out the significant difference between the mean score of the higher secondary students in their awareness towards Global Warming with respect to their, (i) Sex (ii) Type of School (iii) Locality.

Limitations Of The Study

The study is subjected to the following limitations.

1. The sample size is only 200 higher secondary students from the schools in Coimbatore District in Tamil Nadu, India.

2. Present investigation was carried out only in five schools from Coimbatore district.

Methodology

The investigator has used normative survey method for the study. A total sample of 200 students was taken for the present study. Stratified random sampling process was followed for data collection based on the Sex, Type of School and Locality. Accordingly, 200 Questionnaires (i.e., 5 x 40 = 200) were distributed among the students.

Tools: The tool entitled "A Scale of Awareness towards Global Warming" was developed by the investigator. The reliability of the awareness scale was found to be 0.675.

Data Collection: The investigator visited personally the higher secondary Schools in Coimbatore District, Tamil Nadu to collect the data. The data were collected with the help of the developed tool. The investigator sought permission from the headmasters and approached the students and explained to them the concept of the study. She assured that their responses would be kept confidential and used for research purposes only. Clear instruction was given as to enable them to give their responses meaningfully. The gathered responses were scored.

Statistical Technique: The investigator used Descriptive, Differential statistics for data analysis. She used the software "SPSS 11.0" Standard version for data analysis. The data were analysed by using Mean, SD, 't' test. The study examined whether or not awareness is differentiated by factors such as Sex, Type of School and Locality.

Table - 1

Difference between Higher Secondary Students Awareness towards Global Warming with reference to Gender, Sex, Type of School, Locality

Levels	Variables	N	Mean	Mean (%)	SD	t-value	Significance
I	Male	80	28.00	75.67	4.65	1.380	N.S
	Female	120	28.90	74.10	4.31		
II	Government	92	27.15	77.57	5.15	4.094	S
	Private	108	29.72	76.20	3.37		
III	Rural	115	27.25	80.14	4.41	5.119	S
	Urban	85	30.28	77.64	3.91		

Significance difference at 0.05 levels: - 1.984

Hypotheses Of The Study

1. There is no significant difference between the mean score of the higher secondary students in their Awareness towards Global Warming with respect to their, (i) Sex (ii) Type of School (iii) Locality.

Table-1 (i) shows that the calculated value t = 1.380, is less than the tabulated value. This indicates that there is no significant difference between male and female higher secondary students with respect to the awareness towards Global Warming. Hence the Null Hypothesis is accepted.

Table-1 (ii) shows that the calculated value t = 4.094, is greater than the tabulated value. This indicates that there is a significant difference between the government and the private higher students with respect to awareness on Global Warming. Hence the Null Hypothesis is rejected. The private school students have better awareness than the Government School students on Global Warming.

Table-1(iii) shows that the calculated value t = 5.119, is greater than the tabulated value. This indicates that there is a significant difference between the rural and urban higher secondary students with respect to awareness on Global Warming. Hence the Null Hypothesis is rejected. The rural students have better awareness than the urban students towards Global Warming.

Findings Of The Study

There is no significant difference between the mean score of the Male and the Female Students with respect to their Awareness on Global Warming.

There is a significant difference between the mean score of the Higher Secondary Students in their Awareness on Global Warming based on Type of School and Locality. The Private School Students and the Rural Students have better awareness than the Government School Students and the Urban Students respectively.

Educational Implications

Science clubs / Environmental awareness programmes / Celebrating Environmental Day can enrich the knowledge of higher secondary students.

Environmental Studies can be made as a part of the curriculum (Chen-Yen Chang, 2005)

Students can be facilitated to visit the environmental conservation centres.

Students can be made to take part in the environmental conservation programmes conducted by conservation centres.

Conclusion

Vast changes must be made on a global scale, such as stabilizing population growth, reducing consumption rates, adjusting technology, and empowering the communities in managing and planning their environment. Each of us as individuals and collectively must take actions that change our lifestyles towards creating more sustainable environmental systems in our homes and schools.

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Compulsory Environment Education at Junior College Level in Maharashtra State

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ABSTRACT

This paper deals with present scenario of compulsory environmental education at junior college level in Maharashtra state as per the directives of Honorable Supreme Court and guidelines of National Council for Education and Training Research (NCERT), New Delhi.

Information regarding the implementation of compulsory environmental education at Junior College level in Maharashtra state was collected. This process was facilitated by the circulars issued by Maharashtra State Secondary & Higher Secondary Education Board (MSSHSEB) to colleges under Right to Information Act (RTI) from board. The present paper is an effort to focus on the present scenario with respect to its year of implementation, syllabus, and distribution of workload, appointment of lecturers (temporary/permanent/fix pay basis/clock hour basis), qualification criteria, remuneration paid and the examination pattern.

A special attention has given to the lacunas and shortcomings in the system adopted for the implementation of this subject. It also provides suggestions for proper and effective implementation of this subject to comply the moto of Honorable Supreme Court.

Keywords : Environment education, Supreme Court, RTI, NCERT, MSSHSEB.

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Introduction

Environmental problems such as depletion of natural resources, degradation of environment, environmental pollutions, loss of biodiversity, global warming and climate change have become prime concerns at global level.

The causes, consequences and remedial measures of all the environmental problems were widely discussed at national and international level during last few decades. Environmental education has been unanimously accepted as an important tool to provide awareness to the global human society about the environmental problems, future plans for environmental protection and conservation, and to inculcate the knowledge to the younger generation.

Environmental education plays a vital role in the process of environmental awareness and forms an integral part of sustainable environment. Environmental education is also important in conservation and protection of environmental quality (Tbilisi Declaration, 1977).Therefore there is an appeal to launch *an international environmental education Program (*United Nations, 1972*).*

Awareness and training in environmental education is given more emphasis as a strategy for the sustainable development (Rio, 1992). Increasing importance of environmental education process leads to the reflection on the definition and goals of Environment education, as well as on its place within basic education (Montreal, 1997).

Honorable Supreme Court of India directed all state education boards to incorporate compulsory environmental education in its judgments on the writ petitions (M.C. Mehta Vs Union of India, 1991; M.C. Mehta Vs Union of India, 2003). The Supreme Court Bench had issued an order on November 22, 1991 to make environmental education a compulsory subject from school to graduation level for all disciplines (India times, 2003).

The Supreme Court has directed the NCERT to take appropriate steps to prescribe course content for environmental education. In pursuance of this, the NCERT framed a syllabus and incorporated environmental education as a compulsory subject from IXth to XIIth standard. Government of Maharashtra implemented the compulsory environmental education from the academic year 2005 – 2006 for class IX, from 2006 -2007 for classes X and XI and from 2007 – 2008 for class XII (Mehta, 1991, MSSHSEB, 2005).

