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(With Compilation of Lectures on Science and Environment)

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Foreword

Orissa Environmental Society (OES) founded in 1982 has been actively engaged in promoting mass awareness for conservation of natural resources and environment. The Society's related activities include study, research, documentation, publication, education, lobbying, liaison, persuasion, mass mobilisation campaign, conference, seminar, workshop, colloquium, public meeting, issue based discussion and consultation, etc. As on today, it has more than 600 life members and institutional members who are motivated academics, technocrats, architects, planners, doctors, economists, development managers, bureaucrats, corporate houses, government and non-government institutions, and persons interested in biodiversity, natural resources and environment conservation.

Among many of the successful programmes of the Society are the activities for Anugul, Similipal and Mahendragiri. Based on a research study by OES on the problems of fluoride pollution due to industrial activities a project for fluoride-free water supply to 11 villages in Anugul district was implemented in 2000-2001 under Orissa Environment Programme (Indo-Norwegian Cooperation). The Central Pollution Control Board has identified Anugul as a hot-spot due to industrial pollution. OES launched an intensive campaign, to move Government of India and Government of Odisha, leading to creation of the eighth biosphere reserve of the country in the Similipal Forest of the Mayurbhanj District in 1994. For last several years sustained campaign by OES is towards protection and conservation of the epic fame Mahendragiri hill complex. Mahendragiri is studded with rare biodiversity and archaeological monuments. Efforts are made to impress upon appropriate authorities for recognition of this hill forest ecosystem as an Entity of Incomparable Value (EIV) and raise the status to a Biosphere Reserve and also to include in the list of Heritage Sites.

About seven years back, in 2009 the Society launched the programme of Monthly Seminar on 'Current Issues on Environment and Science'. Every month on the first Sunday the programme is organised. A subject expert on any current issue on environment and science is invited to deliver a talk followed by floor discussion. Sometimes the summary of the discussions on the topics of local importance and relevance along with the recommendations is communicated to appropriate authorities. Current issues like dispute of sharing inter-state river water, conservation and management of water, mismatch of figures from tiger census, elephant depredation, natural disasters, Paris Climate Summit, etc have been discussed on the floor. UN-declared themes like International Year of Soil, International Year of Pulses, etc and national themes on environment, natural resources, science and technology are also discussed. Such intellectual discussions of high academic order in lucid language, I am sure, helps to augur and augment future course of action at individual and collective level to serve the common interest of a resilient society. The programme is regularly conducted unfailingly.

It is a matter of pride that the valuable monthly seminar lectures are compiled and published in the Annual Report of the Society this year. I hope the Society will continue to do so in the coming years. The Annual Report published in shape a book will have the referral value for the scholars, students and persons interested in the subject.

Dr Sundara Narayana Patro
President, OES

From the Pen of Immediate Past President

Looking back to history one can realise that humankind used the natural environment to build civilisations. On the contrary paradoxically the modern scientific and technological advances, together with rapid industrial progress, have compromised with the quality of natural environment and embraced luxury intensive modern lifestyle. Today, the socio-economic activities have enormous implications for the global environment. Problems such as climate change, global warming, ozone depletion, deforestation, desertification, frequent natural calamities, extinction of species and loss of biological diversity, new kind of non-communicable diseases, over-dependence on fossil fuel energy to meet the requirement for excess energy consumption, threaten humanity's very prospects for survival.

The Earth is a complex system of subtle interrelationships among the air, water, soil, animals and plants. We have only Earth to live in, and we have moral obligation to leave it in liveable condition for future generations. Earth, our shared home, is a miraculous planet capable of supporting life, known to humanity so far. We must endeavour to establish a new society based on harmony with our natural environment. In this way, we can leave for future generations a more prosperous, just and safe world. As conscious and responsible citizens we must undertake environment-friendly local initiatives, superseding national boundaries and generational differences to view the future of the Earth from the perspective of the whole of humanity. In this regard the activities of Orissa Environmental Society are a small noble endeavour to address to the global issues through local solutions.

I had the opportunity to be the President of Orissa Environmental Society for a period of nine years (2006-2015). I am happy that during the tenure the programme of Monthly Seminar on 'Current Issues on Environment & Science' was introduced. In expressing appreciation for the presentations made by the invited experts, the Society hopes to raise awareness and stimulate interest among the people on the related issues, more particularly in Odisha State. The lectures of the invited experts recorded in this publication cover subjects ranging from scientific research on climate change and the interrelatedness of the atmosphere and the ocean to the preservation of ecological and biological diversity, sustainable agriculture and aquaculture, food production, etc. Furthermore, their messages point to the importance of sustainable development for meeting the needs of current and future generations.

Orissa Environmental Society believes wholeheartedly that, through the ingenuity and earnest efforts, the serious environmental problems that we now face will someday be solved.

I sincerely hope that this publication, containing valuable information, will be available to a wider audience as an aid to solve local environmental problems and the global problems as well.

Prof. Satyananda Acharya
Immediate Past President, OES

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Lectures and Speakers

International Year of Soils, 2015: An Introduction

(OES release, September 02, 2015)

The 68th General Assembly declared 2015 as the International Year of Soils (IYS).

The Food and Agriculture Organisation (FAO) of the United Nation's (UN) has been nominated to implement the IYS 2015, within the framework of the Global Soil Partnership and in collaboration with governments and the secretariate of the United Nations Convention to Combat Desertification. The Kingdom of Thailand was the key promoter of the IYS.

FAO's vision of sustainable food and agriculture is about a world in which nutritious food is accessible for all by managing the natural resources such that they maintain ecosystem functions to support current and future human needs.

The approach to socio-economically and environmentally sustainable food and agriculture is based on improving efficiency and conserving/ protecting/enhancing natural resources. This is in addition to, protecting rural livelihood, enhancing resilience to climate change and market volatility, and good governance, for healthy natural and happy human systems.

Healthy Living Soils have an important role in achieving this vision and approach to sustainable food and agriculture.

Hence, the IYS- 2015 aims to increase awareness and understanding of the importance of soils for food security and essential ecosystem functions for generations.

The specific objectives of the IYS 2015 are to:

- Raise full awareness among civil society and decision makers about the profound importance of soil for human life;

- Educate the public about the crucial role soil plays in food security, climate change adaptation and mitigation, essential ecosystem services, poverty alleviation and sustainable development;
- Support effective policies and actions for the sustainable management and protection of soil resources;
- Promote investment in sustainable soil management activities to develop and maintain healthy soils for different land users and population groups;
- Strengthen initiatives in connection with the Sustainable Development Goals (SDG) process and Post-2015 millennium agenda;
- Advocate for rapid capacity enhancement for soil information collection and monitoring at all levels (global, regional and national).

Being significant reservoirs of water and carbon and its sequestration, soils are the important foundation of Climate- Smart Agriculture (CSA) to increase food security, build resilience and adaptation to climate change, and reduction of greenhouse gas emissions compared to expected trends.

The six key messages identified for dissemination in the international year of soils are:

- Healthy soils are basis for healthy food production.
- Soils are the foundation for vegetation which is cultivated or managed for feed, fibre, fuel and medicinal products.
- Soils support our planet's biodiversity and they host a quarter of the total.
- Soils help to combat and adapt to climate change by playing a key role in the carbon cycle.
- Soils store and filter water, improving our resilience to floods and droughts.
- Soil is a non-renewable resources; its preservation is essential for food security and our sustainable future.

Soil Health:
Present Scenario and Future Vision in Odisha

(Date of presentation: 06.09.2015)

K. K. Rout

Soil Health

Soil is a precious natural resource that forms the base on which our entire life system survives. It plays important role in ecosystem functioning. The quality of life on this earth depends on the quality of this precious natural resource base, soil quality and soil health; both denote soil's capacity to function within ecosystem boundaries to sustain not only the biological productivity but to maintain environmental quality and promote plant and animal health. As compared to soil quality, soil health portrays the soil more as a living and dynamic organism. Both soil health and soil quality are however, synonymously used. Soils world wide are being subjected to increasing degrees of stress coming from over exploitation of land, indiscriminate use of agricultural inputs, industrial effluents and climate change.

The 68th UN General Assembly declared 2015, the International Year of Soils (IYS-2015) that aims at increasing awareness and understanding of the importance of soil for food security and essential ecosystem functions.

Land Degradation in Odisha

In Odisha increasing pressure on land resources caused by the rapidly increasing population, urbanization and industrialization is accelerating the process of land degradation. Deforestation of different types including shifting cultivation, inappropriate land use, improper crop management, lack of conservation practices, spread of canal irrigation, surface mining and increase in vehicular traffic are some important anthropogenic factors affecting soil health and causing land degradation. Similarly climatic factors, natural disasters

like cyclone and drought are also responsible for land degradation in Odisha. Soil degradation is recognized as a serious and widespread problem.

Broadly there are two major categories of land degradation: displacement of soil material by water and wind erosion of soil and soil deterioration *in situ* which can be physical, chemical and biological degradation processes. The displacement of soil material by water can have several negative consequences. The removal of part of the usually fertile top soil reduces its productive capacity where as in extreme cases the rooting depth will be restricted. The run off water may also lead to gullies eating away valuable soils and making the terrain unsuitable for farming. Water erosion is common in Odisha. There may be physical, chemical and biological degradation of soil *in situ.* There are four types of chemical degradation processes such as loss of nutrients and/or organic matter, salination, acidification and pollution. All chemical degradation processes are of a great threat to soil health which is manifested in the form of problem soils, infertile soils and polluted soils.

In Odisha there are many inherent soil related crop production constraints and some are developing over years due to improper agricultural management practices and other reasons like urbanization, and industrialization etc. Some of the important soil related production constraints encountered in Odisha situation are soil acidity, salinity, water-logging , poor soil structure, poor water retention, poor infiltration, multi-nutrient deficiency, poor biological activity, accumulation of heavy metals etc . For successful crop production these problems need to be managed in the state.

Soil Health Management

Some of the research, development and policy strategies suggested to control land degradation and to restore and maintain soil health on long term basis are:

1. Effective soil and water conservation measures, suitable land capability based crop and cropping system, conservation or reduced tillage, surface residue management, efficient water management, reclamation of problem soils, reduction in nutrient

removal –use gap and balanced fertilization

2. Promotion of management practices which enhance carbon sequestration, soil organic matter and biological activity.
3. Rehabilitation of wastelands and mine spoils and
4. Mass awareness about the importance of land care and soil maintenance.

As health of a nation's soil directly affects national security, sustaining soil quality or health is the most effective method for ensuring sufficient food to support life. So it's suggested that the responsibility of all people within a state or nation is to safe guard the integrity of the soil resource.

Dr K. K. Rout

Professor (Soil Science), OUAT, Bhubaneswar

Dr Kumbha Karna Rout was born in 1962 in village Siaria of Dhenkanal district. After school and college education in Dhenkanal, Rourkela and OUAT, Bhubaneswar he joined as an Lecturer in Soil Science in OUAT in 1987. Dr Rout joined Indian Agricultural Research Institute, New Delhi for PhD programme in Soil Science in 1995. From 1999 Dr Rout served as Associate Professor and from 2007 Professor of OUAT. Dr Rout holds first class first through out his career and received many awards and Fellowship. He received the prestigious Dr S. P. Ray Choudhury Gold Medal during 1999 for the best PhD work. Dr Rout has over 25 PhD students. He handled 10 Research Projects as Principal Investigator, and has published two books, 4 book Chapters and more than 30 research articles and many popular articles. Dr Rout is also known as a very good extension worker. He is a life member of many Professional Societies, and worked as counselor for Indian Society of Soil Science and Indian Society of Water Management. Dr Rout is a member of many technical and diagnostic Teams of University and Govt. of Odisha and is associated with the activities of Public Service Commissions and Boards of ICAR.

Combating Desertification

(Date of presentation: 01.11.2015)

Sailabala Padhi

Climate is an active factor in the physical environment of all living things. Its influence on human welfare range from the immediate effects of weather events to complex responses associated with climate change. The impact of climate change results in the occurrence of floods, droughts, cyclones, heat waves or other disasters resulting crop failures, property damages, famines or deaths**.** Activities resulting in global climate are expected to trigger droughts with a substantial impact on agriculture. Human activity such as over farming, excessive irrigation, deforestation and erosion adversely impact the ability of the land to capture and hold water.

Drought and Water Shortages-

Threat and Economic Problems

Land is a vital resource for producing food, preserving biodiversity, facilitating the natural management of water systems and acting as a carbon store. Degradation of soils and land due to soil erosion and other degradation processes is a severe problem in many regions in India. Under natural conditions excessive moisture is far less an agricultural problem than is drought. Drought is the deficit that results when soil moisture is insufficient to meet the demands of potential evapo-transpiration.

Three classes of drought may be differentiated. These are: (1.) Permanent drought associated with arid climates, (2.) Seasonal drought, which occurs in climates with distinct annual periods of dry weather and (3.) drought due to precipitation variability. In each

case, the underlying cause of drought is insufficient rainfall, although any factor that increases water-need tends to aid in causing drought. Low relative humidity, wind and high temperatures are contributory factors because they lead to increased evapo-transpiration. Soils which lose their moisture rapidly by evaporation and drainage also augment drought. Drought does not begin with the onset of a dry spell. It occurs when plants get inadequate supply of moisture from the soil. Thus crops growing on soils which have a high capacity for holding water are less susceptible to short period of dry weather.

Prolonged drought alters the pattern of agricultural land-use on a major scale. In the past, such alterations have caused migration of people from drought affected areas. Several years of abnormal dry weather are usually accompanied by above-average temperatures that accentuate the droughty conditions. Since drought is a condition where the water need is in excess of available moisture, the prevention of damage to growing crops due to drought is a matter of (1.) decreasing the water need of crops, or (2.) increasing the water supply or (3.) possibly a combination of the two. Planting of crops that have low water demands helps reduce the water need.

Cultivation practices which improve the soil structure and inhibit runoff are effective, but limited drought-preventive methods are to be adopted. Weed control is especially important if the available water is to be used most effectively for crops since weeds accelerate water loss by transpiration at the expense of soil moisture. Whenever the water need of crops cannot be reduced to confirm to the moisture supply, the only available options are to abandon agriculture or to provide water artificially. The artificial stimulation of rainfall has rather narrow limitations for supplementing precipitations. On the other hand, irrigation is a common method for providing all or part of the water need of crops.

In arid regions agriculture is possible only with irrigation. In semiarid and sub- humid climate irrigation makes possible large yields and a greater variety of crops. It also lengthens the period during which

land can be used productively and makes yields more consistent from year to year. In humid regions, its main value is supplementary in times of drought or to meet the special demands of certain crops, for example rice. The chief limitations on irrigation are the availability of water from surface or ground water sources and the cost of getting it to the fields. Within these limits, irrigation has the advantage that it can be regulated as an element in the water budget to meet the variable demands of different crops and different seasons of chance for drought.

Land degradation reduces the productivity of land particularly in dry lands. It can leave the soil exposed and make it vulnerable to climatic hazards such as drought. During 2016, drought has affected 10 states and more people are affected by drought. Deficit monsoons create situation for drought conditions. Drought and food security are artificially linked. Drought-prone districts account for 42 % of the country's cultivable land. With 68% of India's net sown areas dependent on rain, the rain-fed agriculture plays a key role in the country's economy. A long term strategy to make India drought free is one the biggest challenges of the 2016 crisis.

Sustainable land management (SLM) is a comprehensive approach, with the potential of making very significant and lasting differences in the near future and over the long term. In order to increase production from the land efficient use of water can be achieved by reducing high water loss due to runoff, harvesting water, improving infiltration and maintaining water storage. Strategic choice of crop varieties which are resistant to drought, salinity and other constraints hold further opportunities. MGNREGA has been effective in mitigating drought. This was evident in 2001, when poor and marginal farmers in chronic drought-prone areas successively managed the drought condition.

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Dr (Smt.) Sailabala Padhi is the first woman Botanist of Odisha to have a DSc degree, and is presently the Director at Centre for Environmental Studies under Forest and Environment Department, Odisha. She was born on 07 June 1950 and completed her education for BSc, MSc, MPhil, PhD and DSc from Berhampur University. For 38 years from 1972 onwards she taught students of Botany at BSc Honours and Post-Graduation. Dr Padhi is a member of Board of Studies in Universities at Mizoram, Varanasi and Delhi. She visited universities and laboratories in Massachusetts, North California, Buffalo and Harvard in the USA and Dhaka in Bangladesh. She was a member of Committee under Gopalswamy Commission of Govt. of Orissa (Odisha) for conservation of Chilika Lake. Dr Padhi successfully cultivated the Red Seaweed *Kappaphycus alvarezii* (Doty) Doty ex. P.Silva in Odisha at Gokhurkuda and Purnabondho villages on the coast of Ganjam District and promoted these for development of the fisher women community. The seaweed has a high potential to be a key ingredient in animal feeds based on its nutritional content and commercial value. Dr Padhi is the member of a number of professional bodies within and outside Odisha.

Human-Environment Relationship: Its Synergy in Ganga Basin - a Coincidence or Consequence

(Date of presentation: 01.12.2016)

K. C. Sahu

Abstract

Traditionally Man affects environment in a variety of ways but very little information is available on environmental changes affecting Man. Environment not only affects human behavior but also has serious impacts on cluster of human beings that is known as society. Ecological abuse or ecocide is known to end up with collapse of many ancient civilizations and culture.

Human – Environment relationship is best understood in an Earth-People system, ideally represented by a fresh water ecosystem like that of a river basin, wherein many ancient civilizations evolved, flourished or even collapsed due to ecological abuse. The Ganga, Yamuna and their tributaries, the lifelines of the gangetic basin, are polluted beyond recuperation and their waters appropriated upstream through dams, irrigational diversion and industrial use. The pristine environment of the basin has undergone complete transformation through intensive agricultural activities, industrialization and urbanization, worsened by population explosion and their gubernatorial habits.

The Indo-gangetic plain boasts for a reputed ancient civilization and culture but presently pervaded by a group of "Failed States", best described as BIMARU States, where kleptocracy reigns over democracy in the entire region. This observed synergicity of environment and human culture in the Gangetic basin in a period of about 5000 years, from Vedic to present time, is a mere coincidence or consequence, is the bone of contention in the present paper.

Human – Environment Relationship

Man made changes in environment began when the hunter-gatherer man settled down for farming, fishing and family raising. The anthropocentric changes of earth's environment became significant and alarming after the Industrial Revolution and now man has become a significant agent of global changes, equivalent or at times larger than the natural processes. GHG emission, generation of erosional fluxes from mining, civil engineering constructions and mechanical agriculture, diversion of river courses and creation of lakes and reservoirs, transformation of landscapes, mobilization of "civilizational" heavy metals, nitrogen fixation in soil, deforestation and defaunation, urbanization and industrialization are some of the glaring changes, for which science, technology and global engineering practices have come as convenient tools. Vitousek et al (1997) quoted by Sachs (2008) estimates human domination, alteration and appropriation of several major components of Earths' system as, Land transformation, including photosynthesis: 50%, Atmospheric CO2 concentration: 25%, Water use: 60%, Nitrogen fixation: 60%, Plant invasion: 20%, Bird extinction: 25% and Marine fisheries: 67%. Scientific literature is flooded with data and information on environmental changes and the impact is even quantified by the famous "Eye-Pat" equation of Commoner (1972):

I = PAT, where

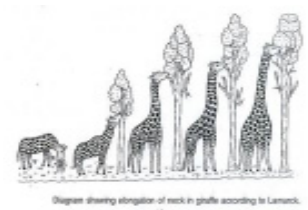
I = Impact, P = Population, A = Affluence, T = Level of Technology.

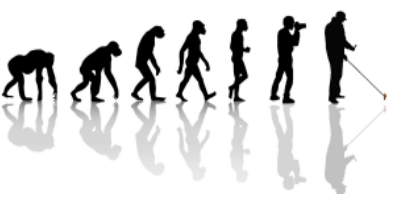
A more plausible equation of estimation of Impact on environment ought to be: Im = PACT, where, Im = Impact, P = Population, A = Affluence, C = Conscielence (Inverse of Resilience), T = Level of Technology.

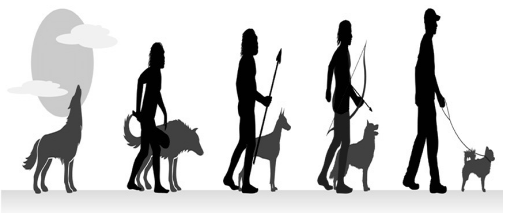
Commercialization of the impact is found in the routine EIA and EMP mantras, practiced in various developmental projects that involve drastic changes in local and regional environment.

Man Changes Environment

Environment Changes all Creatures (Including Man)







While human effect on environment has been a common theme of studies, little information is available on effects of environmental change on living creatures, particularly on humans. History of evolution unequivocally demonstrates major morphological changes in living creatures, including their extinction, with changing

environment, albeit through geological time. Development of lungs in amphibian in place of gills in fish to enable the creature to venture from aquatic to terrestrial environment, evolution of extra-ordinary long neck in giraffe to reach receding foliage for food (Lamarckian theory), the lizards taking up wings and the arising of *Homo erectus* from the quadruped hominids to use fore-legs for gathering food, for holding baby, for using tools, even for fighting, are some of the glaring instances that needs and environmental changes apparently effected morphological development of living creatures. Change in environment, even in a relatively shorter period affecting behavior of animals is found in domestication of animals, particularly by transformation of wolf to dog. Intense exposure to sun light or lack of it has strong effect on skin color of man and even pollution is known to result in various metabolic diseases and genetic disorders. Evolutionary change proposed by Charles Darwin was focused onto human beings by his cousin Francis Galton (1872) with the statement that "nature is all that a man brings with himself into the world, nurture is every influence that affects him after his birth". Environmental change effecting cluster of human society leading to collapse of several ancient civilizations are on record in human history. To mention a few, these include the Neolithic Chinese civilization along Yangtze and Yellow rivers, the Indus valley civilization of 3300-1300 BC, the Egyptian civilization of 3152-332 BC, the Mesopotamians of 3100-549 BC, the Mayas of Central America (1400 BC -800 AD), the great statue builders of Easter Island and the Angkor of Cambodia.

Collapse of some ancient civilizations due to abuse of ecosystem services

Our life is identified by what is around us and what is happening in time and space – this was the rule of Nature from primate to *Homo erectus* until we considered ourselves as "double wise" and started controlling Nature, modified environment and bend the ecosystem services to suit our comfort and convenience. This ability to control Nature and environment enabled man to survive in most regions of the earth, pole to equator and in fresh to polluted environment and now poised to extend our settlement into ocean floor, but has resulted in unforeseen feed-backs, the impact of which being slowly realized in the modern stressful society through various signals of failure. We are now in search of a "sustainable development" and knocking at the doors of different planets.

The science behind biological determinism is that "our genes are fixed but their expression is highly dependent on what our environment throws onto us". The basic assumption is that, at birth, the human mind is a blank slate – "Tabula Rosa", and this gradually gets filled up as a result of experiences that are "nurtured" through environment. "Give me a dozen children….and I can produce any specialist as I want"- the famous controversial statement by the behavioral psychologist John Watson in 1930, triggered the debate of "Nature versus Nurture" in relative contribution of genetic inheritance and environmental influence in development of human behavior. Biology can determine the ability, but when it comes to man, what one does with the ability is decided by Free Will.

It is true that nature is all that a man brings with him into the world; nurture is every influence that affects him after his birth (Francis Galton, 1874). The physical features can be identified as identical to the parents but not necessarily the talents. The environment where one grows up may have a lasting effect and influence on the way one talks, behaves and responds to the things around him. Abstract attributes like, personality, intelligence, social orientation, likes and dislikes are not gene coded in DNA. The nurture theory holds that environment factors are the real origin of human behavior. Children living along highways, where the ambient air is loaded with lead aerosol from automobile exhaust, are known to have lower IQ compared to those living away from the road. Deprived upbringing increases the risk of deviant behavior in adulthood. Environment stress leaves mark in the body, shorten telomeres and alter

epigenetic brain processing, crucial during brain development – 3rd trimester of pregnancy to end of adolescence. Modern life with more people and more gadgets certainly seems more stressful than the life in the past (Frank Vereeckon, 2012).

Traditionally physical environment effects human thought, feeling and behavior. Conflict and struggle among people at a trickling municipal water tap or supply tanker, dispute among States for river water share, even war among adjacent nations are signs of water stress environment at different scales. The first victim of overcrowding (for example, in local trains of Mumbai) is mutual respect to each other and that is what population explosion does. High consumption can put strain in environmental resources and can have serious effect on society, because "consumption exacerbate inequality and accelerates poverty-inequality and environmental nexus" (Oskamp et al, 1998), generates waste residues that are centers of pollution and heralds transmigration of pollution across States. Ecological issues of people's relationship to their environment, has assumed crucial importance to our quality of life, sustainability of development including maintenance of peace among communities (Oskamp & Schulz, 1998).

Water stress environment

Stress from overcrowding

Recent research lays more emphasis on human activities on environment, whereby historical changes in society consequent to environmental changes have little attention. "Historical study of human society pursued as scientifically as the study of dinosaurs' extinction will profit to our own society today by teaching us what shaped the modern world and what might shape our future"(Jared Diamond, 1997).

Human society responds to environmental signals through multiple pathways including collapse or failure, migration or creative inventions through discoveries. Extreme draught has triggered social collapse or ingenious management through irrigation, such as in Israel. Between 14th and 18th century, Western Europe responded to environment crisis by innovations, intensification and adaptation and avoided collapse. Resilience and readoption depends upon identified option, improved understanding, cultural solidarity and fresh ideas (Karl Buitzer, 2012). Society on the edge becomes brittle, lose resilience including ability to adopt social values, make them more susceptible to the impact of potential perturbation of several kinds including climate change, political corruption, war and terrorism.

The disturbing fact in the history is that the primary cause of collapse of many civilizations has been the destruction of the environmental resources which they depend upon. Deforestation and habitat destruction, soil problems like erosion, salinization and fertility loss, water mismanagement, over hunting and fishing, introduction of invasive species, overpopulation, climatic change, building up of toxins in the environment, energy shortage, limits of photosynthesis capacity of land, are considered to be some of the factors that lead to collapse of a State (Diamond, 1997). The Indus valley civilization, the great statue builders of Easter Island, The Mayas of Central America, the Pharos and Mesopotamian civilizations, the Fertile Crescent of Middle East and Angkor in Cambodia are all considered to be due to unrealized and self inflicted ecological damage. Today it is known as Ecocide, a suicide of society.

HUMAN–ENVIRONMENT RELATION

(Earth-people System) In a River Basin

The ideal method to understand effects of environmental changes on living kingdom, particularly on humans, is by a system approach, where earth and people make a close knit system. The Earth – People System can be focused onto a visible scale of space and time in a river basin or watershed (Riverine system), where actually human civilization started, flourished or failed in course of historical time.

Land and water are ecologically linked in a natural system called catchment, drainage basin, watershed or river basin. The basin also

includes habitats such as plants and animals, including Man, which live in it, and all other things which have been added to it, such as roads and rails, buildings, dams, factories and farm lands. Everything we do affects the water basin and vice versa. "The truth is , we live downstream of someone and upstream of someone else". That is, we are all connected through the water basin ecologically, economically and socially. The river basin is a web of life, a virtually living body, the streams, channels and rivers are like arteries and veins coursing with life and are crucial to sustain it (WWF).

Soil is a basic watershed resource, but when polluted by chemical fertilizers, pesticides and industrial pollutants, gets degraded in course of time, affecting the very habitats it sustained in its natural state. Plant cover operates in the basin in a major way – intercepts rain cloud, increases precipitation, harvests solar energy, provides food to the food-chain, control temperature, prevents evaporation and dust formation, fallen twigs and leaves supply back nutrients, absorbs carbon and supplies oxygen. Removing the native greens from the catchment (deforestation) is disastrous to the whole life system (ecological death) especially to humans.

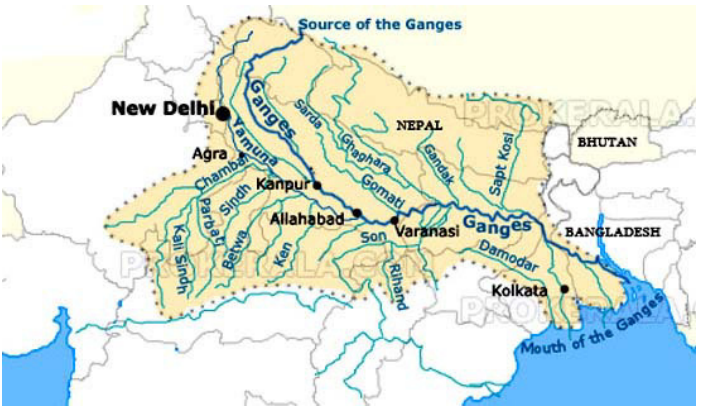
River basins are characterized by processes resulting from complex climatic, biotic and land use interactions. Climatic change results in change in temperature and in the elements of hydrologic cycle such as precipitation, evapotranspiration, runoff, ground-water storage etc (Gleick, 1987). Changes in hydrologic characters lead to changes in food production, environment, health and hygienic conditions as well as, in long terms, on culture and civilization.

Degradation of the watershed or watershed-elements is loss of ecosystem services. Loss of ecosystem services is catastrophic to human evolution. Historically loss of ecosystem services has led to collapse of many societies. Typical of the societies collapsed for ecological abuse, otherwise known as ecocide , have been mentioned earlier.

Ganga Putras, The Principal Habitat of Ganga Basin

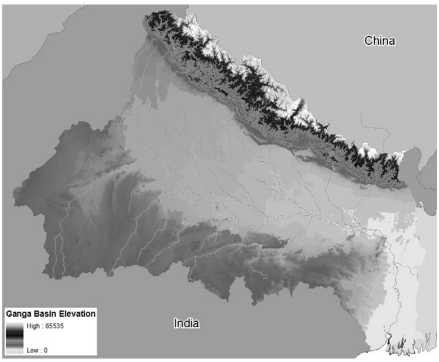
If abuse of ecosystem has led to historical collapse of many ancient civilizations, and Indus valley finding at our doorstep is not an exception, the complete transformation of the gangetic basin through intense agricultural practices, industrialization and

urbanization, pollution of the fresh water ecosystem including the principal rivers Ganga and Yamuna and depletion of the water-table by 100 to 150 meters, need to be critically examined for the future fate of the present human habitat of the gangetic basin.

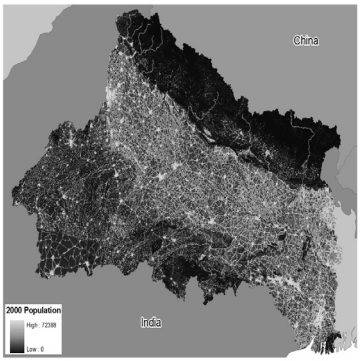


Ganga basin, a potential fresh water ecosystem facing extreme abuse

Arising in Himalayas and emptying into Bay of Bengal, Ganga flows a distance of 2500 km and drains an area of one million sq. km., one fourth of Indian territory.



The "Green" Ganga basin



The urbanized Ganga basin

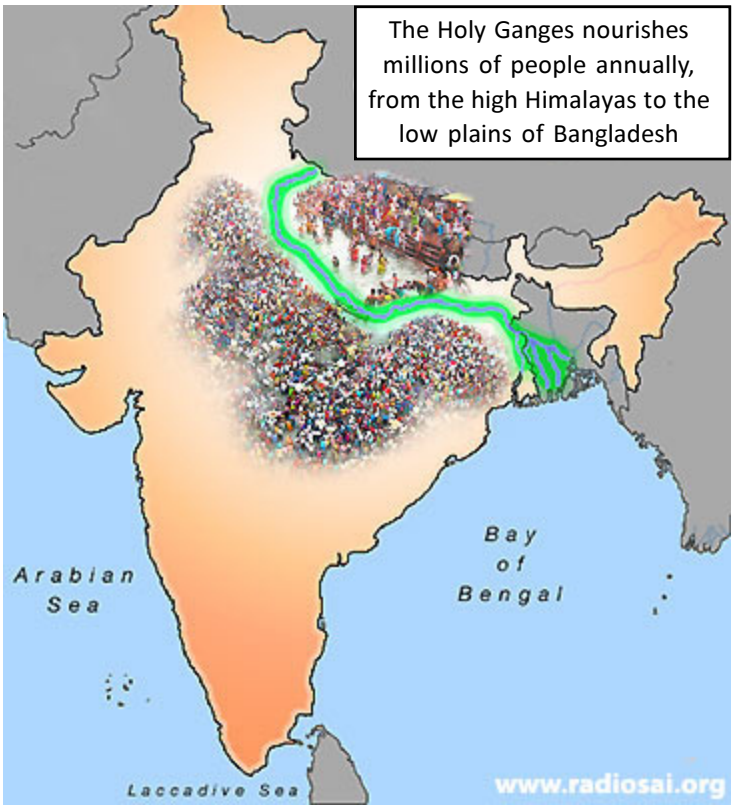
The Ganga basin supports 500 millions people and has been a cradle of successive civilization from Mourya empire of Asoka in the 3rd. century BC to Mogul empire founded in the 16th. Century AD. The pre-historic Vedic/Upanishadic period in the gangetic basin dates back to 5 to 10 thousand years and forms the substratum of the Indian culture.