Maharashtra state has been selected for a case study to assess the present scenario of compulsory environmental education at Junior college level. The circulars issued by the Maharashtra State Secondary & Higher Secondary Education Board were collected under Right to information Act (RTI) and existing implementation modalities such as year of implementation, syllabus, distribution of workload, appointment of lecturers (temporary/permanent/fix pay basis/ clock hour basis), qualification criteria for appointing, remuneration paid and the examination pattern. The study results are summarized below.

i) Year of Implementation

Maharashtra State Higher Secondary Education Board (MSHSEB) had issued

the circulars to junior colleges for implementing the compulsory environmental education from academic year 2006 – 2007 for class XI and from 2007 – 2008 for class XII for all disciplines(Arts, Commerce, Science, Vocational etc) (MSSHSEB, 2005a & MSSHSEB, 2006a).

ii) Syllabus pattern

As per the directives of Honorable Supreme Court, the National Council for Education Training and Research (NCERT) has framed a uniform syllabus at state level. The NCERT has given the guidelines to Maharashtra Higher secondary Education Board to incorporate the environmental education as a separate and compulsory subject in syllabus scheme of classes XI & XII. The environmental education syllabus has been classified in two parts i.e., theory, for 60 marks and project for 40 marks (MSSHSEB, 2006a & MSSHSEB, 2007).

iii) Distribution of workload

Two periods per week are allotted to teach the compulsory environmental education subject (MSSHSEB, 2005).

iv) Appointment of Lecturer

Considering the non-grant policy adopted for implementing the compulsory environmental education at junior college level, there are no specific guidelines for appointment of lecturers for teaching this subject. The lecture hours allotted for the compulsory environmental education subject are distributed to the existing teachers from any subject in respective colleges. However, some reputed colleges of Maharashtra appoint the lecturers on a fixed pay basis for teaching subject (MSHSEB, 2005).

v) Qualification criteria for teaching

As this subject is implemented on a non-grant basis, there is no provision for appointing a separate subject teacher for teaching environmental education in junior colleges.

vii) Remuneration for appointed teacher

As this subject is being taught by the existing teaching staff from other subjects there is no remuneration. However, in some reputed colleges where the lecturers are appointed to teach environmental education on a fixed pay basis i.e. Rs. 4000-5000 /- per month or appointed as Shikshan Sevak and the nature of their duties are temporary (Dainik Pudhari, 2008, Times of India, 2009, Loksatta, 2009, Maharashtra Times, 2009).

viii) Exam pattern

Initially, the state education board has decided and informed the respective colleges, which the board will conduct the exam for this subject for hundred (100) marks and the marks obtained by the student in this subject will be incorporated in the mark sheet separately. But, in due course of time the state education board has declared that the exam for environmental education will conducted at the college level and marks secured by the students are converted into grade instead of marks.

Because of this the students, teachers and the implementing authorities have taken both evaluation in a very casual manner (MSHSEB, 2005 & 2006b).

The incorporation of grades instead of marks obtained by the students in this subject may responsible to the negligence towards the Environmental Education subject by the many students in twelfth standard which has resulted in most students losing their academic year 2007-08 (Shinde, 2008).

This was due to the lacuna in the adoption of the appropriate implementation system for the environmental education. It is essential, considering the importance of environmental education, to review the existing system adopted for implementing environmental education at all levels to ensure the proper inculcation of environmental education (Dhapate, 2007b).

Perspective Policy Decisions

For proper and effective implementation of environmental education at Junior college level, the following appropriate steps need to be taken;

i) The compulsory environmental education subject at junior college level should be implemented on a grant basis instead of non-grant basis. So, the problems in adopting the separate appropriate policy decisions for this subject can be mitigated (Dhapate, 2007a).

ii) As the existing teachers from other subject are unable to give the justification to this subject due to their existing workload from their own core subject and due to inadequate knowledge about the basic concept and components of environment. So, there should be a provision for separate lecturers for teaching this subject and their appointment should be made permanent (Loksatta, 2007).

iii) The qualification criteria for appointing the lecturers for teaching this subject should be M.Sc in Environmental Science with B.Ed only.

iv) By considering the content of syllabus and distribution of marks for theory and project work, the existing workload i.e. two periods per week are not adequate. The workload norms should provide adequate time for teaching this subject.

v) The theory examination for environmental education should be conducted by state higher secondary education board instead at the college level for the uniformality in examination pattern and there should be a separate passing for theory and project work.

vi) To maintain the seriousness of the subject, the marks obtained by the student in this subject should be incorporated in mark sheet instead of converting into grades.

Conclusion

The present status of implementation of this subject and the approach of students and teachers treats this as just a show and does not touch the heart.

Hence, there is a need to take the initiative for making the students and teachers to understand and to appreciate the values regarding this subject. Otherwise the environmental education subject will remain on paper and only a subject of

lectures, conference, seminars, workshops and programmes for publicity purpose only.

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Environmental Awareness among Senior Secondary School Students

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ABSTRACT

The present study is an attempt to examine the environmental awareness of senior secondary school students in relation to sex, residential background and type of school. For this purpose, 800 students of class 11were taken from the Govt. Aided and Private schools (both from rural and urban) recognized by UP Board and CBSE in the Meerut province. Environmental Awareness Ability Measure (EAAM) developed by Dr. Praveen Kumar Jha (1998) was used to measure environmental awareness of students. The present study highlighted that in total, there is influence of type of school, sex, and stream on the level of student's environmental awareness.

Keywords : Environmental awareness, Environmental Pollution, Gender, UP Board and CBSE Schools.

Introduction

World educators and environmental specialists have repeatedly pointed out that a solution to environmental crises will require an environmental awareness which should be deeply rooted in the education system at all levels of school education (Shukla, 2001). Today, environmental awareness is a very important topic for discussion and lots of conferences and seminars are being held at various levels. The environmental and energy related problems can not be solved unless students are aware of them, because the students are the future citizens of the country. It is very much an essential need for each individual to develop an awareness of protection and preservation of the environment. The role of students would go a long way in achieving such desired goals. The present study is an attempt to examine the environmental awareness of senior secondary school students in relation to sex, residential background and type of school.

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Objectives

1. To study the level of environmental awareness among senior secondary school students in the Meerut province.

2. To study the difference between rural and urban students in their level of environmental awareness.

3. To study the difference between boy and girl students in their level of environmental awareness.

4. To study the difference between students of government aided and public schools in their level of environmental awareness.

5. To study the difference between students of science and arts streams, in their level of environmental awareness.

6. To study the difference between students of the U.P. Board and the CBSE in their level of environmental awareness.

Method

Methods of research are generally determined by the theory of the topic under study, objectives of the study, resources of the researcher etc., The investigator has used the descriptive survey method by adopting all the steps and characteristics described as essential for the descriptive method of research by several authors.

Participants

In the present study, an equal number of boy and girl students studying in class 11 were taken from the Govt. Aided and Private schools recognized by the UP Board and the CBSE in Meerut province. Using stratified random sampling, students of class 11 were selected from both rural and urban senior secondary schools, constituting a sample of 800 students in all.

Material and Procedure

To achieve the objectives of the present study Environment Awareness Ability Measure (EAAM) developed by Dr. Praveen Kumar Jha (1998) was used to measure environmental awareness of students. The tool measures the level of awareness of students about environmental pollution and its protection, as consisting of five dimensions, viz. causes of pollution, conservation of soil, forest, air, and energy conservation and of human health, wildlife and animal husbandry. There are 51 items on this scale. A numerical weightage of 1 was assigned to the response category of agree in the case of positive items and disagree in the case of negative items. Thus, on the total scale, the scores of 51 items ranged between 0-51. The total scale gives a composite score of environmental awareness of the student.