The fertile alluvial mantel of the plain, besides supporting an agricultural society had once a dense forest with large animals like elephants, bison, rhino, tigers and lions, most of whom have disappeared and the entire basin is intensely cultivated or urbanized. The river, once a rich source of fish and life line for survival of the ancient Kaivartas, the tribal river folks who worshiped the river as Adimata (the primordial God) and treated themselves as progeny of Ganga (sons of Ganga or Gangaya). The Mahabharata famed Satyavaty is virtual Ganga Devi, born as a mortal woman in the world, in a Kaivarta hamlet in Ganges valley. The Aryan king Shantanu met the fisher women while on a hunting spree and married her. The offspring – the Ganga Putra, otherwise known as Devabrata or Bhisma in later days, represent the most exemplanary character of human values in ancient Indian culture. The essence of all that stated above is that, Mahabharata gives a human form to Ganga in the veil of Shantanu's wife and mother of Bhisma – the noble Ganga putra of yore. In short, Ganga is the virtual mother of India's ancient culture and civilization, and it is no exaggeration that "the story of Ganga from her source to sea, from the old time to now, is the story of India's civilization and culture", and as Jawaharlal Nehru says "The Ganges have been to me a symbol of memory of the past of India, running into the present and flowing into the great ocean of the future".

The Indian system of belief is based on an intimate relationship of life with Nature. An offshoot of this is reverence accorded to the river Ganga as a gesture of acknowledgement of her life-supporting ability for a primarily agricultural society. In an ancient society that depends on seasonal monsoon for its agricultural needs, the perennial nature of Ganga was a God send. Ganga also dumped rich alluvial soil, a veritable boon for agriculture along its course and made up the fertile alluvial gangetc plain.

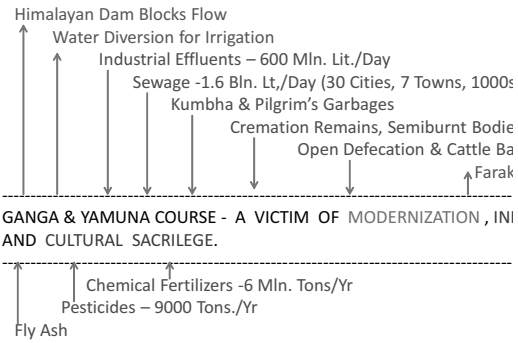
The Indian subcontinent, specially the gangetic valley, having a glorious start of Vedic civilization has undergone waves after waves of changes in terms of invasion, influence and insurgence – first with conquest and plunder, than through colonial rule and lastly the tide of industrial revolution in the last two centuries.

The post-independent scenario, where Kleptocracy reign over democracy, has devastated the society and the transitory success of industrialization and modernization has been carried onto irreversible

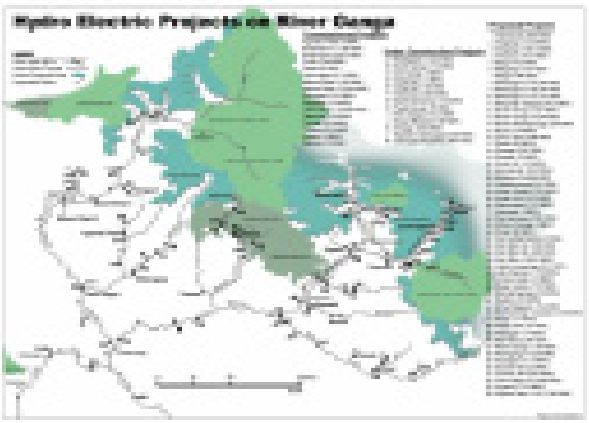


ecological collapse. Scores of major industries discharge effluents upstream, rendering once the pure water, polluted with harmful ingredients, dams appropriate the waters on highland, throttling the flow downstream, diversion of water for irrigation robs of the precious water from the downstream people, plants and aquatic life, even the famous Ganga dolphin Susu has lost vision and has become blind because of turbidity and pollutant in the river. The barrage at Farakka prevents migration of Hilsa upstream. 1.6 billion liters of sewage from 30 cities, 7 towns and thousands of villages along the course of Ganga, and 260 million liters of industrial effluents containing heavy metals like mercury and hexavalent chromium reach the river every day. Several million tons of fly ash, otherwise known as “Bhasmasur” from Badarapur, Indraprastha and Rajghat power plants in Delhi, enter the Yamuna water. Six million tons of chemical fertilizers and 9000 tons pesticides go into the land annually for agricultural use. Only 40 % of the fertilizer applicated is taken up

by plants and the rest ends up in the water. Fertilizer and herbicide residue poisons the agricultural runoff when it returns to the river again or contaminate the ground water and soil of the region. While the population increase and their consumption residues have added to the human discharges into the river, the ancient culture of river worshipping makes millions of folks flock into pilgrimage towns along the river round the year. Discharges of the ceremonial rites including that during festival times like Kumbha Mela, and cremation remains of semi-burned bodies degrade the river beyond imagination. The modern day Ganga and Yamuna courses have become victims of modernization, industrialization and cultural sacrileges.



The Present Fate Of Ganga And Yamuna Course

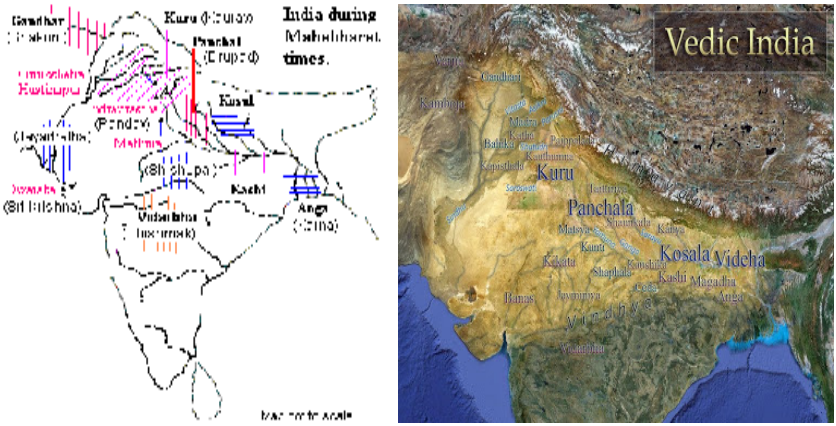


Appropriation of Ganga water by Dams in eco-fragile and seismic zones in Himalaya

State of Pollution of Ganga (pictures taken from Google)

"Ganga Tu Baheti Kyun ?", sings Vupen Hazarika

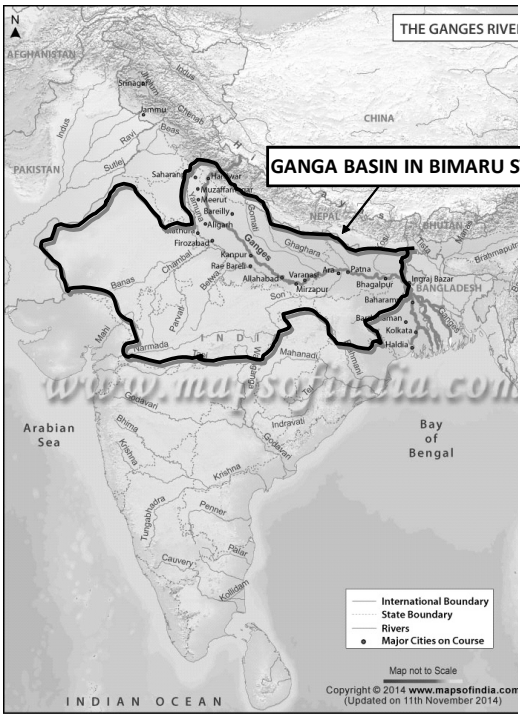
The Indian history depicts through epics, mythology, archeological and historical records, a high quality of ancient civilization in the gangetic basin. The philosophical thoughts of Tirthankar and Gautama Buddha, the Vedic and Upanishadic descriptions, the principles of Ramaraya and the deliberations in the battle field of Kurukshetra (recorded in Gita) and the series of institutional sites like Hastinapur, Taxila, Nalanda, Pataliputra etc. that appear in the historical map of India, stand support to the existence of an extremely high quality of human civilization in the gangetic basin. "Ancient India had an amazing wealth of science that had its beginning around 3000 BC. It had specialized among others in cosmology, mathematics, astronomy, aerodynamics, medicine, surgery, agriculture, yoga – the science of body and mind, besides language, grammar and communication. The scientific knowledge was used only for the service of mankind and preservation of the Nature and no scientific research that is inimical to Man and his environment was encouraged or allowed. The demolition of the great culture of India by foreign invasion have left the country in shamble by the mid-twentieth century". (T.Ramakrishna of ESWARA, -personal communication).



Ancient civilization in northern India

Human civilization, born and developed in the Indo-gangetic basin for several thousands of years – the relationship was benign and symbiotic. But things changed during the last couple of centuries when population growth, industrialization, economic development, Green Revolution led to unprecedental transformation of the fresh water ecosystem and consequent biodiversity loss.

The gangetic basin spread over an area of one million sq. km. coincidently includes the BIMARU States of Bihar including Jharkhand, M.P., Rajasthan and the erstwhile U.P. (Ashish Bose,1980). Going by the specific aspects of governance and growth, such as law & order, primary health and population control, primary education, literacy, agriculture, consumer market, investment scenario, budget and prosperity, the BIMARU States and their offshoots occupy conspicuously lower position compared to any other Indian States. Delhi and Haryana in the West, lying in the Yamuna basin and W.Bengal lying in the east, downstream of Ganga basin, though not included in the BIMARU criteria of Ashish Bose (1980) because of industrial development and education respectively, excel in law and order problem as compared to other Indian regions. Political unrest and corruption, failure in governance, mass exploitation through religion, cast and creed, land, sand and mining mafia, industrial unrest and violence have rapidly increased in all the States that make up the gangetic basin. These States have been rendered virtually ineffective



and unlike other Indian States in the South, not able to enforce their laws uniformly or provide basic goods and services to the citizens because of high crime rates, extreme political corruption, impenetrable and inefficient bureaucracy, judicial ineffectiveness, mafia influence in politics and cultural situations in which traditional leaders wield more power than State over most areas of governance. Consumerism – Poverty – Inequality – Environment nexus has pinnacled social and ethical violence. Extreme poverty in some of the tribal but resources rich regions has exhausted governing institutions, depleted resources, weakened sober leadership, crushed hopes – fueling a volatile mine of depression and instability. Poor fragile State can explode into violence or implode into collapse …..as livelihoods are crushed, investment flies, people migrate to other States and ungoverned territories become a spawning ground of threats like terrorism, trafficking, environmental degradation and disease (after Lael Brainard, et al, 2007). In short kleptocracy has replaced the hard earned independence and democracy in the entire gangetic basin.


Education in Ganga basin – Yesterday and Today (Mass copying).


Transportations Yesterday *Transportations Today*

This remarkable observation that a river basin which once held a supreme habitat of ancient civilization, nurtured and sustained by an aviral Ganga, transformed into a group of "Failed State" and through which flows the same river in a bewildered state of pollution. This synergicity of human – environment relationship is a coincidence or consequence, needs serious scrutiny by experts from various specialties to prevent collapse of Indian culture and civilization in the gangetic basin. A pertinent question is, "if Bhagirath brought the Ganga from the mountain to quench the thirst of 60 thousand people in the plains", how long the river will survive when the Himalayan glaciers are first disappearing due to global warming, human appropriation of its water upstream throttles the downstream course and pollution has far exceeded natural recuperation. The contribution of post-independent developmental approach has so far been negative because the governing model has been exploitive. When all the elements of the fresh water ecosystem in Ganga watershed has changed – soil salinitised, water polluted, climate changed, population exploding, fertile lands urbanized, aquatic life thinned out species decimated and forest denuded, can humans be left behind? An unhealthy parenthood, deficient upbringing and degraded environment cannot but give rise to a deficient progeny.

No wonder, the modern "Ganga Putras" of Ganga basin, instead of surviving on the nectar of the mother, seems to have started milking her violating the very system, which has sustained them for generations.

With the violation of Ganga the basic structure of Indian civilization stands endangered in the very basin where it flourished. Besides questioning "For whom the Ganga flows ?" or searching for the "Brhama Dravya", the enigmatic substance that once kept the Ganges water pure, the viable solution will be in a course correction in our ecological relation with the sacred river .

Acknowledgement

This paper was prepared after listening to Swamy Tejomayananda Ji, International Head of Chimayo Mission in his concluding remark in a seminar on Save Ganga program held in Mumbai in Oct.2013, wherein he emphasized to look for various "signals" in the society consequent to pollution of the sacred river. The paper heavily borrows from Internet (including the pictures from Google), Wikipedia and writings of authors mentioned in the Reference.

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Dr K. C. Sahu was born in Odisha on 4th Oct.1934 and completed graduation in Geology & Geophysics from IIT-Kharagpur in 1957. After doing MTech in Applied Geology from IIT-Kharagpur in 1960 Dr Sahu completed Mineral Research for his PhD from University of Sheffield, UK. in 1963. Professor Sahu specializes in Geology/Earth Science, Environmental Geology and worked on heavy metal pollution arising out of urbanization, industrialization, mining, and fly ash disposals from coal based thermal power plants. For seven years Prof. Sahu held the position of Geologist in Orissa Mining Corporation, Bhubaneswar, and for three years he was Scientist in Regional Research Laboratory (CSIR), Bhubaneswar. During his tenure of 30 years in IIT Professor Sahu held positions of Asst. Professor, Associate Prof., Professor and Chairman, Earth Science Dept. For two years he was Vice President, New India Mining Corpn., Mumbai. Prof. Sahu is a Life Fellow/Member of several learned societies and has published some 150 papers, supervised 16 PhDs and undertook several national and international projects. As a retired Professor he is pursuing his interests in environmental activities. The Society of Geo-Scientists and Applied Technologist (SGAT), Bhubaneswar bestowed him Lifetime Achievement Award in Dec. 2015.

Pollution Prevention Day

(Date of Presentation: 01.12.2015)

S. N. Patro

Introduction

Bhopal Gas Tragedy, considered as the world's worst industrial accident, occurred on the night of December 2, 1984 at the Union Carbide India Limited (UCIL) pesticide plant near Bhopal city in Madhya Pradesh, India. It was due to the leakage of harmful Methyle Isocyanate (MIC) gas. The toxic gas made its way in and around the shanty town and villages located near the plant. Over 5,00,000 people were exposed to the MIC and other chemicals. Estimates vary on the death toll. The Government of Madhya Pradesh confirmed a total of 3,787 deaths related to the gas release. Other sources estimated, 8,000 died within two weeks and another 8,000 or more subsequently. A government affidavit in 2006 stated the leak caused 5,58,125 injuries including 38,478 temporary partial injuries and approximately 3,900 severely and permanently disabling injuries[1].

The UCIL was the Indian subsidiary of Union Carbide Corporation (UCC), West Virginia, USA. In 1994, the Supreme Court of India allowed UCC to sell its 50.9 percent interest in UCIL to Eveready Industries India Limited (EIIL), which subsequently merged with McLeod Russel (India) Ltd. Eveready Industries India Limited, ended clean-up on the site in 1998, and turned over control of the site to the Government of Madhya Pradesh. Dow Chemical Company purchased UCC in 2001, seventeen years after the disaster. The local site is yet to be free from contamination; and the victims continue to suffer from ailing health and have not received the compensation as due to them.

The Tragic Incident

The UCIL factory was built in 1969 to produce the pesticide Sevin (UCC's brand name for carbaryl) using MIC as an intermediate. About

ten years after its establishment, the MIC production plant was added in 1979, while it was being imported earlier. The chemical process employed in the Bhopal plant had methylamine reacting with phosgene to form MIC, which was then reacted with 1-napthaol to form the final product, carbaryl (Sevin).

During the night of 2 December 1984, water entered Tank E610 containing 42 tons of MIC. A runaway reaction started, which was accelerated by contaminants, high temperatures and other factors. The reaction was sped up by the presence of iron from corroding non-stainless steel pipelines. The resulting exothermic reaction increased the temperature inside the tank to over 200° C (392° F) and raised the pressure. This forced the emergency venting of pressure from the MIC holding tank, releasing a large volume of toxic gases. About 30 metric tons of MIC gas escaped from the tank into the atmosphere in 45 to 60 minutes. The gases were blown in southeastern direction over Bhopal. Apart from MIC, the gas cloud may have contained phosgene, hydrogen cyanide, carbon monoxide, hydrogen chloride, oxides of nitrogen, mono-methyl amine and carbon dioxide, either produced in the storage tank or in the atmosphere. The gas cloud was composed mainly of materials denser than the surrounding air, stayed close to the ground and spread outwards through the surrounding community. The chemical reactions would have produced a liquid or solid aerosol with high density. The concentrations at ground level would have been much higher than earlier published. The initial investigation was

conducted entirely by the Council of Scientific and Industrial Research (CSIR) and the Central Bureau of Investigation.

Factors leading to the magnitude of the gas leak mainly included problems such as storing MIC in large tanks and filling beyond recommended levels, poor maintenance, and failure of several safety systems. The situation was worsened by the mushrooming of slums in the vicinity of the plant, non-existent catastrophe plans, and shortcomings in health care and socio-economic rehabilitation. Other factors identified by the inquiry included use of a more dangerous pesticide manufacturing method, large-scale MIC storage, plant location close to a densely populated area, undersized safety devices, and the dependence on manual operations. Plant management deficiencies were also identified – lack of skilled operators, reduction of safety management, insufficient maintenance, and inadequate emergency action plans.