Results and Discussion

Analysis of results for level of awareness among students of senior secondary schools on environmental awareness was done by separating them into low, moderate and high category. Frequency and Percentage of students falling under different levels are presented in table -1.

It is evident from table-1 that 54.00 % of total senior secondary school students lie at moderate level of environmental awareness, while 23.25 % at low, and

22.75 % at high level of environmental awareness. It was also found that the number of urban students with high level of environmental awareness (29.50 %) is more than their counterparts of rural students (16.00 %). Similarly the girl students have a high level of awareness (30.00 %) than boys (15.50 %). The awareness was more among private school students (30.25 %) than students from government aided schools (15.25 %). Science students score more in level of awareness (26.75 %) than student from arts stream (18.75 %). The CBSE students have better level of awareness (30.00 %) than their counterparts in the UP Board students (15.50 %). Further it is noticed that the urban students have a moderate level of environmental awareness (58.25 %) than rural students (49.75 %).

Table- 1: Frequency and Percentage of students falling under different levels of Environmental Awareness

Group of students	N			Low (1-15)	Moderate (16-36)	High (37-51)
Rural	400	No.	%	13734.25	19949.75	6416.00
Urban	400	No.	%	4912.25	23358.25	11829.50
Boys	400	No.	%	7318.25	26566.25	6215.50
Girls	400	No.	%	11328.25	16741.75	12030.00
Govt aided school	400	No.	%	13533.75	20451.00	6115.25
Private school	400	No.	%	5112.75	22857.00	12130.25
Science stream	400	No.	%	7819.50	21553.75	10726.75
Arts stream	400	No.	%	10827.00	21754.25	7518.75
UP Board	400	No.	%	11428.50	22456.00	6215.50
CBSE	400	No.	%	7218.00	20852.00	12030.00
Overall	800	No.	%	18623.25	43254.00	18222.75

It is evident from table-1 that 54.00 % of total senior secondary school students lie at moderate level of environmental awareness, while 23.25 % at low, and 22.75 % at high level of environmental awareness. It was also found that the number of urban students with high level of environmental awareness (29.50 %) is more than their counterparts of rural students (16.00 %). Similarly the girl students have a high level of awareness (30.00 %) than boys (15.50 %). The awareness was more among private school students (30.25 %) than students from government aided schools (15.25 %). Science students score more in level of awareness (26.75 %) than student from arts stream (18.75 %). The CBSE students have better level of awareness (30.00 %) than their counterparts in the UP Board students (15.50 %). Further it is noticed that the urban students have a moderate level of environmental awareness (58.25 %) than rural students (49.75 %).

Table- 2: Summary of t-test for difference between students on Environmental Awareness

Group of students	N	Sum	Sum of Sqr.	Mean	S.D.	t- Value
Rural	400	9058	253840	22.645	11.050	11.468*
Urban	400	12558	438224	31.395	10.497	
Boys	400	10336	309722	25.840	10.338	2.880*
Girls	400	11280	382342	28.200	12.689	
Govt. aided school	400	9545	277957	23.863	11.216	7.967*
Private school	400	12071	414107	30.178	11.176	
Science stream	400	11347	375989	28.368	11.645	3.294*
Arts stream	400	10269	316075	25.673	11.465	
UP Board	400	9966	297872	24.915	11.146	5.197*
CBSE	400	11650	394192	29.125	11.729	
Overall Students	**800**	**21616**	**692064**	**27.020**		

* Significant at 0.01 level

It is observed from Table-2 that t-value between the means of rural and of urban student on environmental awareness was found to be 11.468, which was significant at 0.01 levels. This reveals the fact that rural and urban students differ significantly on environmental awareness. Since mean difference was in favor of urban students, it indicates that urban students were found to have more environmental awareness than rural students. Similarly the t-values between the means of boys and girls, of the Government aided and private schools, science and arts streams, the UP Board and the CBSE were found to be 2.880, 7.976, 3.294 and 5.197 respectively, which were significant at 0.01 level. This reveals that significant differences exist on environmental awareness. Since the mean differences were in favor of girls, private school students, science students and students of the CBSE, it indicates that girls were found to be more aware about environment than boys. In the same manner the students of Private schools were found to have more environmental awareness than Government aided schools students, science students were more aware than arts students and the CBSE students were also found to have more environmental awareness than the UP Board students. The overall mean of all 800 students was 27.020 and lies in moderate level of environmental awareness, which implies that all the students were found to be in moderate level of environmental awareness.

Conclusion

The present study highlighted that in total there is an influence of type of school on the level of student's environmental awareness. This finding of the study corroborated with the finding of Rou (1995), Prajapat (1996), Kaur & Kaur, and Shobeiri et.al. (2007), who reported that there is significant difference between the Government and

private school students in the level of environmental awareness. Whereas this contradicted with the finding of a study by Tripathi (2000) who reported that type of school management has no effect on student's environmental awareness. The findings reveal that students of private schools have more environmental awareness than government aided school students. The reason for higher environmental awareness among students of private schools may be the family background and educational qualification of parents. Parents of students studying in private schools are graduates and are economically well of. Such parents are mainly concerned with inculcating environmental awareness to their children as they are aware of the dangers and consequences of environmental degradation at global level. On the other hand, students studying in Government aided schools come from poor families and have less educated or illiterate parents, whose main priority is to fulfill the needs of their family members. They are not aware of environmental issues, so they can't pass on these awareness measures to their children. Results also indicated that in total there is a significant difference between boy and girl students in their level of environmental awareness. Girls were found to be much aware about environmental issues than boys. This finding of the study corroborated with the finding of Shahnawaj (1990), Rou, Sabhlok (1995), Patel (1995), Szagun and Pavlov (1995) and Tripathi (2000) who reported gender has an effect on the level of students environmental awareness and contradicted with the findings of Shobeiri, *et..al.* (2007).

All these findings suggest to us and to the government to make efforts to provide proper classrooms, library facilities, environment related books in local language and necessary infrastructure in the form of computers and internet facilities for the students studying in different schools, especially in the rural schools. The teachers in government aided schools and rural schools should make more efforts to provide better education and environmental awareness to their students.

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Role of Forest Invasive Species on the Convention on Biological Diversity (CBD)

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ABSTRACT

Invasive Alien Species (IAS) and climate change are considered as some of the greatest threats to biodiversity. These two drivers of ecological change acting together could produce extreme outcomes. IAS is damaging a number of natural or agricultural ecosystems, including native forests and their biological diversity. Rapidly accelerating trade in forest associated products, tourism, transport, and extensive travel over the past century have dramatically enhanced the spread of invasive species, allowing them to surmount natural geographic barriers.

The CBD has established invasive alien species programme, as cross-cutting issues on priority basis, meaning that it is relevant to all other CBD programmes. The Convention also adopted the guiding principles for prevention, introduction and mitigation of impacts of alien species that threaten ecosystems, habitats or species.

An attempt has been made in this paper to provide information to policy makers, planners, developmental agencies, and all those having a stake in forestry regarding gaps and inconsistencies in international regulatory framework, in–depth review of the IAS programme at national, regional and sub regional level of activities and capacity-building, development of communication, education and public awareness, development of tools for management, as discussed in the Conference of Parties-9. India has shown its concern over this issue and taken preventive measurements through Environment Protection Act 1986 (Rules 1989) and established a nodal agency under the Ministry of Agriculture to enforce the latest regulations on "Plant Quarantine Order, 2003".