Poor Maintenance and Monitoring

The MIC tank alarms had not been working for four years before the incidence took place and there was only one manual back-up system compared to a four-stage system used in the United States. The flare tower and several vent gas scrubbers had been out of service for five months before the disaster. Only one gas scrubber was operating; it could not treat such a large amount of MIC with sodium hydroxide (caustic soda), which would have brought the concentration down to a safe level. The flare tower could only handle a quarter of the gas that leaked in 1984, and moreover it was out of order at the time of the incident. The refrigeration system was kept idle in order to reduce energy costs. The MIC was kept at 20^0 C instead of 4.5^0 C as recommended in the manual. Even the steam boiler, intended to clean the pipes, was non-operational for unknown reasons. Slip-blind plates that would have prevented water from pipes being cleaned from leaking into the MIC tanks were not installed and their installation had been omitted from the cleaning check-list. The water pressure was too weak to spray the escaping gases from the stack. They could not spray high enough to reduce the concentration of escaping gas. In addition to it, carbon steel valves were used at the factory, even though they were known to corrode when exposed to acid.

According to the operators, the MIC tank pressure gauge had been malfunctioning for roughly a week. Other tanks were used, rather than repairing the gauge. The build-up in temperature and pressure was believed to have affected the magnitude of the gas release. UCC admitted in their own investigation report that most of the safety systems were not functioning on the night of 3 December 1984. No disaster management action plans had been established to cope with incidents of this magnitude. The employees, local authorities, and the resident public were not made aware of the dangers of chemicals used in the pesticide plant. In November 1984, most of the safety systems were not functioning and many valves and lines were in poor condition. In addition to this, several vent gas scrubbers had been out of service as well as the steam boiler, intended to clean the pipes was non-operational. At the time of incidence, workers were cleaning out a clogged pipe with water about 400 feet from the tank. They claimed that they were not told to isolate the tank with a pipe slip-blind plate. The operators assumed that owing to bad maintenance and leaking valves, it was possible for the water to leak into the tank.

Much speculation arose in the aftermath. The closing of the plant to outsiders (including UCC) by the Government of India and the failure to make data public contributed to the confusion. Whether hydrogen cyanide (HCN) was present in the gas mixture is still a controversy. Cyanide concentrations of 300 ppm can lead to immediate collapse. The non-toxic antidote sodium thiosulfate ($Na_2S_2O_3$) in intravenous injections increases the rate of conversion from cyanide to non-toxic thiocyanate. Initial reports based on the autopsies of victims' bodies suggested cyanide poisoning based on which UCC's Dr Bipan Avashia advised amyl nitrate and sodium thiosulphate. Treatment was tentatively used on some people, with mixed results. Exposed to high temperatures, MIC breaks down to hydrogen cyanide (HCN). According to Kulling and Lorin, at +200 °C, 3% of the gas is HCN. However, according to another scientific publication, MIC when heated in the gas-phase starts to break down to hydrogen cyanide (HCN) and other products above 400 °C. Chemically, HCN is known to be very reactive with MIC. HCN is also known to react with hydrochloric acid, ammonia, and methylamine (also produced in tank 610 during the vigorous reaction with water and chloroform) and

also with itself under acidic conditions to form trimers of HCN called triazenes. However, laboratory replication studies by CSIR and UCC scientists failed to detect any HCN or HCN-derived side products. None of the HCN-derived side products were detected in the tank residue. Reversible reaction of glutathione with MIC probably allows the latter to be transported into the body.

Theories differ as to how the water entered the tank. The workers maintain that entry of water through the plant's piping system during the washing of lines was possible because a slip-blind was not used, the downstream bleeder lines were partially clogged, many valves were leaking, and the tank was not pressurized. The water, which was not draining properly through the bleeder valves, may have built up in the pipe, rising high enough to pour back down through another series of lines in the MIC storage tank. Once water had accumulated to a height of 6 metres (20 feet), it could drain by gravity flow back into the system. Alternatively, the water may have been routed through another standby "jumper line" that had only recently been connected to the system. Indian scientists suspected that additional water might have been introduced as a "back-flow" from the defectively designed vent-gas scrubber. However, none of these postulated routes of entry could be duplicated when tested by the Central Bureau of Investigators (CBI) and UCIL engineers.

Impact on the Environment and Health

The initial effects of exposure were coughing, vomiting, severe eye irritation and a feeling of suffocation. The acute symptoms were burning in the respiratory tract and eyes, blepharospasm, breathlessness, stomach pains and nausea. People awakened by these symptoms fled away from the plant. Those who ran inhaled more than those who had a vehicle to ride. Owing to their height, children and other people of shorter stature inhaled higher concentrations. Many people were trampled trying to escape. Thousands of people had succumbed by the morning hours. The causes of deaths were choking, reflexogenic circulatory collapse and pulmonary oedema. Findings during autopsies revealed changes not only in the lungs but also cerebral oedema, necrosis of the kidneys, degeneration of the liver and necrotizing enteritis. There were mass funerals and mass cremations. Bodies were dumped into the

Narmada River, less than 100 km from Bhopal. The still-birth rate increased by up to 300%, and neonatal mortality rate by around 200%. 1,70,000 people were treated at hospitals and temporary dispensaries. No one under the age of 18 was registered at the time of the accident. About 2,00,000 children (below 15 years age) and 3,000 pregnant women were exposed to the gases, it was estimated. The official immediate death toll was 2,259, and in 1991, 3,928 deaths had been officially certified. About 2,000 buffalo, goats, and other animals were buried. Within a few days, leaves on trees wilted, became yellow and fell off making the area barren of vegetation. Supplies, including food, became scarce owing to suppliers' safety fears. Fishing was prohibited causing further supply shortages.

On 16 December, tanks 611 and 619 were emptied of the remaining MIC. This led to a second mass evacuation from Bhopal. Formal statements were issued that air, water, vegetation and foodstuffs were safe within the city. At the same time, people were informed that poultry was unaffected, but were warned not to consume fish.

In the immediate aftermath of the disaster, the health care system became overloaded. Within weeks, the State Government established a number of hospitals, clinics and mobile units in the gas-affected area to treat the victims. Since the leak, large number of private clinics were opened in Bhopal. In the severely affected areas, nearly 70 percent were under-qualified doctors. Medical staff was unprepared for the thousands of casualties. Doctors and hospitals were not aware about proper treatment methods for MIC gas inhalation and they were directed to give cough medicine and eye drops to the patients. The Government of India had focused primarily on increasing the hospital-based services for gas victims thus hospitals had been built after the disaster. When UCC wanted to sell its shares in UCIL, it was directed by the Supreme Court to finance a 500-bed hospital for the medical care of the survivors. Thus, Bhopal Memorial Hospital and Research Centre (BMHRC) was inaugurated in 1998 and was obliged to give free care for survivors for eight years. BMHRC was a 350-bedded super speciality hospital where heart surgery and hemodialysis were done. However, there was dearth of gynaecology, obstetrics and paediatrics. Eight mini-units (outreach health centres) were started and free health care for

gas victims were to be offered till 2006. The Company also donated $5 million to the Indian Red Cross after the disaster.

The waste left behind at the Union Carbide factory is continuing to poison people around the plant, reported the Centre for Science and Environment (CSE)[3]. Latest tests show that groundwater in areas even three km from the factory contains almost 40 times more pesticides than Indian standards, according to CSE. The report stated that the focus of the government was to just dispose off the stored waste and ignore the site contamination problem is, therefore, not going to solve the environmental problems, caused due to the gas leak. Further, the report mentioned that the chemicals present in the soil of the factory lead to leaching into the ground water leading to slow poisoning of residents. The health impact of this slow poisoning was enormous. The chlorinated benzene compounds can affect and damage the liver and blood cells.

In order to provide safe drinking water to the population around the UCIL factory, Government of Madhya Pradesh presented a scheme for improvement of water supply. In December 2008, the Madhya Pradesh High Court decided that the toxic waste should be incinerated at Ankleshwar in Gujarat, which was met by protests from activists all over India. On 8 June 2012, the Centre for incineration of toxic Bhopal waste agreed to pay Rs.250 million (US$3.74 million) to dispose of UCIL chemical plants waste in Germany. On 9 August 2012, Supreme court directed the Union and Madhya Pradesh Governments to take immediate steps for disposal of toxic waste lying around and inside the factory within six-month. A drinking water sample from a well near the site had levels of contamination 500 times higher than the maximum limits recommended by the World Health Organization. In 2009, the Centre for Science and Environment (CSE), a Delhi based pollution monitoring lab, released test results showing pesticide groundwater contamination up to three kilometres from the factory. Also in 2009, the BBC took a water sample from a frequently used hand pump, located just north of the plant. The sample, tested in UK, was found to contain 1000 times the World Health Organization's recommended maximum amount of carbon tetrachloride, a carcinogenic toxin. In October 2011, the Institute of Environmental Management and Assessment published an article

and video by two British environmental scientists, showing the current state of the plant, landfill and solar evaporation ponds and calling for renewed international efforts to provide the necessary skills to clean up the site and contaminated groundwater.

Addressing Social Issues

The world's worst industrial disaster killed thousands in Bhopal, is yet to extradite the main accused Warren Anderson[2]. Government of India in December 2010 moved the Supreme Court seeking Rs. 7,700 crore compensation [4] . The apex court had fixed the amount of compensation in February 1989 at Rs250 crore ($470 million). Initially a suit was filed in the Bhopal district court for a compensation of $3.3 billion. However, the District Court directed payment of Rs350 crore. On appeal by Union Carbide, the High Court reduced it to Rs250 crore. With regard to criminal liability, a trial court on June 7,2010 had handed down a mild sentence under Section 304A of the Indian Penal Code to the then officers of Union Carbide, the Government recalled in its petition. It submitted that the matter concerns a large number of victims of gas tragedy and that Union Carbide was liable to pay the damages.

Immediate relieves were decided two days after the tragedy. Relief measures commenced in 1985, when food was distributed for a short period along with ration cards. Madhya Pradesh Government's finance department allocated Rs.874 million (US$14 million) for victim relief in July 1985. Widow pension of Rs.200 (US$3.20)/per month (later Rs.750 (US$12)) were provided. The government also decided to pay Rs.1500 (US$24) to families with monthly income Rs.500 (US$8.00) or less. As a result of the interim relief, more children were able to attend school, more money was spent on treatment and food, and housing also eventually improved. From 1990 interim relief of Rs.200 (US$3.20) was paid to everyone in the family who was born before the disaster. The final compensation, including interim relief for personal injury, was for the majority Rs.25,000 (US$400). For death claim, the average sum paid out was Rs.62,000 (US$990). Each claimant was to be categorized by a doctor. In court, the claimants were expected to prove "beyond reasonable doubt" that death or injury in each case was attributable to exposure. In 1992, 44 percent of the claimants still had to be medically examined.

By the end of October 2003, according to the Bhopal Gas Tragedy Relief and Rehabilitation Department, compensation had been awarded to 5,54,895 people for injuries received and 15,310 survivors of those killed. The average amount to families of the dead was $2,200. In 2007, 1,029,517 cases were registered and decided. Number of awarded cases were 5,74,304 and number of rejected cases 4,55,213. Total compensation awarded was Rs.15,464.7 million (US$250 million). On 24 June 2010, the Union Cabinet of the Government of India approved a Rs.12,650 million (US$200 million) aid package which would be funded by Indian taxpayers through the government.

Madhya Pradesh Government has sought a compensation of Rs.10 lakh each from the Centre's Group of Ministers (GOM) to the kin of 15,342 deceased in the Bhopal gas tragedy as per the revised death figures in the ICMR report[5]. A decision in this regard was taken in the quarterly review meeting of the Gas Relief and Rehabilitation Department by State Chief Minister. The state government has been backing the demands of gas-affected people and is also making efforts for their rights. Further, it was stated that a new action plan worth Rs.272.75 crore has been sanctioned by the Union Government. During the next three years, Rs.33.55crore for medical rehabilitation, Rs. 104 crore for economic rehabilitation, Rs.85.20 crore for social rehabilitation and Rs.50 crore will be made available for potable water arrangements in the gas-affected areas. Besides, Rs 94.69 crore has been spent as per the action plan so far. It was disclosed in the said meeting that compensation worth Rs.10 lakh each will be provided to the kin of 5,295 deceased persons.

Legal Measures

UCC chairman, CEO Warren Anderson was arrested and released on bail by the Madhya Pradesh Police in Bhopal on 7 December 1984[1]. On 14 December 1984 Anderson addressed the US Congress, stressing the company's "commitment to safety" and promising to ensure that a similar incident "cannot happen again". The Indian Government passed the Bhopal Gas Leak Act in March 1985, allowing the Government of India to act as the legal representative for victims of the disaster, whether or not in India, leading to the beginning of legal proceedings. In 1985, Henry Waxman, a California Democrat,

called for a US government inquiry into the Bhopal disaster, which resulted in US legislation regarding the accidental release of toxic chemicals in the United States. Complaints of lack of information or misinformation were widespread. An Indian Government spokesman said, "Carbide is more interested in getting information from us than in helping our relief work". The civil and criminal cases are pending in the District Court of Bhopal, India, involving Warren Anderson, who was the Chief Executive Officer (CEO) of UCC at the time of the disaster. In June 2010, seven ex-employees, including the former UCIL chairman, were convicted in Bhopal of causing death by negligence and sentenced to two years imprisonment and a fine of about $2,000 each, the maximum punishment allowed by Indian law. An eighth former employee was also convicted, but died before the judgment was passed.

Conclusion

The industrial revolution, no doubt has given us more comfort and luxury, but is remains always associated with the environmental pollution problems that degrades the quality of life. After the Bhopal Gas Tragedy many more industrial tragedies, big or small, are occurring all over the country. We had some piecemeal regulatory legislation like Water (Prevention & Control of Pollution) Act, Air (Prevention & Control of Pollution) Act and such other at the time of Bhopal Gas Tragedy. It was in 1986 the first comprehensive Environment (Protection) Act was enacted, and a lot of measures are initiated now at Centre and State to deal with environmental polluted issues. But unfortunately the activities related to mining and industries continue to pollute the environment and cause human causalities, much to the displeasure of the local communities. A case in point is the recent mishap in Bhusan Steel Plant in Dhenkanal District of Odisha that occurred on November 13, 2013. It claimed three lives and left 30 workers injured, while 974 workers were working at the blast furnace-2 of plant when a blast took place. The Odisha State Pollution Control Board (OSPCB) has filed a case against the Company for violation of the Water (Prevention and Control of Pollution) Act 1974, and the Air (Prevention and Control of Pollution) Act 1981, since the company only had the consent to establish, and there was no consent to operate. On 21st November 2013 the District

Collector shut down the cold rolling mill, the 256-MW power plant, and an extension project of blast furnace at Meramundali after it was found that those were functioning illegally[6]. The power plant was set up without approval of the Board. It was observed that there was lack of safety measures in the plant and laxity on the part of the State Government, and there was no monitoring mechanism as per the Factories Act 1948 and the Industrial Employment (Standard Orders) Act 1946.

The National Pollution Control Day is celebrated every year on 2nd of December in India in memory of the thousands of human beings who had lost their lives because of the Bhopal Gas Calamity. It was identified as the biggest industrial pollution disaster of the history worldwide which needed serious preventive measures. Most of the problems can be reduced and prevented with a comprehensive pollution prevention programme with committed efforts. The common man, the legislative, the judiciary, and the executive machinery must act prudently to address to the problems of environmental pollution. The Constitution of India guarantees the citizen's the right to live peacefully, and also expects the citizens to fulfill their obligations to the nation. December 2nd is observed as Pollution Prevention Day every year in our country with a view to arousing mass awareness. The day is also observed elsewhere, other than India.

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Dr Sundara Narayana Patro

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Dr Sundara Narayana Patro was born on 27 August 1944 in his native village Nuapada in Ganjam District and had his education to be a Botanist with PhD on ecological aspects of shifting cultivation. During his 35years of education service in Government of Odisha Dr Patro taught Botany to students up to MPhil in a number of colleges across entire Odisha. Dr Patro's research ranged through natural habitat, biodiversity conservation, ethno-botany and industrial pollution impacts. Dr Patro dedicated his life for the cause of conservation and management of nature and environment through his profession as well as association with a number of organizations at the state, nation and international level championing causes of science, environment, culture and issues of the civil society. For five years he was the Coordinator of Indo-Norwegian programme on Environment in Odisha. He initiated the foundation of Orissa Environmental Society in October 1982 and has been sensitizing people on science and environmental issues and influencing government policies by way of interactions. The OES launched an intensive campaign for creation of Similipal Biosphere reserve and has launched sustained campaign towards giving status of a biosphere to Mahendragiri hill complex on the Eastern Ghats. The Bhubaneswar Chapter of Indian Science Congress Association was founded by him in 1996. The Government of Odisha honoured Dr Patro in 2009 with the state level Biju Patnaik Award for Wildlife Conservation. The 'House of Nature, Environment and Society Trust' (HONEST) founded with award money received by Dr Patro from different sources is also promoting awareness on a number of issues related to environment, human population, development projects, community participation and sustainable future.