Key words: Convention on Biological Diversity (CBD), Conference of Parties (COP), Invasive Alien Species (IAS), Forest Invasive Species (FIS), Asia-Pacific Forest Invasive Species Network (APFISN)

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Introduction

The problem of Invasive Alien Species (IAS) is global in its scope, and requires international cooperation to enhance the actions of governments, economic sectors and individuals at national and local levels. Sharing information and expertise at a global level is a critical component in prevention and management of IAS. A country can only prevent invasions if it is known which species are likely to become invasive, where they may come from and what are the best management options (CBD Invasive Alien Species – A threat to biodiversity, May 2009).

In India, current legislation actually prevents the spread of IAS. It is clear that a National policy on Invasive Species is required. The policy would have to cover the regulation of introduced species, measures to prevent their spread, their control and their eradication. This work should be carried out on a priority basis otherwise India cannot meet the Convention on Biological Diversity targets for 2010: 'Target 6.1.Pathways for major potential alien invasive species controlled' and 'Target 6.2. Management plans for major alien species that threaten ecosystem, habitats or species' (Rauf Ali 2008). Preventing the international movement of IAS and their rapid detection on borders are less costly than their control and eradication. Preventing the entry of IAS is carried out through inspection of international shipments, custom checks and quarantine regulations. Quarantine measures to be strictly monitored at sea ports, airports and country's entry/ border points for food items, seeds, plants, animals, wooden material, human beings, marine animals, fish, etc.,

Since 2005, under the Convention on Biological Diversity (CBD), governments have been working together to take more aggressive measures to prevent alien species from invading natural forests, preparing checklist of Invasive Alien Species (IAS) at the national level. Indian Council of Forestry Research and Education (ICFRE), Dehradun, has prepared a country report –Stock-taking of National Activities on Forest Invasive Species (FIS), which has been submitted by Union Ministry of Environment and Forests to Asia pacific Forest Invasive Species Network (APFISN). ICFRE has identified about 75 forest invasive species (an invasive species, typical of forest ecosystem is referred as Forest Invasive Species) in different parts of the country, which are a threat to the natural forest cover, besides there are 36 other Forest Invasive Species (FIS) which are localized in limited areas but have taken invasive proportions in other bio-geographical regions of the country. Many of the invasive species have got naturalized, in India. Few of them are being used for various purposes such as for medicinal use, furniture making and composting (Forest Invasive Species, ICFRE, Publication, 2005).

Materials and Methods

I. Major Floral Invasive Species in India

Lantana, an offensive weed, is dispersing fast in the hilly regions of the Western Himalayas. In hilly regions, it has expanded wildly from lower altitudes to higher areas, up to 1800 m and above. The plant has become a serious threat to agricultural land and especially to ground flora in the forest as it takes control of land immediately after invasion. Being

deep- rooted it is difficult to uproot it. Its enormous seed production and high survival rate helps in the promotion of the species. Burning and cutting of the plant further encourages its massive growth. It does not allow any other species to grow around, probably due to its dense canopy and allelopathic effects. Since it is unpalatable, wild animals do not graze on it. Various attempts to control the species have been launched including biological and mechanical means. But none of them were able to check the growth of the species (*www.hesco.in/weed.aspx*).

Eupatorium glandulosum was introduced as an ornamental plant in the Calcutta Botanical Garden in 1840. Since then it has spread throughout South-East Asia. Its capacity for regeneration and prolific seed production enables it to form dense tangled bushes which suppress native shrubs as well as the growth and yield of crops such as rubber, cardamom, coffee, tea and mango. Since the plant has no local or commercial use, it has widely spread in denuded and forestlands (Venkataraman, 2009).

Mikania micrantha, another prominent weed, is a perennial fast growing weed of the Neotropical origin, has become a major menace in natural forests, plantations and agricultural systems in northeast and southwest India. It is a herbaceous climber, grows 8 to 9 cm a day and muzzles small plants and chokes larger trees such as coconut, oil palm and invades young teak plantations. The survival of teak saplings is very much affected by the overgrowth of this weed (Venkataraman, 2009).

Prosopis juliflora was introduced in India during the last century and was thought to be a very promising species for afforestation of dry and degraded lands. But over the years, it has emerged as a noxious invader which can grow in diverse ecosystems. Its invasive menace has been reported in the states of Tamil Nadu, Andhra Pradesh, Gujarat, Rajasthan, Haryana, Karnataka and parts of Uttar Pradesh. Cattle, which feed on the pods, aid in its dispersal and spread.

CBD's 9th Conference of the Parties (COP-9 Bonn, May 2008) has conducted a global in- depth review of work to date on invasive alien species, reviewing the implementation of all COP decisions related to invasive species by governments, intergovernmental organizations and other relevant stakeholders.

Recognizing the magnitude of the problem and the opportunities afforded by COP-9, the CBD process needs to define a focused set of objectives and desired outcomes. These objectives should reinforce national implementation efforts, regional coordination and collaboration, and guidance on international policy priorities (*www.cbd.int/invasive/cop-decission.shtml*).

An attempt has been made in this paper to outlines priorities that COP-9 has emphasized as priority steps for future action and to update stakeholders regarding the decision taken in COP 9 on Forest Invasive Species and their impacts in different ecosystems at national levels and their management.

II. The COP-9 to CBD

The ninth meeting of the Conference of the Parties (COP 9) to CBD was held at

Bonn, Germany, from 19 to 30 May 2008. (UNEP/CBD/COP/9/INF/32.2008). The COP-9 has adopted 37 decisions on various issues such as protected areas, forest biodiversity, marine and coastal biodiversity, agriculture, inland biodiversity, invasive alien species, dry lands, biodiversity and climate change, etc., In the decision IX/4, in-depth review of ongoing works on alien species that threaten ecosystems, habitat or species are as follow:

A. Gaps and inconsistencies in international regulatory framework

Recalling its decision VIII/27, the COP-9 has reaffirmined the need to address the gap and inconsistencies identified by the Ad Hoc Technical Expert Group on Gaps and Inconsistencies in international regulatory framework in relation to IAS (UNEP/CBD/SBSTTA/11/INF/4). It encourages Parties to make use of the risk assessment guidance and other procedures and standards developed by the International Plant Protection Convention (IPPC), the World Organization for Animal Health (WOAH), and other relevant organizations to contribute in closing the identified gaps on IAS at national level, and to consider applying procedures and standards for quarantine pests to all IAS that have adverse impacts on plant biodiversity. The COP-9 invited IPPC to continue its efforts to expand the actual coverage of IAS and its impact on biodiversity, including aquatic environments.

The COP-9 encouraged Parties to raise the issue of the lack of international standards covering IAS, in particular animals that are not pests of plant under the IPPC, in WOAH, the FAO and World Trade Organization (WTO). It also encourages the Committee on fisheries of the FAO to consider the development of technical guidance by the Secretariat of FAO. It invited Parties to submit to the Executive Secretary the example of best practices for addressing the risks associated with the introduction of alien species as pets, aquarium and terrarium species, and as live bait and live food.