Climate Change and the Paris Deal

(Date of presentation: 03.01.2016)

Madhab Chandra Dash

Scientific study confirms that global warming is real . Global warming can be defined as the average temperature increase of world's atmosphere causing climate change. The impact of climate change with an increase of one degree centigrade in world's temperature than the preindustrial period is now felt all over the world, especially in India, S-E Asia and east coast of USA.

Looking at the occurrence of heavy rain, flood, and drought and weather disturbances and irregularity of monsoon occurrence in the coastal states of India, the acceptance of the effect climate change appears to be confirmed. Climate flip-flop is now very common in the world. During the last few hundred years of human activities, particularly, industrialization, urbanization and ecosystem fragmentation have caused serious damage to the planet. Accumulation of green house gases (GHG) in the atmosphere has occurred in the last three centuries culminating in climate flip-flop that every nation is now concerned. The climate change may worsen the availability of basic human requirements, spread of diseases etc affecting the quality of life.

In this context, UNO has taken proactive action and convened many international conferences to take positive action to lessen the effects of climate change in the world. Recently from 30 November 2015 to 11 December 2015, 195 countries met in Paris to make a deal to reduce the effect of climate change. The deal centers around reduction in the emission of GHG by adopting renewable energy sources and phasing out fossil fuel, especially coal and oil and increasing the GHG sink potential of every nation.

Many developing countries including India are emerging economies and depend largely on coal as energy source and trying to bring

change in the society as a large percentage of people are poor and do not have access to electricity. During the last 50 years these countries are also emitting huge amount of GHG from coal burning. On the other hand, the affluent countries have developed to this stage using fossil fuels as energy source for the last few hundred years and emitted huge quantity of GHG to the atmosphere causing the present situation. These industrially developed countries have also developed technologies to harness energy from the sun and other renewable sources.

The key issues were to phase out fossil fuels and adopt renewable energy sources, technology transfer, increasing GHG sink potential and contribution to the adoption fund. After Copenhagen climate change conference in 2009, which was not fully successful, Paris deal was considered very important to arrive at consensus to find answers to the different issues and to march ahead to create a habitable WORLD for the future generations. The expectations of all nations, especially developing nations and island nations on the Paris deal was huge and our discussion will deal these issues.'The Paris deal, commits countries to try to keep global temperature rises "well below" 2^0C, the level that is likely to herald the worst effects of climate change'. An accompanying, non-binding agreement requires developed countries to continue a goal of "mobilising" $100 billion of public and private finance for developing countries each year after 2020.

Temperatures have already increased by about 1^0C since pre-industrial times. To make sure global warming stays "well below" 2^0C (3.6^0F) and to "pursue efforts" to limit the temperature rise to 1.5^0C. and to achieve that goal, governments pledged to stop the rise in heat-trapping greenhouse gas emissions "as soon as possible". By some point after 2050, the agreement says, man-made emissions should be reduced to a level that forests and oceans can absorb. In order to reach the long-term goal, countries agreed to set national targets for reducing greenhouse gas emissions every five years. More than 180 countries have already submitted targets for the first cycle beginning in 2020. Only developed countries are expected to slash their emissions in absolute terms; developing nations are "encouraged" to do so as their capabilities evolve over time. Until

then, they are expected only to rein in growth of emissions as their economies develop.

President François Hollande, the summit host, welcomed "the most beautiful and peaceful revolution" and said the deal was a "major leap for mankind". Sounding a note of caution, Mr. Barack Obama, president of USA said: "We cannot be complacent about today's agreement. The problem is not solved because of this accord." The pact sent out a powerful signal that the world was committed to a low carbon future. "This agreement represents the best chance we have to save the one planet we have got. "I believe this agreement can be a turning point for the world," he said. "We may not live to see the full realisation of our achievement." "What matters is today we can be confident that this planet will be in better shape for the next generation and that is what I care about."

Some other opinion:

1. 'An exciting opportunity for business'(Carolyn Fairbairn, CBI director-general).
2. There is no penalty for countries that miss their emissions targets.

   But the agreement has transparency rules to help encourage countries to actually do what they say they will do. That was one of the most difficult pieces to agree on, with China asking for softer requirements for developing countries. The agreement says all countries must report on their emissions and their efforts to reduce them. But it allows for some flexibility for developing countries.
3. The agreement says wealthy countries should continue to offer financial support to help poor countries reduce emissions and adapt to climate change. It also encourages other countries to pitch in on a voluntary basis. That paves the way for emerging economies such as China to contribute, even though it doesn't require them to do so. Actual dollar amounts were kept out of the agreement itself, but wealthy nations had previously pledged to provide $100 billion in climate finance by 2020.
4. Loss and damage: In a victory for small island nations threatened by rising seas, the agreement includes a section recognizing "loss and damage" associated with climate-related disasters. The US

long objected to addressing the issue in the agreement, worried that it would lead to claims of compensation. In the end, the issue was included, but a footnote specifically stated that loss and damage does not involve liability or compensation.

5. WWF offers mixed verdict

WWF offers a mixed verdict on three key points:

(i) Create a plan to close the ambition gap, including finance and other support to accelerate action now and beyond 2020.

(ii) The agreement includes some of the elements of an ambition mechanism such as 5-year cycles, periodic global stock-takes for emission reduction actions, finance and adaptation, and global moments that create the opportunity for governments to enhance their actions. However, the ambition and urgency of delivering climate action is not strong enough and will essentially be dependent on governments to take fast and increased action, and non-state actors, including cities, the private sector and citizens, to continue ambitious cooperative actions and to press governments to do more.

Deliver support to vulnerable countries to limit climate impacts and address unavoidable damage. The agreement, however, does not go far enough in securing the support necessary for the protection of the poor and vulnerable.

(iii) Establish a clear long-term 2050 goal to move away from fossil fuels and to renewable energy and sustainable land use. By including a long-term temperature goal of well below 2^{0}C of warming and a reference to a 1.5^{0}C goal, the agreement sends a strong signal that governments are committed to being in line with science. In addition the recognition of the emissions gap and the inclusion of a quantified 2030 gigatonne goal should serve as a basis for the revision of national pledges ahead of 2020. Various other related aspects were discussed.

Post-Script: India has ratified the proceedings of Paris Deal on 2nd October, 2016 and Government has announced that 40% of our energy from electricity sector will be generated from renewable sources by 2030

Prof. Madhab Chandra Dash

Former Vice Chancellor,
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Professor M. C. Dash, an eminent academician and authority, was born in 1939 in Puri district of Odisha. After education upto MSc in Zoology from Utkal University he joined University of Calgary, Canada as Research Assistant in 1967 and completed PhD in Biology-Ecology & Environmental Science. Professor Dash holds over 53years of experience in teaching, research in the lab as well as the field and Environmental Consultancies. After return from Calgary Prof. Dash joined Berhampur University in February 1971 and started his School of Life Sciences in Sambalpur University from April, 1973. Prof.Dash conducted some pioneering work on the conservation of sea turtles and amphibian life history strategies, ecology, larval energetic, intra- and inter-specific competition studies in lab and developed models which are widely cited. One of the most significant work by Prof Dash is on soil biology & Vermitechnology. He introduced modern Ecology/Environmental Biology in all universities of Odisha in 1970s. He has written 250 research & technical papers and 40 books and book chapters on Ecology & Environmental Sciences. Now he is interested in studies on land use management and reclamation of degraded land, food security aspects and carbon sequestration. He has received NABET accreditation with A category. Professor Dash supervised thirty five doctoral theses and three DSc theses.

Rice – A Climate-resilient Species

(Date of presentation: 02.02.2016)

B. C. Patra

Rice (*Oryza sativa* L.) is one of the most important cereal crops providing more than 50% of the world's staple food with 20% of the world's dietary energy source (Schatz M.C. *et al* 2014). Rice is grown in more than 100 countries. Considering the future food demand of world population which has been predicted to be increased by 25% or more (Seck PA, 2012) by 2030, and the current rate of population growth with the rapid declining of arable land area, unpredictable environmental factors such as drought, flood, ill-soils, increasing the yield/productivity of rice adopting innovated technology to develop new high yielding cultivars with resistances to multiple stresses is utmost vital means to survive the future world population. Rice is cultivated as far north as the banks of the Amur River (53º N) on the border between Russia and China, and as far south as central Argentina (40º S) (IRRI, 1985). It is grown in cool climates in the mountains of Nepal and India, and under irrigation in the hot deserts of Pakistan, Iran and Egypt. It is an upland crop in parts of Asia, Africa and Latin America. At the other environmental extreme are floating rices, which thrive in seasonally deeply flooded areas such as river deltas - the Mekong in Vietnam, the Chao Phraya in Thailand, the Irrawady in Myanmar and the Ganges-Brahmaputra in Bangladesh and eastern India. Rice can also be grown in areas with saline, alkali or acid sulphate soils. Clearly, it is well adapted to diverse growing conditions. In India, it is cultivated under a wide range of growing conditions such as below sea level farming in Kuttanad in Kerala to high altitude farming in the Himalayas. Because of its adaptation to such variable agro-ecosystems, fortunately a rich genetic diversity and variability is encountered which will help sustain the adverse alterations in temperature, precipitation and sea level rise in coming

decades as a result of climate change. There are varieties which can withstand submergence during flood and there are others which can grow under moisture stress during drought condition and also at soil and water salinity. Rice has been well known to be the most diverse genus among food crops (Calpe 2003; Juliano 2001) by a large collection of 124,000 rice accessions (Roslen Anacleto et al, 2015). This rich genetic diversity has been the driving force for rice improvement in the past, and will be so for the future. Despite such diversity of within-species genetic diversity and varietal group differentiation were collected and maintained, less than 5 % of these accessions have been used in breeding programs (Sackville-Hamilton, 2013). Therefore, accelerated genetic gains in rice improvement are needed to mitigate the effects of climate change and loss of arable land, as well as to ensure a stable global food supply. The enormous rice genetic diversity available in the gene banks will be the foundation of the genetic improvement of the crop through unraveling the new genes and traits that will help rice producing farmers who are facing the challenges brought about by climate change, insect pests and diseases, and other unfavourable conditions. It is well known that the traditional rice varieties, landraces and their wild relatives constitute an invaluable gene pool in terms of resistance/tolerance to biotic and abiotic stresses, which can be exploited for developing modern varieties having enough resilience to sustain adverse climatic changes.

Rice belongs to the genus *Oryza* with two cultivated species *Oryza sativa* and *O. glaberrima* and 22 other wild species. Asian cultivated rice was reported to be domesticated from its wild progenitor *O. rufipogon* and/or *O. nivara* around 8,000–9,000 years ago (Ouyang Y and Zhang Q, 2013). Based on hybridization studies and genetic differentiation, Asian cultivated rice is further divided into two subspecies; *indica* and *japonica.* Japonica is further sub-divided as temperate and tropical japonica ecotype. A recent study based on extensive DNA sequence analysis of *indica* and *japonica* varieties has concluded that there may have been only one centre of domestication.

The *indica* cultivars were tall and non-responsive to nitrogenous chemical fertilizer. Hence, efforts were made to introduce some

exotic germplasm from China, Japan, Taiwan and Russia which were semi tall and having nitrogen responsive character. During mid 1960s, Dr R.H. Richharia, former Director of NRRI had introduced 67 varieties from Taiwan, tested them at NRRI farm, two or three cultures were dwarf types and one of them was identified as Taichung Native 1 (TN 1) which laid the foundation for Green Revolution in the country and marked the landmark in the history of rice breeding in India. This was the single variety adaptable to whole of India starting from Kashmir to Kanyakumari. Due to superior response to the high level of nitrogen fertilizer, this variety out yielded significantly both in *kharif* as well as in *rabi* seasons. Jaya was the first variety of IIRR while Ratna was the first miracle rice variety of NRRI developed by Dr J. K. Roy; both were released by Central Variety Release Committee in 1968 and 1972, respectively.

In the past, the scientists involved with crop improvement programme at different research stations undertook the evaluation of germplasm and were choosing the varieties through pure line selection. The rice research in the country started between 1911 and 1929 when 21 rice research stations were established in different agro-climatic zones and as many as 37 rice varieties were bred. GEB 24 (Government Economic Botanist 24) was the first rice variety recommended by the Paddy Breeding Station, Coimbatore for cultivation in whole of Madras Presidency as well as in Central Provinces. It was a short duration variety and was a selection from Konamani, a land race. During early 1920s, some improved strains of rice, namely, Benibhog (autumn), Cuttack 1 , Cuttack 2 , Cuttack 3, Cuttack 5 (winter), Kujang 1 and Kujang 2 (for the saline tract) were developed for cultivation in Bihar and Odisha (Ramiah and Rao 1953). In Odisha (Orissa), T 141 was selected from Saruchinamali of Cuttack district; it had fine translucent grains and good cooking qualities, 150 days duration and had wide adaptability. Some other very popular pure line selections were T 90 (a selection from Machhakanta of Balasore district), T 442 (a selection from Kalakartika of Sambalpur district), T 812 (a selection from Rangalata), T 1145 (a selection from Ussa of Puri district), T 1242 (a selection from Magura), SR 26B (a selection from Kalambanka, a salinity tolerant variety) and FR 13A, a

selection from Dhalaputia, a flood tolerant variety was released in West Bengal and Odisha (Orissa) in 1953. A few rice cultivars have been identified which survive submergence up to 80 cm water depth, for 10 to 12 days at early vegetative stage of the crop. Recently, using FR 13A as a donor, Swarna *Sub 1* has been developed and released in India which is gaining popularity among the farmers. Odisha is the first State in the country to release the Swarna *Sub1* variety, which was developed by NRRI, IRRI and University of California-Davis by deriving the flood-tolerant gene *Sub1* from FR 13A, a pure line variety of traditional rice Dhalaputia.

Similarly, drought is a major abiotic stress that adversely affects the crop leading to low productivity. The need for other stress-tolerant varieties is now felt as the paddy cultivation in the region is largely affected by extreme natural calamities like drought, cyclones and most recently, after rapid climate change, through a fickle monsoon. After repeated screening some landraces were identified as tolerant to vegetative stress drought and they are being utilized to develop drought tolerant improved cultivars. At Rice Research Station, Nagina (Uttar Pradesh) N 22 was selected through pure line selection from a landrace 'Rajbhog' which is internationally known as a very good donor for high temperature tolerance, drought tolerance and grain dormancy. Direct seeding is common in rainfed lowlands. In eastern India sometimes early rain causes water stagnation in the field just after sowing which results in poor crop establishment. Two cultivars namely, Panikekoa and T 1471 were identified as anaerobic seeding tolerant rice germplasm. A number of resistant germplasm were short-listed for major pests like Brown Plant Hopper (BPH) like Salkathi, Panidubi, Dhoiya Bankoi, Banspati, Dhobanumberi and Jalakanthi. The landraces collected from Assam have been found to have high level of protein (14-15%). Traditional varieties like Bindli is now reported to have high Zn (>50 ppm) in brown rice.

Despite all the adversities arising due to climate change, today India has emerged as foodgrain exporter because of the constant and dedicated efforts of scientists and has been included in 15 exporter countries in the field of agriculture produce like rice, cotton and sugar.

Dr Bhaskar Chandra Patra

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Dr B.C. Patra was born in Balasore town. He is a Post-Graduate and PhD from Utkal University, during which he collected, identified and enumerated 994 angiospermic plant species belonging to 601 genera and 141 families from different habitats, particularly of the undivided Dhenkanal district. He also characterized and conserved more than 7000 accessions of rice genetic resources from all parts of the country. He was selected for All India Agricultural Research Service (ARS) in 1986 and joined as an ICAR Scientist in Economic Botany. In 2007 he became Principal Scientist. Some of his national surveys were in North-West for Basmati rice, Chotanagpur for upland and drought tolerant rice; North-East for traditional rice; Bastar for medicinal rice; Malabar, Konkan and coastal Gujarat for saline-tolerant rice; eastern UP for aromatic short grain 'Kalanamak' rice; Sikkim and Arunachal Pradesh for cold-tolerant hill rice, Kerala for medicinal rice 'Njavara' and salt tolerant 'Pokkali' rice, and the Andaman & Nicober islands for wild and weedy rices. The National Rice Research Institute released 114 high yielding varieties of rice using the germplasm collected by Dr Patra. In his 'Oryza Garden' in NRRI Campus all 22 wild rice species of the world were conserved. He could commercialize 28 technologies through several companies and registered 20 extant/new varieties and 23 farmers' varieties with Protection of Plant Variety and Farmers Rights Authority (PPV & FRA). Dr Patra completed projects funded by Project Elephant, Dept. of Biotechnology, PPV & FRA, FAO/UNDP and NALCO. He has published more than 51 research papers and authored several book chapters, technical bulletins and edited many scientific articles including Annual Reports of the National Rice Research Institute.

Faunal Diversity of Rice Fields and a few Environmental Issues

(Date of presentation: 06.03.2016)

Kshira Sagara Behera

Rice covers about 69% of the cultivated area in our state. In addition to a variety of plant species other than paddy, fields are also a rich reservoir of faunal diversity. Faunal diversity refers to the number and variety of organisms within a particular area and has three components viz. species diversity, ecosystem (or habitat) diversity and genetic diversity. Species diversity relates to the number of the different species and the number of individuals of each species. Ecosystem diversity is the diversity of habitats or ecosystems within an area. Genetic diversity is the genetic variability of a species. Rice fields comprise a type of wetland ecosystem dependent on rain or irrigation. Therefore, the structural, functional, and spatial aspects of biodiversity in rice fields vary over time. Some organisms are resident species that occur even in the absence of the crop, some are visitors while some are recruited with the advent of the crop. Basically life processes start in the paddy field with the inundation of water. The biodiversity of the paddy agro-ecosystem, therefore, depends not only on the paddy fields themselves but also on water channels, irrigation ponds, levees, surrounding fallow fields, neighboring farmlands etc. The macro fauna is dominated broadly by invertebrates (especially arthropods) inhabiting the soil, water and vegetation of the rice fields. Hymenopterans (wasps) share almost 50% of the different groups of organisms prevalent in rice ecosystem (Fig. 1). The terrestrial arthropod community in rice fields consists mainly of insects and spiders along with other vertebrates (Table 1).

Functional diversity of organisms in rice environment

Based on the role played by the individuals, the functional diversity of organisms in rice fields can be categorised as pest, predator, parasitoid, neutral etc. It is essential to understand the variety of animal communities available during the growing season of rice to manage them properly for our advantage.

Pests are the organisms that cause economic loss by damaging the crop at different stages of growth. Over 1400 insect species attack standing and stored rice in the world. However, about 20 insect pests have major significance in different rice growing regions of India. Among these, yellow stem borer, brown plant hopper, white backed plant hopper, gall midge, leaf folder, case worm and gundhi bug are found to cause substantial damage to crop across the country. Maximum number of lepidopterans (moths and butterflies) mostly in their larval stage, cause severe damage to the crop; while a few plant and leaf hoppers and dipterans (flies) also cause considerable damage.

Predators are the most conspicuous organisms and consume many preys during their life span. They are mostly general feeders. Many predators are cannibalistic, also attack other beneficial insects and thus can survive to some extent in the absence of host species. Predators of rice pests are the early invaders of the rice fields. Rice insect predators in India belong to 25 families of six orders. Among the orders Coleoptera ranks first and the family Coccinelidae (ladybird beetles) is exclusively predacious with a few exceptions. Dragonflies and damselflies are amongst the most abundant insect predators in irrigated rice fields. They were observed to predate on moths of rice yellow stem borer and leaf folder on wing. Fourteen species of dragonflies and damselflies have been recorded from rice fields at Cuttack. Predatory spiders form an integral part of rice ecosystem. Some of them (wolf spiders) actively hunt their prey while others construct webs (orb web spiders) and wait for the prey. Thirty three species of spiders were collected from rice fields in Cuttack. Among the orb web spiders, species of *Tetragnatha* are most common in the rice environment, while *Pardosa pseudoannulata* is the predominant

hunting species. Rice green bug is the most commonly reported and widely distributed insect predator on brown plant hopper. Besides, the predominant invertebrate species a few vertebrate predators like snakes, frogs; birds like drongo and egrets are also commonly observed in rice fields (Table 2). Flock of cattle egret, *Bubulcus ibis* running behind the tractor or country plough in the field is a very common sight in the rice paddy. A definite succession of birds has been observed from the beginning of the crop till harvest. These birds feed on worms, moths and caterpillars as well as harmful soil organisms. However, some species of the granivorous group of birds such as parrots, mynas, munias, baya weaver and sparrows etc. cause direct loss of grain yield at the reproductive stage of the crop. Studies revealed that insectivorous fishes like Kau, Magur and Singee present in the semi deep paddy fields can devour brown plant hopper and caseworm larvae. They also feed on the larvae of stem borer and emerging adults from base of the rice plant.

A parasitoid is an organism that lives in or on another larger living organism (host) and requires only one or partial individual to complete its life cycle and invariably kills the host. A parasitoid that attacks another parasitoid is called a hyper-parasitoid. Hymenoptera is the most important insect order due to a number of insect species, which are potential pollinators and parasitoids. Most of the female parasitoids usually have long and pointed ovipositors (egg laying apparatus) like syringe needles to facilitate egg laying in the host body. Three important parasitic wasps namely, *Trichogramma japonicum, Telenomus dignoides* and *Tetrastichus schoenobii* have been recorded on egg mass of yellow stem borer, the foremost destructive pest of rice. Studies indicated that there is change in the succession of these parasitoids over the years. Studies also indicated that extent of parasitism of egg masses and number of parasitoids involved, decreased gradually from inland to coastal area. As many as 35 species of parasitoids have been reared from the rice leaf folders that exert natural biological control of the pest.

Those species such as chironomids and collembola, for example, that are neither pests nor natural enemies and yet are useful as

alternative food of generalist predators, can be referred to as neutral, yet important components of the community.

Based on the inventory of surveys made at NRRI, Cuttack the rice field organisms belonged to 20 groups (Fig.1) representing 419 species designated as pests, predators, parasitoids, hyper-parasitoids and neutral species (Fig. 2). Among the hymenopterans, majorities were parasitoids and a few were hyper-parasitoids. Several neutral species of organisms were also recorded. Spiders, damselflies and dragonflies are the most conspicuous and abundant predators observed in the rice fields.

Different components of agricultural intensification especially, use of agrochemicals have been the largest threat for various taxa. In agro-ecosystems, farmers incidentally manage biodiversity by selection of variety and crop management practices. The overall effect of hybrid rice, organic rice, aerobic rice and climate change on faunal diversity, especially pest problems are subjects of great concern.

Effect of agrochemicals on faunal diversity

Insecticides

Application insecticides for realization maximum yield potential are very common among farmers and many a times unwarranted prophylactic or un-recommended insecticides are applied. Field trials indicated that between spray and granular formulations of insecticides the latter is found to less toxic to parasitoids. Maximum damselflies, dragonflies and spiders were observed in neem seed, neem oil and granular insecticide (e.g. carbofuran) treated plots.

Herbicides

More recent socioeconomic changes have led to reduction in availability of labour force for different agricultural operations, thereby increasing dependence on mechanization and use of agrochemicals like herbicides instead of manual weeding. Herbicides like Pretilachlor negatively affected the spider population, where as parasitoid population was least affected. Population of the lady bird beetle was maximum in the weedy plots followed by Pretilachlor treated plots.

Fungicides

Application of selected fungicides like Bavistin, Mancozeb, Hinosan, Tilt, Contaf, Sheathmar etc. during wet season had no effect on some of the leaf feeding insects like leaf folder, whorl maggot and the horned caterpillar whereas, population of spiders was affected significantly by Hinosan. Sheathmar was found to be relatively safer for parasitoid population, whereas minimum negative impact on spiders was observed where tilt was sprayed. During dry season, the fungicides had negative impact on population of spiders, grasshoppers, dipterans, coleopterans, damselfly, green leafhopper and white leafhopper.

Effect of new cultivation technologies on faunal diversity

Hybrid rice

Cultivation of hybrid rice is one of the recent developments for increasing grain yield popular among farmers. Hybrid rice is genetically more uniform and has greater biomass. Sampling of the crop canopy indicated that rice hybrids harboured more arthropod species. As it appears hybrids supported greater diversity of organisms, especially spiders than the HYVs.

Aerobic rice

Water is a critical and precious commodity. The trend now is to develop management policies for the efficient operation of irrigation systems; technologies that reduce water consumption. Scientists are working on creating a high-yielding tropical rice plant that grows on dry but irrigated land instead of flooded fields , calling it “aerobic rice.” Under such conditions termite, thrips, short horned grasshopper and rice green semilooper are more prevalent pests with less of predator population.

System of Rice Intensification (SRI)

This method of rice cultivation in recent times has become increasingly popular in Odisha. Some of the SRI practices like wider spacing, weed free condition and absence of stagnant water make

the micro-environment of this method of rice cultivation non conducive for some of the major pests of rice like brown plant hopper and gall midge. Low incidence of stem borer, leaf folder, whorl maggot, hispa and green leaf hoppers have been recorded in such fields. In general under SRI method of cultivation pests and damselfly population were less.

Role of reservoir hosts in sustaining faunal diversity

In conventional rice cultivation biodiversity is destroyed with harvest. At this stage both pests and natural enemies are destroyed or driven away. Certain weeds in rice environment are infested with insects that alternatively support rice pest parasitoids in off-season. *Echinochloa stagnina* is an important weed species harboruing a non-rice leaf folder that in turn supports rice leaf folders' parasitoids during off-season. Spider eggs support certain parasitoids that also attack rice pests. Midges forming galls on the grass hosts e.g. *Paspalum* sp., *Cynodon* sp. and *Mnesithia* sp. have been identified as reservoir hosts of gall midge parasitoids. A few rice pest parasitoids have been recorded on the chrysomelid beetle feeding on *Commelina* sp. a common weed in the irrigation channels and rice fields.

Methods to increase biodiversity

Habitat enhancement focuses on the establishment of flowering annual or perennial plants that provide pollen and nectar needed during certain parts of the insect life cycle. Introduction of nectar rich flower plants onto non-rice areas as resources for predators and parasitoids. Among the plants being used are Til (*Sesame indicum*), Vishalyakarani (*Tridax procumbens*). Intercropping of crop plants like mustard and sesame etc. provide nectar to the natural enemies and support their population. Other habitat features include water, alternative prey, perching sites and overwintering sites. By providing ample organic matter to fields, the population of harmless organisms can be increased and with that the population of generalist predators. Conservation of existing natural population through a major reduction in insecticide use and an increase in habitat heterogeneity is also an important approach. Egg parasitism due to *Telenomus*

dignoides, the dominant and most widely distributed parasitoid wasp, was increased by 15-20% in the presence of nectar producing plants, especially mustard. Similarly, spider population also increased in fields where Azolla, a type of fern, was used as green manure.

Environmental threats

During recent times, farming practices and management systems have been intensified in many rice-producing areas. Furthermore, more recent socioeconomic changes have also affected the crop and in turn the organisms sustaining on it. One such example is the recent developments in road & rail networking coupled with bright lighting arrangements that adversely affect the flowering of rice, as environmental signals like light control the time of flowering in short-day plants like photosensitive rice varieties. Under such situations the rice crop tends to remain at vegetative stage and flowering is delayed or arrested.

Issues in the future

The important issue would be how to manage and optimize biodiversity, stability and productivity within agroecosystems. The paddy ecosystem is an integrated, water-dependent system, which can contain many kinds of living organisms like birds, fish, reptiles, amphibia, arthropods, and plants. Paddy fields were originally wetlands that are artificially constructed for rice production. Nowadays, very few natural wetlands remain and many aquatic organisms now depend partly or fully on paddy fields. Future areas of research include the influence of different crop establishment methods, aerobic rice, precision farming, global warming, new plant type etc. on faunal diversity. Furthermore, developments in molecular taxonomy and IT based biodiversity informatics will help to manage agricultural biodiversity in a better way.

Fig 1: Functional diversity of macrofauna in rice agroecosystem

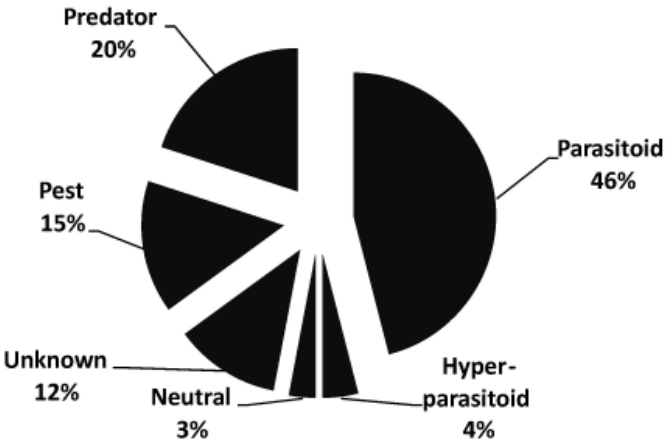

Fig 2: Faunal diversity of macrofauna in rice agroecosystem

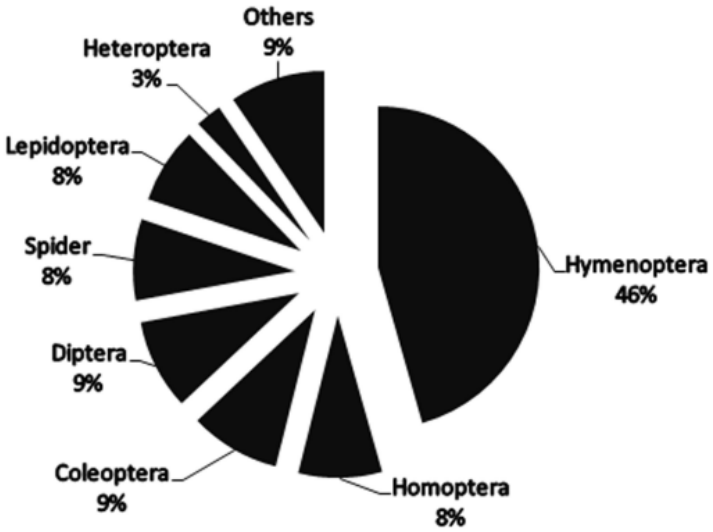

Table 1. Examples of selected rice field fauna based on 'Species Diversity'

Taxonomic Group	Common Name	Scientific Name	Odia Name
Hymenoptera	Wasps, ants & bees	*Aphanogmus fijiensis* (Ferr.)	Birudi jatiya poka
		Telenomus dignoides Nixon	
		Temelucha philippinensis (Ashmead)	
		Apis dorsata Fabr.	Baghua mahumachhi
Homoptera	Leaf hopper	*Balcuthina viridae* Pruthi	Patradian poka
		Cofana spectra Distant	Dhala patradian poka
	White backed plant hopper	Sogatella furcifera (Horvath)	Dhalapithia gundi poka
Coleoptera	Lady bird beetles	*Coccinella repanda* (Thunberg)	Harada phalia poka
		Micraspis discolor (Fabr.)	Indragopi bhrunga
	Rove beetle	*Paederus fuscipes* (Curtis)	Bhramankari bhrunga
Diptera	Flies & mosquitoes	*Anopheles pallidus* Theobald	Masa
		Argyrophylax nigritibialis Baranov	Machhi (parasrayi)
Aranae	Spiders	*Oxyopes pandae* Tikader	Budhiani
		Thomisus cherapunjeus Tikader	
		Argiope catenulate Doleschall	
Lepidoptera	Butterflies & moths	*Scirpophaga innotata* (Walker)	Dhala kandabindha poka
		Sesamia inference (Walker)	Patal kandabindha poka
		Parnara naso (Fabr.)	Dhan prajapati
		Cnaphalocrocis medinalis (Guenee)	Patramoda poka
Heteroptera		*Dysdercus koenigii* Fab.	Kapara nail sosak poka

		Coramus fuscipennis (Bigot)	
		Nezra viridula Fab.	
Amphibia (Frogs)	Tiger frog	*Haplobatrachus tigerinus* (Daudin)	Brahmani Benga
	Tree frog	*Polypedates maculates* Grey	Katha Benga
Aves (Birds)	Bronzed drongo	*Dicrurus aeneus* Vieill	Kajalpati
	Median egret	*Mesophoyx intermedia* (Wagler)	Majhian baga
	Cattle egret	*Bubulcus ibis* (Lin.)	Gai baga
	Baya weaver bird	*Ploceus philippinus (Lin.)*	Baya chadhei
	Little cormorant	*Phalacrocorax niger* (Vieill.)	Pani kua
Pisces (Fishes)	Catfish	*Clarius batrachus* (Lin.)	Magur
	Cat fish	*Heteropneustes fossilis* (Bloch)	Singee
	Eel	*Monopterus cuchia* (Hamilton)	Kuchia
Reptilia (Snakes)	Russel's viper	*Daboia russelii* (Shaw & Nodder)	Chandan boda
	Rat snake	*Ptyas mucosa* (Lin.)	Dhamana
	Water snake	*Enhydris enhydris* (Schneider)	Dhanda
Mammalia	Bandicoot rat	*Bandicota bengalensis* Gray	Bila musa
	Field rat	*Mus booduga* (Gray)	Gatua musa
Thysanoptera	Thrips	*Stenchaetothrips biformis* (Bagnall)	Ukunia poka
Trichoptera	Caddisfly	*Diapseudopsis pallida* Martynov	
Strepsiptera	Twisted wing insect	*Elenchus* sp.	
Neuroptera	Ant lions	*Helicomitus* sp.	
Collembola	Springtails	*Seira* sp.	
Isoptera	Termite	*Odontotermes obesus* Rambur	Ooi
Orthoptera	Grasshopper	*Atractomorpha crenulata* Fab.	Jhintika
Crustacea	Crab	*Paratelphusa hydrodomous* (Herbst.)	Kankada

Table 2. Examples of selected rice field fauna based on their 'Functional Diversity'