It has requested the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) to consider the establishment of an *ad hoc* technical expert group to suggest means, including practical guidance, for addressing the risks associated with the introduction of alien species as pets, aquarium and terrarium species.

B. Follow-up to the in-depth review of the programme of work

(I) National, regional and sub regional activities and capacity building

The COP-9 requested the Global Environment Facility (GEF), Parties, Governments and relevant organizations to support developing countries in implementing national strategies and programmes on IAS. It has welcomed the offer of New Zealand to host a technical workshop to address the experiences and lessons learned on regional coordination to IAS in islands, particularly the Pacific Invasive Initiative, can inform and, support the implementation of the Convention related to the prevention and management of IAS on island biodiversity.

The efforts of farmers and of indigenous and local communities in the management of IAS are acknowledged by COP-9. It has asked Parties to include such activities in implementation of national strategies and action plans on IAS. The COP has noticed with concern the increasing impacts of IAS along with increasing global trade, transport and travel, including tourism, climate change and land use change resulting in significant losses of biodiversity, and negatively impacting socio-economic conditions, human health and sustainability of indigenous and local communities. It emphasized the need for additional efforts and resources to address these growing threats. It also invited Parties to take into account and, as appropriate, build capacity to address, how climate change affects the risks associated with introduction, establishment, spread and impacts of IAS.

(ii) Exchange of Information on best practices and lessons learned and development of tools

The COP-9 further has requested Parties to compile the information of all types of organisms, taxonomic groups, pathways, and threats of IAS to all levels of biodiversity, and to make it available through clearing house mechanism. It also requested Parties to submit case studies, and lessons learnt and best practices for implementation of the guiding principles for legal framework, risk assessment, control, and eradication of IAS. Submission from Parties should focus *inter alia*, on examples of successful use of risk assessment procedures, health and environmental impacts of IAS, practical implementation of the precautionary approach, in accordance with principle 15 of Rio Declaration on Environment and Development, monitoring and surveillance programmes, restoration and rehabilitation of ecosystems degraded by the presence of IAS, including the socio-economic aspects.

COP-9 has further requested the Executive Secretary to develop practical tools, in collaboration with Global Invasive Species Programme (GISP) and other relevant organizations, to facilitate the implementation of the decisions of the COP on IAS and the development and implementation of national IAS strategies. These tools should be built upon case-studies, lessons learnt, and best practices submitted by the Parties.

(iii) Management, pathways and assessment

COP-9 has encouraged Parties and other Governments to consider and place mechanisms to manage pathways, for potential alien species, especially in inland water, marine and coastal ecosystems in harmony with the Convention and relevant international obligations. It has further invited Parties, and relevant research organizations to study the impact of other drivers, in particular, land use change, climate change adaptation and mitigation activities on introduction, establishment and spread of IAS, and their related socio-economic, health and environmental impacts.

(iv) Communication, Education and Public Awareness

COP-9 has invited Parties to strengthen national level communication and synergy across sectors to develop Issues Based

Modules on IAS, and support awareness raising programmes at all levels for decision-makers and practitioners in the fresh water, marine, and terrestrial environment sectors, in particular in agriculture, aquaculture, forestry, and in the horticulture trade and pet trade which are potential pathways of biological invasions through travel, tourism and trading.

It has requested the Executive Secretary to develop training materials in support of awareness generation, in collaboration with GISP and relevant organizations, and to encourage the organization of practical workshops to strengthen capacity for the implementation of Guiding Principles and other measures to address the threats from IAS.

COP-9 further asked Parties to ensure inter-operability of IAS data, their taxonomic information for national implementation, and to provide all relevant information to develop Invasive Species Compendium to all stakeholders at national and international levels through their network programmes.

3. Results and Discussion

II. Follow–up action taken by India on regulating introductions and managing Invasive Alien Species (Article 8(h))

Some of the measures undertaken for regulating of IAS species are given as follows:

- 173 alien plant species recorded in India till 2007.
- India follows international quarantine regulations.
- Directorate of Plant Protection, Quarantine and Storage, Faridabad, Ministry of Agriculture is the nodal agency to enforce the regulations; Latest regulations are 'Plant Quarantine Order 2003'.
- Environment Protection Act 1986 (Rules 1989) states' to protect or restrict substances having potential to cause damage to environment, plants and animals'.
- ICFRE has established a 'Forest Invasive Species (FIS) Cell' in the Forest Research Institute, Dehradun, to deal with various aspects of management of FIS in the country.

In India, a multi agency and multi programme approach, involving several Ministries and agencies, is being followed for regulating introduction and management of IAS. Major activities include regulation on the introduction of exotic living materials, their quarantine clearance and release for research and direct use. In general, Ministry of Agriculture (MoA) deals with cultivated plants, fish, and farm livestock, including poultry. It also has projects on eradication and management of invasive weedy plants, pathogens, pests, and harmful fishes. The Ministry of Environment and Forests (MoEF) deals with all forest materials and wild animals. It also supports and coordinates programmes on eradication/control measures/utilization of such species in different forest areas and conducts national survey on their spread, prepares reports on damage caused, and

undertakes restorative measures. There is, however, a need to develop a unified national system for regulation on introduction and management of all IAS, across the jurisdictions of all concerned Ministries and relevant sectors (India's Fourth National Report to CBD, June 2009).

According to the Eleventh Five Year Plan (2007-2012), Govt. of India, Planning Commission, New Delhi, report Rs 69.80 lakhs budget, has been allotted to the Ministry of Environment and Forests, for controlling weed and Invasive alien species, under following programmes(*http://planningcommission.nic.in/aboutus/committee/wrkgrp11/wg11research.doc*).

- ✯ Database creation at National and International levels and capacity building to facilitate research and management of forest invasive species.

- ✯ Development of regional strategies for control of forest invasive species through increased coordination and cooperation among the State Forest Departments and Regional Institutes of ICFRE.

- ✯ Promote exchange and share information on forest invasive species at National & International levels through Asia Pacific Forest Invasive Species Network (APFISN).

On the basis of information, it could be concluded that:

- ➢ There is a strong need for better environmental education and greater accountability for sectors that are responsible for the introduction of invasive species. The Government of India needs to officially designate the State Forest Departments and ICFRE Institutes as authorities for monitoring, control of FIS and implementation of import / export controls from forest, National Parks and other protected areas.

- ➢ A national inventory and assessment of invasive and potentially invasive species needs to be made to create a database and to determine the status of their threat to the country.

- ➢ Effective communication systems among the local institutions responsible for specific tasks relating to the management, monitoring and eradication of invasive species should be established.

- ➢ Awareness to masses on Invasive species through posters, charts and dissemination of information at public places such as Railway stations, Bus stands, Schools, Colleges, Libraries, Community Centres, Post Offices, Panchayat Buildings, etc., to minimize losses and invasion and spread of Invasive species, and for the conservation of existing biodiversity.

- ➢ There is need to augment the existing capacity for control and regulation of IAS, especially at entry points of the country (at airport and seaports).

- ➢ An Action Plan on how participating institutions can effectively

contribute to an "Invasive Species Monitoring Programme" should be developed.

- Local resources and sources of funding to enable participating institutions to effectively implement proposed invasive species activities should be identified.

- Local institutions should be aware of the botanical invasive species in the neighbouring countries and devise ways for early detection of their invasion and prepare eradication strategies.

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Role of Forests in Disaster Mitigation

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ABSTRACT

India, on account of its geographical position, climate and geological setting, is the worst-affected theatre of disaster in the South Asian region. Drought and floods, earthquakes and cyclones devastate the country with grim regularity, year after year. They are spiraling out of control, increasing in frequency, causing more and more injury, disability, disease and death, adding to the health, economic and social burdens of the nation. These disasters are caused by serious damage to mountain ecology, overuse of groundwater and changing patterns of cultivation. When forests are destroyed, rainwater runs off unimpeded, causing floods, and reducing the recharging of groundwater. The spate of landslides in the Himalayas in recent years can be directly traced to the rampant deforestation, and network of roads that have been indiscriminately laid in the name of development. It is by now a well-established fact that human-made structures, including canals, dams and embankments, have worsened the flood situation in the country.

Under the Indian Constitution, disaster management is the responsibility of the state governments. However, there is a National Crisis Management Group, headed by the Cabinet Secretary to assess the impact of major disasters. This Group consists of various nodal ministries. Many international organizations, voluntary agencies and national governments have been working towards reducing the impact of disasters and minimizing the loss of life and property on account of human-made and natural disasters.

As there are a number of the most vulnerable regions in India, preparedness and adaptation to disasters has emerged as a high priority agenda for the country. In this paper an attempt has been made to inform the role of forestry in mitigating disasters. Tropical countries are experiencing rapid forest degradation and loss leading to decline in biodiversity, soil erosion, ground water and availability of forest products. Afforestation and Reforestation (A&R) Projects provide multiple environmental and socio economic benefits, including protection and mitigation of ambit impacts of disasters, apart from carbon sequestration for global environmental benefit.

Key words: disasters, disaster management, deforestation, loss of biodiversity, mitigating disasters.

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Introduction

Forests play a vital role in regulating fresh water in the environment as well as impact of floods and droughts in tropical ecosystem. Changing climate has affected the Himalayas more because of its height and being a home for the vast expanse of glaciers that have the potential for flooding local settlements. Thousands of glaciers in the Himalaya Mountains are the source of water for nine major Asian rivers whose basins support 1.3 billion people. The unusual melting causes lakes to form at the base of glaciers, which may then break their banks and flood down the densely inhabited valleys (Nature New-A WWF, 2008). In the tussle between people and nature, it is the nature which has always emerged more powerful. Notwithstanding our efforts to predict disasters, one cannot stop their occurrence, but with advanced technology and skilled human resources, we can reduce and minimize the magnitude of destruction. For doing so, we need a viable and efficient disaster management policy. However, so far we have succeeded in managing disasters only with a partial success. Disasters in the country can be classified as:

1. Wind-related, i.e., storms, cyclones, hurricanes, blizzards etc.
2. Water-related, i.e., floods, excessive rains, cloud busts etc.
3. Geological, i.e., earthquakes, land-slides etc.
4. Climate-related, i.e., drought, famine, etc.

According to the XIth Planning Commission Report, all the States and Union Territories (UT'S) in our country are prone to one, or a combination of disaster situations. These extreme events either natural or anthropogenic, exceed the tolerable magnitude within or beyond certain time limits; make adjustments difficult, result in catastrophic losses of property, life and income, paralyzing the society.

A long list of earthquakes like in Latur in Maharashtra and Uttarkashi in Uttarakhand in 1993, Gujarat in 2001, have left at least 30,000 dead and millions homeless. The Super cyclone of Orissa in October 1999, in famous tsunami of 2004, regular massive floods in Bihar, Assam and other states, drought conditions in Rajasthan and in a few other regions caused immense loss of life and property across the country.

1. Causes of Disaster

i. Climate induced Disasters: Climate induced disasters can have devastating effects on the economy, cause huge human losses and can significantly set back developmental efforts of a region or the country. India, like any other developing nation has low adaptive capacities to withstand the adverse impacts of climate change, due to high dependence of a majority of the population on climate-dependent sectors like agriculture and forestry, on poor infrastructure facilities, coupled with weak institutional mechanisms and lack of financial resources. There are vast sectoral and regional disparities in India that affect the adaptive capacity of the country to climate change. For instance, irrigation coverage is above three-fourths of total cultivated area in Punjab, while in Orissa it is less than a quarter. Farmers in Orissa are more dependent on the monsoon than in others States, thus more vulnerable to climate change.

ii. Deforestation

After independence, the monolithic-driven developmental strategy has led to massive diversion of forest land for various non-forestry purposes. The rate of diversion of forest land was of the order of 1.5 lakh hectare per annum, during the period from 1950 to 1980 and caused serious national concern. Deforestation in many states like Andhra Pradesh, Bihar, Chhattisgarh, Gujarat, Madhya Pradesh, Orissa etc., (Press Information Bureau, Government of India, Ministry of Environment and Forests, March 2006) are responsible for man-made disasters for example, logging activities in the hilly areas destabilize slopes, cause landslides and increase mudflow and silting in the nearby rivers. The revenue generated by logging is far less than the losses incurred due to frequent problems of landslides, silting and ecological catastrophes. There should not only be a plan for afforestation and regeneration of the logged area, but for its stabilization also. Some of the hazard-prone areas should be identified and notified as "protected areas". The Forest Survey of India (FSI) publishes the State of Forest Report (SFR) on a biennial basis. As per the SFR-2003, the State-wise decrease of forest cover in comparison to SFR-2001 is given in Table -1.

Table-1: State-wise decrease in forest covers between from SFR 2001 and SFR 2003 (sq.km.)

S. No.	State/Union Territory	Forest Cover		Change in Forest Cover between 2001 and 2003
		SFR 2001	SFR 2003	
1.	Andhra Pradesh	44,637	44,419	-218
2.	Arunachal Pradesh	68,045	68,01	-26
3.	Bihar	5,720	5,558	-162
4.	Chhattisgarh	56,448	55,998	-450
5.	Gujarat	15,152	14,946	-206
6.	Haryana	1,754	1,517	-237
7.	Himachal Pradesh	14,360	14,353	-7
8.	Karnataka	36,991	36,449	-542
9.	Madhya Pradesh	77,265	76,429	-836
10.	Maharashtra	47,482	46,865	-617
11	Orissa	48,838	48,366	-472
12.	Punjab	2,432	1,580	- 852
13.	Rajasthan	16,367	15,826	-541

The decrease in forest cover, for the States mentioned in Table-1 is due to shifting cultivation, diversion of forest land, encroachments, felling etc. The decline of forest cover has taken place despite the following measures which are already opulence.

- Legal measures like Indian Forest Act, 1927, Wildlife (Protection) Act, 1972, Forest (Conservation) Act 1980 and Environment (Protection) Act, 1986 and the rules, guidelines thereof.

- Management measures like working of forests according to approved Working Plans, Forest Development Agencies and Joint Forest Management activities.

- Financial measures like providing assistance to the States/Union Territories under Centrally Sponsored schemes and externally aided projects.

- Other measures like creation of Protected Areas, Substitution of Wood, etc.