Functional Category	Common Name	Scientific Name	Odia name
Pests			
	Yellow stem borer	*Scirpophaga incertulas* (Walker)	Haladia kanda bindha poka
	Brown plant hopper	*Nilaparvata lugens* (Stal)	Matia gundi poka
	Caseworm	*Nymphula depunctalis* (Guenee)	Nali poka
	Gall midge	*Orseolia oryzae* (Wood-Mason)	Kahalia poka
	Gundhi bug	*Leptocorisa acuta* (Thunberg)	Gandhi poka
	Panicle aphid	*Hysteroneura setariae* Thomas	Jaupoka
	Mealy bug	*Brevennia rehi* (Lindinger)	Dahia poka
	Rose ringed parakeet	*Psittacula krameri* (Scopoli)	Sua
Predators	Ladybird beetle	Cocinella arcuata (Fabr.)	Indragopi bhrunga
	Rice green bug	*Cyrtorhynus lividipennis* Reuter	Sabuja sundha poka
	Crow billed drongo	*Dicruru. annectans* (Hodg.)	Kajalpati
	Dragonfly	*Crocothemis servilia* (Drury)	Kanki
	Damselfly	*Ceriagrion coromandelianum* (Fabr.)	Saru kanki
	Predatory bug	*Andrallus spinidens* (Fab.)	
	Ant	*Camponotus* sp.	Pimpudi
	Spider	*Tetragnatha mandibulata* Garvely	Dwidantia budhiani
	Wolf spider	*Pardosa birmanica* Simon	Gadhia budhiani

Parasitoids	Wasps	*Trichogramma japonicum* Ashmead	Birudi jatiya poka
		Xanthopimpla flavolineata Cameron	
		Charops bicolor (Szepligeti)	
		Cardiochiles nigricollis Cam.	
		Kriechbaumerella rufimanus Walker	
		Platygaster oryzae Cameron	
		Stenobracon nicevillei Bingham	
Hyper-parasitoids		*Trichomalopsis apanteloctena* (Crawford)	
	*	*Elasmus claripennis* (Cameron)	
		Echthrogonatopus nigricornis Hayat	
	*	*Brachymeria albotibialis* Ashmead	
Neutrals		*Sarcophaga* sp.	
		Pltyscelio sp.	
		Nala lividipes (Dufour)	
Functional role uncertain		*Dacus cucurbitae* Coq.	
		Tapinoma sp.	
		Zuphium oleris	

*Act both as a parasitoid and hyper-parasitoid depending host species

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Dr K. S. Behera was born on June 5, 1952 in Angul and educated in Bhubaneswar. After PhD in Zoology from Utkal University he joined Orissa Education Services and in 1978 joined Agricultural Research Service in CRRI, Cuttack, now known as ICAR-National Rice Research Institute. In 1999 he became Senior Scientist and Superannuated as Principal Scientist in 2014. Dr Behera received training at International Rice Research Institute (IRRI), Philippines on 'Entomological aspects of Hybrid Rice' and 'Breeding of Crop Pests and Parasitoids' at Commonwealth Institute of Biological Control, Bengaluru. Dr Behera worked in different projects of NRRI, IRRI and NATP. He worked on Bt formulations and did many basic studies on faunal diversity and biological control of pests in rice habitat. He established that dual cropping of *Azolla* enhanced spider population in the rice field. As a student and scientist he owns several awards and has published more than 60 research papers. He is a Doordarsan Expert for imparting training on rice crop protection by farmers and officials. He has developed his own roof-top garden for vegetables, fruits and nuts.

Strategies for Enhancing Pulse Production in Odisha

(Date of presentation: 03.04.2016)

L. M. Garnayak

Pulses occupy a strategic position in intensive as well as subsistence agriculture, as they are an excellent source of dietary protein for millions of people, nutritious feed for livestock and are the mini nitrogen plants having profound ameliorative effects on soil. Pulses form an integral part of the vegetarian diet in Indian sub-continent. Pulses contributed significantly in addressing the hunger, food security, malnutrition and human health and are also a vital source of plant-based proteins and amino acids. The UN has declared 2016 as the International Year of Pulses (IYP) with the objective to heighten public awareness of the nutritional benefits of pulses as part of sustainable food production to ensure food and nutritional security.

Pulses are second in importance next to cereals, but they are well behind cereals both in acreage, production and productivity in India. India is the largest producer and consumer of pulses in the world and imports about 3.5 to 4.0 Mt pulses annually to meet its domestic demand. It accounts for over one third of total pulse area and over 20% of total pulse production in the world. The per capita availability of pulses in India has declined from 61 g/day in 1951 to about 42 g/day in 2014. To provide nutritional security and to make country hunger-free, India needs to produce 30.0 Mt pulses by 2020 as against the present level of 19 Mt. Odisha annually produces about 10.6 lakh tonnes pulses from 20.9 lakh ha area with the average productivity of 507 kg/ha. The per capita availability of pulses in the state has increased progressively from 32 g in 1950-51 to the highest ever of 82 g/day in 1990-91, but declined thereafter substantially to the present level of about 30 g/day as against the minimum requirement of 50 g. The requirement of pulses in the state to meet the food demand of

the projected population of 5.64 and 10.24 crores by 2020 and 2050 is 27.2 and 49.4 lakh tonnes, respectively. The key to enhance production is to bring more area under pulse crops and to increase their productivity. During the period from 1950 to 2014, acreage under pulses in the state has increased by five folds and their production only by four fold with marginal decline in productivity by 4%. Odisha is coming under the low pulse productivity region (<600 kg/ha) of the country. The average productivity of pulses in the state is about two third of the national average of 764 kg/ha and is about 30 to 50 % of the demonstrated yield and only 25 to 35% of the potential yields reported from research plots indicating tremendous scope to improve both productivity and production of these group of crops by alleviating various production constraints. Green-gram, black-gram, horse-gram and pigeon pea are the important pulse crops grown in Odisha, which together constitute 88% of total pulse area and 85% of total pulse production in the state. The ratio of *kharif* (wet) to *rabi* (dry) pulses with respect to area is 36:64 and in production is 39:61.

Major constraints in pulse production in the state can be broadly grouped into three categories, *viz*., agro-ecological, biological and socio-economic. Soil acidity, moisture stress, low productivity in rice-fallows, deteriorated soil structure following puddling, timely non-availability of good quality seeds of situation specific genotypes, high susceptibility to insects pests and stored grain pests, inherent physiological barriers to increase productivity, subsidiary status of the crops, low seed replacement ratio, lack of social fencing against stray cattle are few of them.

Avenues for expansion of area under pulses are: inclusion of short duration pulse varieties into various cropping systems either through complete or partial substitution for upland rice, intercropping in agro-forestry systems, newly developed orchards and spring planted sugarcane, inclusion in multiple cropping sequences; inclusion of pulses in rice-fallows; increasing area under summer pulses in areas of limited availability of irrigation water, increasing acreage under non-conventional pulses like Rajmash and ricebean, etc.

Pulses are the energy rich crops grown in energy-starved conditions. Over the years, these crops are grown in marginal and sub marginal

lands with poor management practices. But adoption of improved crop production and protection technologies including improved genotypes, quality seeds, seed treatment with appropriate fungicide and specific *Rhizobium* culture and PSB, soil amelioration with appropriate liming materials, optimum plant stand, efficient and timely farm operations, balanced nutrition including use of biofertilizers, secondary and micronutrients, timely weeding, need based irrigation, integrated pest management and appropriate post harvest technology can bring substantial increase in pulse production in the state This has been well illustrated through FLD programmes where yield improvement of green-gram, black-gram, pigeon-pea and field-pea was by 26-47, 34-48, 30-63 and 22-35%, respectively. Management practices for improving productivity of *paira* pulses are: cultivation of stiff straw, non-lodging, medium duration rice varieties maturing in 135-140 days, proper land leveling for *kharif* rice, harvesting rice crop with 10 cm stubble height and immediately removing the harvested plants from the field, sowing *paira* crop in the 1st week of November, keeping thin film of water at the time of sowing of *paira* crop, using 50% higher seed rate, seed treatment and seed inoculation with *Rhizobium* and PSB, application of phosphorous dose of *paira* crop to *kharif* rice in addition to the dose of rice crop, or 100 kg DAP and 33 kg MOP/ha at panicle initiation stage of rice crop and foliar spray of DAP or urea 2% at flowering of *paira* crop. Suitable varieties for *paira* cropping are: Pusa-9072, TARM-1& 2, OBGG 52, OUM-11-5, LGG-460 of greengram, Ujala, TU-94-2, LBG-17, Mahuri, Shashi of blackgram, Rachna, Aparna, Pusa Pana, Uttara and Alankar of field pea, JG 11, Radhey, L 550 of Bengalgram and Ratan, Prateek of Lathyrus.

In a country like ours where protein deficiency is rampant among women and children, there is need to promote pulses as they are the affordable and highly nutritious source of proteins and vital micronutrients. There is urgent need for increasing pulse production in the state through paradigm shift in crop planning with major attention on adoption of advanced crop production and crop protection technology including post harvest management of the group of crops through establishment of storage/processing units and provision of realistic support price.

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Prof. L. M. Garnayak is a specialist in Water Management, Dry Land Farming, Integrated Farming System and Field Experimentation. He was born in the district of Angul on 03.05.1961. Dr Garnayak received academic scholarships throughout his career and in BSc (Ag.) and MSc (Ag.) received gold medals from OUAT. His PhD in Agronomy was from IARI, New Delhi. He received ICAR fellowships for higher studies. In 1988 Dr Garnayak joined as Junior Agronomist in the All India Coordinated Wheat Improvement Project, RRTTS, Chiplima under OUAT. He became a Professor in 2007. He headed the All India Coordinated Research Project on Integrated Farming System of the University as Chief Agronomist before his selection as Dean, College of Agriculture, Bhubaneswar, OUAT in May, 2015. Dr Garnayak is a life member of many Professional Societies and visited Ohio State University in Columbus and University of California, Davis in USA in connection with programmes on Capacity Building Models and Climate Change Modelling, respectively. With 25 years of teaching experience Prof. Garnayak guided 15 MSc (Ag.) students and five PhD students. He also co-guided 48 PG / PhD students. He has published 38 research articles in national and international journals and written 20 book chapters. He is also a teacher in television on subjects for farmers and officials of the line departments organized by the government agencies, public sectors and NGOs. He is a member of several professional organizations.

Management and Conservation of Wetlands with Special Reference to the Fishery Resources of Lakes and Lagoons

(Date of presentation: 01.05.2016)

Jaya Krushna Panigrahi

Abstract

Wetlands, considered as highly productive ecosystems of the world, are confronted with a plethora of threats at the present juncture that have degraded their environment critically and depleted their bioresources, specifically fishery resources, substantially. Even if the causes are manifold, chronic overexploitation, progressive deterioration of the environmental quality as a sequel to diverse anthropogenic impacts and above all non-existence of an integrated management strategy in many instances, besides some natural perturbations, largely account for the impoverished and degraded state of the wetlands. In the face of such concerns, the foremost task is to formulate and implement a concerted long-term conservation and management programme with multidisciplinary approaches that would undertake effective measures for ecorestoration, watershed treatment, awareness generation, monitoring and further scientific research, in addition to strict enforcement of various regulations. Such a holistic initiative would restore the biological diversity, rich attributes and aesthetic appeal of the wetlands.

Key Words: Wetlands, management, conservation, lakes, lagoons, fish resources

Introduction

Wetlands of the world face serious challenges from diverse corners for their survival in the decades to come. Overexploitation of their

resources, apathy towards the degradation of their environment and dearth of proper initiative for their conservation are steadily making them biologically barren, besides ravaging their heritage value and aesthetic appeal. Further, all natural resources are finite and can be so over-utilized or abused as to reach a point where they are for all practical purposes no longer renewable (Datta, 1998). But as the direct economic benefits in the form of fisheries yields derived from them decline, in due course substantially, the gravity of the circumstance is recognized belatedly and attempts are made to counter environmental degradation and evolve appropriate management strategies. The draft strategic plan 1997-2002, prepared by the contracting parties of the Ramsar Convention in the Brisbane Conference of 1995 thus aptly issues an urgent call for the inclusion of the 'wise use' of wetlands and the guidelines for sustainable development in all land-use, environmental and economic planning. It outlines an ambitious programme in education and public awareness initiatives on wetland values in order to increase public support for planning (Anonymous, 1996). The plan also gives a new emphasis to community participation in conservation management and more attention to the values and experiences of local communities and indigenous peoples. The 'Wetlands of International Importance', which have been added to the list of Ramsar sites in danger (the Montreux Record), warrant high priority for their restoration, conservation and sustainable use as the treasured gifts of nature.

The ever-increasing threats to the environmental quality and the fish resources of the wetlands, emerging from diverse human impacts and natural phenomena, have generated serious concerns, of late at all levels - politicians, administrators, general public and above all, the fishermen communities. However, the deficiencies in the management of the fisheries and the environment as a whole at the present juncture do not help in halting the environmental degradation and the declining trend of the fisheries yield. The declining total yields, low catch rates and insignificant economic profits confirm that there are weaknesses in the management of the fishery (Palfreman and Insull, 1994). When managing a tropical

brackish lagoon, such as Chilika Lake of India, there is a greater complexity of factors that have to be taken into the agenda from a fisheries point of view and in comparison to other environments. This necessitates special conservation and management strategies to alleviate the diverse detrimental impacts and restore a sustainable fishery. Acknowledging the arduous task in fisheries management, the Committee on Ecosystem Management for Sustainable Marine Fisheries of US (1999) drafted a coherent and concise description of the problems that are inherent in managing a resource owned by no one. Because productivity of future fisheries may be contingent on current treatment of fish populations and the ecosystems that produce them, management of the fisheries to protect their capacity for producing a sustained yield is highly desirable (Bond, 1996).

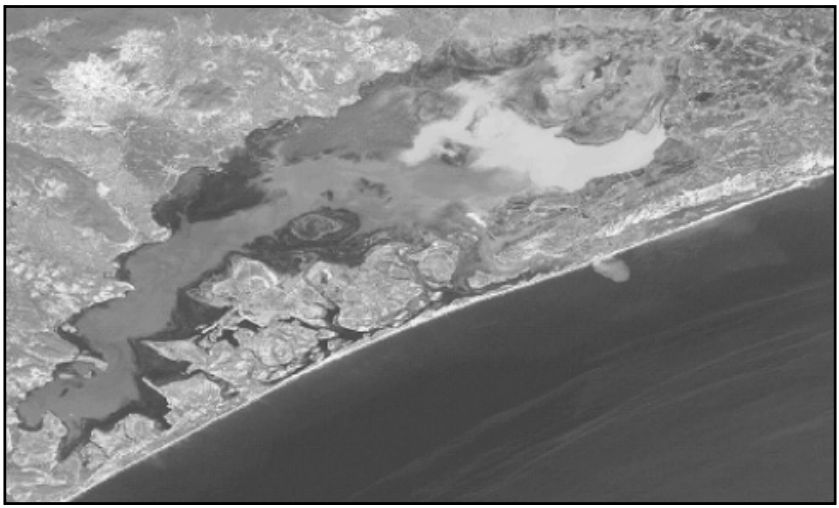

Fig.*: Satellite image of Chilika Lake, the largest brackish water lagoon of Asia, with its artificial mouth opened to Bay of Bengal on 23rd September 2000.*

Harden Jones (1994) states that the most obvious goals of fisheries management are the biological objective of resource conservation, the physical objective of yield maximization, the economic objective of profit maximization and the sociopolitical objectives concerned with employment and equity. While maximum sustainable yield (MSY) basically concerns the weight of fish harvested (Weithman, 1993), optimum sustainable yield (OSY) not only includes harvest

but can also include other benefits of a biological and socioeconomic nature (Bond, 1996). In order to achieve OSY and to restore the rich attributes and intrinsic values of the wetlands, a concerted long-term conservation and management programme needs to be implemented to stop and reverse the wetland degradation and promote the 'wise use' of wetlands.

Suggested Agenda for Management

The key constraints, namely the deficiency of adequate knowledge and awareness, lack of practical experience in managing resources from an ecosystem perspective, insufficient information on biodiversity and its potential use values, a detrimental focus on managing a natural resource as well as limited institutional experience and human resources in ecosystem management, need to be addressed to alleviate the problems of wetlands (Chiuta, 1996). This focuses the need to amend the human activities by integrated management of both the watershed and the wetland. Modern conservation is not about species or ecosystem biology; it is about human behaviour and how it can be changed to reverse the current trend of environmental damage (Hurst, 1996). To stress the significance of conservation in resource management, the IUCN definition of conservation states, " In the case of sectors (such as agriculture, fisheries, forestry and wildlife) directly responsible for the management of living resources, conservation is that aspect of management which ensures that utilisation is sustainable and which safeguards the ecological process and genetic diversity essential for the maintenance of the resources concerned ". Thus, the management efforts need to incorporate conservation measures as key components.