- Guidelines for rationalizing of felling and transit regulations for tree species grown on non-forest private lands to promote large scale afforestation in non-forest areas.

2. Case Study of North-East State

i. Historical Background of Disaster: The North-East is regularly struck by natural disasters in the form of floods and landslides. Landslides take destructive proportion due to incessant rains in the North-Eastern region. The increasing intensity of landslides is attributed basically to the deforestation. This has resulted in soil erosion and making the river basin shallow. According to Joshi, S.R. (*http://necouncil.nic.in/dimnec/dm1.htm*) Brahamaputra carries one of the highest sediment loads in the world, about 332 million metric tonnes annually throughout its course. Recent satellite photographs reveal that Brahamaputra is continuously shifting southwards and in some places, may be migrating at rates as high as 800 m/yr. The shifting of the river is distinctly evident in the districts of Dibrugarh, Morigaon and Sonitpur, where the river has already shifted 2 to 8 km., in the last ten years. Lateral migration of the channel is always associated with large scale bank erosion, aggradations and widening of the river channel. The most important factors for sedimentation or siltation in the river are high sediment supply in the catchment areas after the 1950 and subsequent earthquakes, which caused landslides and uprooted trees.

In the catchment area, landslides are common during the monsoon months and tonnes of debris silt up the river-bed downstream. Although, no hard data is available, the mean water velocity of the Brahamaputra appears to have decreased due to silt deposition. Because of the wanton destruction of forests in the catchment areas and the continuous deposition of silt in the already raised river-bed, the river frequently floods during the monsoon causing disasters in the plains of the North-East.

ii. Cause of Disaster: Large scale deforestation in upper catchments is perhaps the most important anthropogenic factor for cause of floods and land slides in the North-East. Large scale deforestation effected by man for various purposes

such as for expansion of agricultural lands, for supply of raw materials to the wood-based factories, for domestic uses as firewood, and timber for commercial purposes etc., has decreased the infiltration capacity of the forest land and consequently increased surface runoff which without any doubt, is increasing the magnitude of recurrent floods in the plains and land slides in the hilly terrains of the North-East India.

It may be pointed out that dense vegetation allows maximum infiltration of rain water into the ground, because rain drops are intercepted by forest canopy and thus reach the ground slowly in the form of aerial streamlets, through the leaves, branches and stems of trees and hence promotes infiltration into the spongy soil layer formed by the leaf litter. On the other hand, in the absence of forest and other vegetation covers, raindrops strike the ground surface directly and in case of heavy downpour the rainfall exceeds the limits of infiltration soon and thus maximum runoff is generated which reaches the rivers through rills, rivulets and streams and causes the floods. Considering the regular periodicity and gravity of such disasters like floods, land slides, cyclonic storms and earthquakes in the North-East, appropriate accelerated measures like protection, regeneration and improvement of forests need to be adopted and continually refined for management and mitigation of the consequences.

3. Case study Uttarakhand State

i. Historical Background of Disaster: The Uttarakhand region comprise of the Himalayan districts, in North India. During the late sixties, a massive programme to develop roads was undertaken in the region, to create employment opportunities for the local population. Also, many dams without proper seismic studies are being planned and constructed in the state which may lead to disaster, if appropriate counter-measures are not contemplated.

ii. Cause of Disaster: Tracts of forest land were thinned out because of tree felling. Contractors employed local people for these operations. In many cases, stretches of the slopes above the road side have been wiped clean of the trees. Clearing of the innumerable trees has heavily bruised the crust of the forest land, and caused increased run-off of rain water mixed with stones and pebbles.

In 1970, the valley of the Alaknanda, a river traversing the state, was the scene of an unprecedented flood. The entire village of Belakuchi was washed away by the swirling torrents of the Alaknanda, along with several bus loads of tourists. The flood affected an area spread over a length of 400 kilometres and washed away five major bridges, hundreds of heads of cattle and several million rupees worth of property **(**Jain S. Community based Disaster Management, FAO Report).

Even those in the plains were not spared. The area became heavily silted and boulder strewn. Major canal networks were clogged. It was evident to any local resident that once the forest cover disappeared, the economic hardships and the terror of man-eating tigers would be replaced by an even more awesome

terror of floods, landslides, and drying up of previously perennial streams.

The Alaknanda tragedy left a deep impression on the hill folk, and it soon followed by an appreciation of the role that forests play in their lives. They had also watched the slow replacement of broad-leaved forests by economically important species like the pine, and had slowly felt the deleterious effects of this shift on their cultivation and water supply.

iii. Mitigation Programmes: The reaction was spontaneous and simple. *Chipko* – hug the trees was chosen by the local community to save their trees from the saws of timber contractors (Kunwar S. S, 1982).

A major breakthrough for the *Chipko* movement came on March 26, 1974, when 27 women of Reni village in Chamoli district, under the leadership of Gaura Devi, an illiterate lady of 50, resorted to *Chipko* to save 2,451 trees of Reni forests (Mishra Anupam and Tripathi Satyendra, 1978).

The movement has come a long way since then. It gained much acclaim for being a totally community led initiative, without any involvement of outside agencies, not even NGOs. Tree felling has since been totally controlled, and afforestation drives have yielded some positive results in terms of regeneration of forests on the denuded slopes. *Van Panchayats* (forest governing councils) are an innovative institutional instrument that has been very successful in sowing local forests.

4. Case Study of Orissa State

i. Historical Background of Disaster: Orissa has been prone to both natural and human-made disasters, since long. Natural disasters like floods and droughts are regular features in the state, since 1965, but cyclones are less frequently observed. Since 1965, Orissa has experienced floods for 17 years, droughts for 19 years, and cyclone for seven years. Nayak (2002) lists 26 cyclones in the state between 1891 and 1997 (Orissagov.nic.in/p&c/humandevelopment/summary/chap07).

ii. Causes of Disaster: Today, 52% of the state's land suffers erosion due to deforestation. With mangrove forests being cleared, more and more areas have come under the effect of devastating cyclones. Rivers flood more areas due to siltation. Almost 490,000 ha of fertile lands are water logged, salinated and sand cast in coastal Orissa as a result of cyclones and floods.

Massive deforestation in West Orissa is not only destroying the livelihoods of the local people but also silting up river beds, causing floods in downstream coastal Orissa and also exploring these areas to the fury of cyclone. Studies show that forest cover in the state has declined to 4.72 million ha, from around 6.8 million ha, in 1960-61. Of the existing cover, only 2.73 million ha of forests has a density higher than 40%. Barren hills lead to heavy runoff of rainwater resulting in flash floods in the local area, and more floods in Orissa's low coastal areas. With little or no efforts to harvest rain, the state loses around 80% of its rainwater as runoff from

these barren lands, leading to water scarcity. This causes drought, even when rainfall has been only slightly deficient. According to Richard Mahapatra, 2006 (Info Change News and Features, March 2006) in the last few decades, due to erratic rainfall, Orissa has experienced frequent droughts. Similarly, in coastal areas, a slight rise in sea level makes the region extremely vulnerable to floods, as the protective mangrove forests have vanished. Satellite pictures of the 1999 cyclone show that mangrove forests helped reduce the impact of the super cyclone. Ersama, in Jagatsinghpur district of coastal Orissa, that has no mangroves, reported 8,000 deaths during the cyclone, as tidal waves ingressed 10 km into the land. The coastal district of Kendrapara, which had some mangroves left, suffered comparatively less damage. Since the 1960s, Orissa has lost 45% of its mangrove forests.

iii. Mitigation Programmres: The Ministry of Environment and Forests can plan more afforestation in the coastal areas prone to cyclones or sea erosion. It can set a target of about 25% plantations in the cyclone/landslide/erosion - prone areas. The Government seeks to sustain and augment the mangrove forests in the country by both regulatory and promotional measures. The Coastal Regulation Zone Notification (1991) under the Environmental Protection Act (1986) recognizes the mangrove areas as ecologically sensitive and categorizes them as CRZ-I (i) which implies that these areas should be afforded protection of the highest order. Under the promotional measures, as said before, the Government has identified 38 mangrove areas on a country-wide basis for intensive conservation and management. Only promotional measures will not do. States have to review and strengthen their extant legislative measures and ensure that pristine mangrove forests are not destroyed /diverted, for other developmental activities.

5. Case Study of Rajasthan and Gujarat:

i. Historical Background of Disaster: In Rajasthan and Gujarat, natural and anthropogenic factors are the driving forces fordesertification.

According to the United Nations Report, 1992, desertification causes not only the deterioration of the environment and the productivity of the fragile ecosystems, but also aggravates the poverty of people living in the regions. It was estimated that the annual direct economic losses due to desertification amount to more than $42 billion.

Pastures, which are the backbone of the desert economy, are shrinking both in area and productivity because of harsh climatic conditions, low and erratic rainfall and scarcity of soil water. The deterioration of grazing lands is also ascribed due to the large bovine population, free grazing practices and lack of management. Lack of proper planning and management are resulting in growth of many weeds,i.e., *Crotolaria burhia, Tephrosia purpurea* and low quality fodder grasses like *Dactyloctenium sindicum, Aristida* spp., which infested the lands heavily and reduced the carrying capacity of these lands. Changes in the crop pattern from subsistence farming to

commercial farming (Gupta, 1975) and expansion of agriculture caused displacement of graziers to non-command areas, thus exerting even more pressure on the already overgrazed countryside.

Ironically but flood disaster in this desert area, has caused land degradation due to floods and sand deposition at many places affecting vegetation diversity and productivity in the Bhadakha-Kawas area in Barmer (Singh, *et. al.,* 2007). In 1996, flashfloods intruded into the desert state of Rajasthan in western India. The floods killed about 100 people. But in subsequent months more than 1,000 lives were lost due to a malaria epidemic, as the flood-accumulated waters became an ideal breeding ground for mosquitoes. Amplified by a systemic failure, the epidemic took a heavy toll, far more than the flood itself, in a region, not known for water-borne diseases.

ii. Mitigation Programmes: Joint Forest Management (JFM) in Gujarat and Rajasthan with its plantation programme is successful where major proportion of villagers are solely or partly dependent on nearby common forest for their daily requirement of fuel wood and fodder. However, larger groups of people of different castes and origin make the programme implementation difficult, causing land degradation. Non-wood forest products (NWFPs) play key role in the success of JFM for various reasons. Literacy rate has positive effect on JFM, and, therefore, is controlling land degradation. However, higher income household groups showed less interest in cooperation and participation. Thus, lower income people were more interested in doing the activities related to JFM. Women's participation is the key factor for success of the JFM. Low female literacy is the root-cause of many evils prevailing in the rural population.

6. Role of Forests in Disaster Mitigation

India has implemented one of the largest afforestation programmes in the world. The programme was initiated during early 1980s under the social forestry programme. The gross annual rate of afforestation which was less than 1 million ha during 1980-85 increased to 1.7 million ha annually during the period 1985-1990. It is declining since 1991-1992, and during the period 1992-1997, the average afforestation rate was 1.4 million ha annually. The total area afforested since 1980 to 1997 was 18.4 million ha, at over 1 million ha annually. In India, over 90% of forestation is 'afforestation' under the social forestry programme on village commons, degraded revenue land, and farmland (Ravindranath and Hall, 1995). The wasteland area in India that could, therefore, be regenerated is in average of 66 to 130 million ha (Ravindranath *et. al.*, 2002**).** Beside mitigation of the disasters, the incremental climate change mitigation potential of the forestry sector, based on biomass-demand-based scenario, using short and long-term commercial forestry options, is estimated to be 122 MtC for the period 2000-2012 (Ravindranath *et.al.*, 2002). At the rate of 25 tC/ha, 4.8 million ha could be afforested. However, the technical potential of the forestry sector

is very large, and even if only 50% of 66 million ha of wastelands is brought under afforestation and reforestation activities, about 825 MtC could be sequestered in 12 years.

The estimates of investments required for wastelands afforestation at conservative afforestation costs revealed that the present level of investments in afforestation programmes in India is not adequate. On this front, and on economic grounds, India should endeavor to undertake compensatory plantation on behalf of the polluting companies and nations obliged to reduce the emission of GHGs by investing in carbon sinks, as proposed by the Kyoto Protocol on Climate Change. It is expected that the Clean Development Mechanism (CDM) under the Kyoto Protocol would accelerate investments in the establishment of new forest plantation (Balooni, 2003). In India, there is vast scope for implementing afforestation programmes in regions, which are not yet brought within the fold of tree plantation schemes and where there is acute shortage of fodder, fuelwood, timber and other forest produce. This is evident from the fact that Gujarat, Madhya Pradesh and Uttar Pradesh accounted for 34.45% of 13.5 million ha (m ha) afforestation undertaken during 1980-90, and 34.15% of 12.55 m ha afforestation undertaken during 1990-98 (ICFRE, Forestry Statistics India, 2000). On the other hand, there was no study characterizing the environmental conditions of North-Eastern region comprising seven states, which accounted for only 5.28% of 26.05 m ha afforestation undertaken in India during 1980-98. Moreover the forest area in arid region of India is less than 2%, resulting in severe scarcity of fuel wood (Pande, *et.al,* 1999). Gujarat has only 6.42% of its total geographical area under forest with per capita forest of 0.03 ha against national average of 0.075 ha (ICFRE, Forestry Statistics India, 2000).

India is in better position to take extensive afforestation projects, i.e., offsetting national carbon emissions voluntarily, and gaining by offsetting carbon emission of polluting companies and other countries for a price. Furthermore, forestry sector is vital to the Indian economy and need to be given special attention in terms of investments (Balooni, 2003).

Government of India is considering enacting legislation by brining the Compensatory Afforestation Fund Bill, 2008 in Parliament for the purpose of establishment of a Compensatory Afforestation Fund and for utilization of Funds for “Green India” and other afforestation activities nation-wide. The funds are intended to be utilized for a massive afforestation programme to increase tree cover through “Green India” initiative. The principles of environmental conservation would be better handled by this Fund. The accountability of the implementing authority will be increased. independent and concurrent monitoring of the activities is also intended to be enforced.

Needless to say forestry sector does not only offer an environmentally acceptable option for mitigating and

avoiding disasters, but also for meeting the forest products needs of local communities. It additionally has vast potential of mitigating climate change by way of sequestering atmospheric carbon.

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