Bennett (1970) defined fisheries management as "the art and science of producing sustained annual crops of wild fish for commercial and recreational uses ". In the context of Canadian fisheries, Hyatt (1996) states that a strong commitment to a management system that emphasizes habitat protection and wild stock production as the foundation for sustainable fisheries is highly essential. It needs to be realised that though stocks are renewable resources, these may

be severely depleted as more fishermen enter the fishing activity and as better gear is devised, the capacity of the fish populations to produce large numbers of large fish is diminished (Bond, 1996). Keeping these aspects in view and considering the magnitude and critical nature of the problems, the following suggestions are made in order to successfully restore the habitat quality, minimise the human impacts on the wetland ecosystem as well as the watershed, reinstate the abundance of rich fish resources and achieve optimum sustainable yield (OSY).

Evolving an Integrated Management Programme

The foremost task is to formulate and adopt an integrated management programme with multi-disciplinary approaches, since the present strategies in most lakes and lagoons are inadequate and lacking co-ordination among the various agencies working for their conservation and management. Such a holistic programme should consider the diverse other biotic and abiotic components, and the repercussion of the human impacts on the lake as well as in its catchments that influence the fish resources and affect the fishery yield. The guiding principle of fisheries management is the objective of sustainable development (Palfreman and Insull, 1994). The programme should involve:

I. Establishment of an Advisory Committee of specialists from various fields who would crystallize their collective knowledge into a definite integrated long-term programme and suggest appropriate techniques for its implementation.

II. A consortium of various organisations of the government, viz Wetland Development Authority, Fisheries, Wildlife, Forest and Environment, Soil Conservation, Pollution Control Board, Remote Sensing Application Centre, Water Resources, various research organizations and universities working on different aspects of the wetland, is to be constituted to work co-coordinately with specific assigned objectives. The Advisory Committee is to suggest definite conservation measures to be undertaken from time to time.

III. The NGOs working honestly in the locality are to deal with the socioeconomic dimensions of the fishermen, and the environmental education and awareness generation campaign in the villages around the wetlands and in their watershed. The administrative machinery of the Government is to oversee the implementation of the programme.

IV. A manual covering the fishery, avifauna and other biological resources, hydrological characteristics and management practices is to be prepared for the information and reference of all concerned.

IV. A database incorporating the diverse environmental features of the wetlands, their resources, the socioeconomics and all the research findings in these fields is to be established, making it available to those working on diverse aspects.

Enforcement of Laws and Regulations

The next prime objective is to implement stringently the existing laws and regulations, and formulate new regulatory measures. Bond (1996) accentuates that laws and regulations have been instituted historically to protect breeding populations or undersized fish in order to ensure recruitment of adequate numbers of usable-sized fish. The programme should incorporate:

- Stringent enforcement of the existing conservation laws such as the Environmental (Protection) Act of 1986, the Forest (Conservation) Act of 1980, the Water (Prevention and Control of Pollution) Act of 1974, the Wildlife (Protection) Act of 1972 and other relevant laws with all sincerity.
- Strict implementation of the size-limit regulations and banning the capture of small-sized fish to improve the depleted stock and enhance recruitment, and imposing 'closed season' concept to limit the fishing months, days in a week and hours in a day, at least for a few years in severely affected wetlands.
- Prohibiting the capture of seeds, juveniles and brood fish migrating into and out of the lagoons in order to increase recruitment.

- Preventing prawn culture within lagoons, inhibiting improper fishing methods, imposing the minimum stretched mesh-size limit, banning the landing and marketing of juveniles and undersized fish, and carrying out random inspection regularly by fishery inspectors.

- Closure of fishing activities in the identified spawning and nursery grounds within the lagoon as well as in the coastal areas near the inlet, and restricting the number and movement of boats operating in the lake waters.

- Enactment of legislation for these purposes by the Government as and when the Advisory Committee would recommend it.

Ecorestoration Programme

Since the wetlands are highly sensitive to disruption by human activities (Maltby, 1991), and substantial damage has already been caused to the habitat quality and ecosystem functioning of many wetlands, immediate and appropriate ecorestoration measures need to be undertaken. This should aim at maintaining the hydrological characteristics, restoring the ecosystem functioning and pristinity of the wetlands, and enriching their ichthyofauna. Their effective ecological functioning would largely depend on the constancy of salinity conditions (in lagoons), controlling the aquatic weeds, prohibiting encroachment, preventing sedimentation, combating pollution and controlling various other processes that aid to the wetlands' degradation. A further deterioration in these would drastically affect the species composition and abundance, and consequently the fisheries productivity. Thus, to mitigate the adverse impacts and environmental degradation, ecorestoration programmes should entail measures such as:

- Prohibiting reclamation of the wetland area for agriculture, aquaculture, human habitation and other purposes and dispossessing of the illegal encroachers from the reclaimed areas.

- Demarcating sanctuary zones within the lakes to protect the spawning and feeding grounds of fish, undertaking weed control

measures, wherever necessary, in a balanced manner involving the fishing communities.

- Creating a buffer zone along the periphery of the lake by developing vegetation cover that would prevent the inflow of sediments, demarcating the lake area to curb encroachment and free flow of silt into the wetlands, and excavating the shallow marginal areas to maintain the water-spread areas.
- Undertaking afforestation programme around the wetlands, giving priority to the plantation of mangroves in case of lagoons that support the fish population.
- Restricting ecotourism to specific sites and educating tourists not to throw solid wastes and other pollutants into the lake.
- Regulating the discharge of human sewage and garbage from the surrounding environs, and pollutants from various point and non-point sources.

Watershed Treatment

Processes such as reckless deforestation, improper land-use pattern and the consequential grievous soil erosion, and hazardous pollution, occurring in the catchments as the outcome of devious anthropogenic practices, have detrimental effects on the wetland ecosystem and its fish resources. Muruganandam and Sarma (2000) correlate the fisheries potential with the efforts aimed at judicious management of watersheds. Thus, an integrated watershed management programme with preventive, progressive, corrective as well as curative measures need to be implemented. The chief strides in this regard would be :

- Implementing various soil conservation and erosion control measures, such as extensive afforestation, land management and riverbank management programmes as per the master plan to check rapid run-off from the catchments in general, and to minimize the silt transport into the wetlands.
- Monitoring the water quality of the rivers discharging into the lake/ lagoons to control pollution and regulating the riverine flow

to maintain the salinity in case of lagoons and to decrease silt/ sediment inflow.

- Reducing the use of chemical fertilizers and pesticides in agricultural practices, reducing grazing pressure in the erosion-prone regions, undertaking pasture development schemes for feeding the enlarging cattle population and checking soil erosion, and discouraging agricultural practices such as shifting cultivation that incite soil erosion.

Research Initiatives

As Lassen (1997) stresses, we need to rely on facts and scientific surveys, not generalizations and misinterpreted data to understand the scope of the issues and achieve sustainable fisheries yield. Hence, further advanced scientific expertise on fishery and other related sectors with resource conservation values and practical applications would reinforce the management initiatives to greater extent. Malone and Nemazie (1996) are of the view that promoting scientific programmes to provide information on trends and underlying causes, and facilitating consensus among scientists and stake holders would lead to ecologically, culturally and economically sound environmental management. The focus of investigations needs to be based on the following aspects:

- Undertaking further long-term study on the parameters such as spawning frequency, stock and recruitment assessments, migration patterns, larval ecology, juvenile abundance, and natural and fishing mortalities, species composition, genetic diversity, food chains and webs, effects of pollutants, human dimensions, species at risk with special reference to economically important species of fish.
- Developing more accurate statistical methods for generating data on various aspects of fish and hydrological parameters, and proper interpretation of these data.

Monitoring Programme

Continuous monitoring of the conservation measures and evaluation of the state-of-affairs of the wetlands on regular basis would reveal

the effectiveness of the management practices in achieving sustainability. Timothy *et al*. (1996) suggest that increased monitoring is needed to determine the cause where real declines are indicated and whether more conservative habitat restoration or fishery management options are required to reverse the decline. The components of the monitoring programme need to be:

- Establishing an inspecting team in the form of a network under the Fisheries Department to supervise the fishing activities within the lake/ lagoon using protection vessels, inspect the landed fish in the landing centers, and observe the compliance of the fishery regulations and the violations, if any.

- Assessing the stock position and updating it every two years, monitoring the recruitment process of marine migrants and releasing stocks from culture sources into the natural waters of the lakes in case of drastic decline.

- Reducing by-catch of less important species and undertaking resource allocation among various stakeholders.

- Observing the tidal prism, salinity level, and the number and position of the inlets (in case of lagoons), the freshwater inflow into the lake through the rivers, and recording the silt inflow into the wetlands at different points, the silt outflow, the degree of siltation, and the rate of nutrient enrichment, especially by nitrogen and phosphorus.

- Monitoring the habitat restoration and mitigation programmes by observing the hydrological regimes and meteorological characteristics through remote sensing, recording the levels of various pollutants and their point and non-point sources, and determining the effectiveness of the management and conservation measures undertaken.

Awareness and Socioeconomic Programmes

The success of the efforts for the conservation and management of the natural resources, such as capture fisheries, considerably reckons

on understanding and emphasizing the social dimensions involving them. Ruddle (1994) states that for designing management systems information is required on the principal socioeconomic characteristics of the fishing community, besides the ecological structure of the system and the basic aspects of the biology and productivity of the living components. Fisheries administration has also to focus on the creation of new employment opportunities for fishermen in order to relieve pressure on the fisheries sector. Thus, Enin (1996) emphasizes on the development of bio-socio-economic models to effectively determine the directions for fisheries management and attain sustainability of benefits from the capture fisheries. Since those very people who stand at the root the problems also hold the key to the solutions, promotion of public awareness, particularly among the fishing communities whose livelihoods are threatened for the drastic decline in the catch, will provide a tool to the success. For changing their hearts and minds, and for making the management efforts more successful preaching is inevitable. The endeavour in this arena should involve :

- Generating and expanding awareness among the fisher folk and other communities inhabiting within and around the wetlands with regard to the functioning of the ecosystem, the fish resources as exhaustible sources and the need to conserve the lake. This can be undertaken with the assistance of audio-visual aids, film shows and literature prepared on the basis of facts and future projections, and through participatory rural appraisal (PRA) methods.

- Establishing 'ecocentres' in the area for environmental education and awareness generation campaign by involving the local NGOs in the motivation programmes, and organising seminars, workshops, padyatras, village-level meetings and other related programmes at regular intervals highlighting the problems faced by the lake and its fishery resources.

- Creating alternative job opportunities for fishermen to reduce pressure on fishery sector and introducing income generating schemes, such as vegetable and fruit production, poultry and pig

farming, cattle rearing, promotion of handicrafts, and utilization of weeds for production of agar-agar, mats, biogas and bio-manure that would provide new sources of self-dependence.

- Reactivating the fishermen's co-operative societies for regeneration of their socioeconomic life and through these organisations strengthening the participation of indigenous people including women in the conservation process.
- Reviewing the socioeconomic state of the fishing communities at regular intervals and providing basic social infrastructure, education, and health and sanitation facilities to them.
- Ousting the prawn culturists and traders from the lake, wherever occurs, since they are encroaching upon the interests of the traditional fishermen and their presence leads to frequent law and order problems and social conflicts.

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Dr J. K. Panigrahi joined teaching in 1982. Prior to this he has an all-first-class academic record with top positions in the universities of Sambalpur and Utkal. His doctoral research was on environmental impact assessment in Chilika Lake with regard to the fishery resources. In furtherance of his academic pursuit he visited Griefswald and Berlin in Germany, and New York and Atlanta in the USA. Dr Panigrahi has been associated with a number of research projects undertaken by the Orissa Environmental Society and has presented over 45 research papers in various international, national and state-level conferences. Dr Panigrahi has been working as the Convener of Indian Science Congress Association: Bhubaneswar Chapter since its inception at Orissa Environmental Society. The Secretary of Orissa Environmental Society for a long period and is associated with many other learned societies. As a resource person he has delivered lectures over 300 times on environmental and scientific issues in various intellectual forums. He has written a series of books and articles on issues concerning environment and science, and has edited conference proceedings, books and journals. He regularly participates in panel discussions organized by Odia TV channels. Dr Panigrahi has been awarded and felicitated by a number of institutions of the State.

AC Bed: An Energy Saving Innovation

(Date of Presentation – 05.06.2016)

B. S. Patro

The electrical power consumption in one of the colonies of Bhubaneswar is measured on the first day of each month at different times of the day. It is found that in the morning, the consumption is about one MW (Mega Watt). The variation of power is not much during the day. It increases by about 20 to 30% in the evening because of street lights and other lighting load. However, the biggest increase is after 10 pm and during midnight when the load is more than 2.5 MW in hot and humid months of the year.

It is reasoned that people return from their work places, spend time with family, have dinner and watch TV before retiring for sleep. Air conditioning systems are switched on to provide a comfortable ambience. It is observed that most people use AC for sleeping purpose only. In the colony, where the study was undertaken all most all households have at least one AC. It may be concluded that the major cause of the spurt in power consumption is air conditioning.

For a comfortable sleep, people make the bed room air conditioned. But only rich and higher middle class persons can afford the electrical energy bill required for room air-conditioning system. For a room of size 14'x11'x10' i.e. a volume of 1540 cft requires an air conditioner of 1.5 T capacity. If it runs for 8 hours per day the monthly electricity bill could be more than Rs. 2500/-. Thus, it is beyond the reach of Aam Adami. A lot of energy is consumed at the national level because now days a very significant number people use AC.

Instead of air-conditioning the entire bed room, if only the bed is enclosed and air-conditioned, it will save significant amount of energy, while giving the same comfort to the consumer. The project

named 'AC Bed: An Energy Saving Innovation' is new as well as innovative and drastically reduces energy consumption. In case the bed is enclosed, it would demand an AC space of 7'length x 5'width x 4' height i.e. 140 cft i.e. about 9 % of the room space. The air conditioner required would reduce to less than 0.2 T instead of 1.5 T of air conditioning capacity. Similarly, the power requirement reduces from about 2 kW to 300 W. This single step alone drastically reduces the electricity bill and makes air conditioning affordable. The power requirement is so less that the AC system can be operated by an inverter for few hours in case of temporary disruption of electric supply.

Further, people living in non-grid areas or places where there is frequent interruption of power supply, cannot avail the benefit of air-conditioning even if they can afford the cost of running the 1.5 T AC. Therefore, It is prudent to use solar energy to power the air conditioning system of the enclosed bed and the good news is that it is affordable to use solar energy to air condition the bed.

The idea to air condition the bed instead of the room is quite innovative. The implementation of this idea could bring immense benefit to the under privileged sections of the society especially the sick, people with low income and the senior citizens. Some of the major benefits, uniqueness, newness and usp of the project are:

- Utilizing a fraction of energy (typically around 15 to 20%, the people can avail the benefit of air conditioning system.
- Solar energy can be used. Low cost solar air conditioning is affordable for common people
- Air conditioning system is useful in non-grid locations or places with frequent power interruptions.
- Especially useful for sick and senior citizens.
- Unlike traditional AC system, it does not add heat to the environment
- It is "Make in India" as well as "Made in India"
- It will drastically reduce the "Urban Heat Island" effect.

- In ICUs where there are several beds, the effect of contamination from one patient to another will be substantially reduced. Each patient can adjust the temperature as per individual need. Supply of oxygen to a particular patient becomes easier.
- At the national level it can pay rich dividend by drastically reducing power consumption in metros and other urban areas.

This project has been designed by the author, former Principal, College of Engineering and Technology, Bhubaneswar, a constituent college of Biju Patnaik University of Technology. The idea is original. The design, guidance for fabrication and testing has been done by the innovator. The performance of the AC Bed meets the aim and objective and in addition has given immense satisfaction. It may be mentioned here that the first prototype of the AC bed is properly functioning and it consumes only 3. kWh (unit) of electrical energy in a period of 8 hours.

To conclude, it can be said that use of AC Bed can change the electrical usage scenario of our country. In case the Government of India or AC manufacturing corporate support this effort, a better looking, more efficient AC bed can be designed and made available in India. In rural areas, solar powered AC Bed can be supplied to hospitals to save critical cases like severely injured and burn cases irrespective of electricity supply through grids. This has a possibility to become a major energy saving innovation.

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Dr B S Patro was born in 1945, in Surada town. After completing BSc Engineering from UCE, Burla, he did his MTech and PhD in Mechanical Engineering in IIT, Kanpur. His area of specialisation is Random Vibration, Fracture Mechanics and Composite Materials. Two of his papers were declared first in all India level and awarded Aerospace Engineering Division Medal, 1986 and Metallurgy and Materials Engineering Division Medal, 1998 of the Institution of Engineers (India).

He was consultant for the project 'Solid Waste Management of Puri town' supported by Orissa Environment Program under Indo-Norwegian Cooperation. Also he provided consultancy to NALCO and OCFL regarding dam safety.

Dr Patro was Instrumental in shifting the College of Engineering & Technology from the premises of OUAT to the present location. He submitted a proposal to Government of Orissa for creating a Technical university and created two new branches namely Information Technology and Computer Science and Engineering in CET on self sustaining basis.

The idea of air- conditioning the bed instead of a room was conceived by Dr Patro. A prototype has been fabricated and successfully tested by him. The device produced in the first attempt will not only save energy to the extent of 80 % but also be environment friendly. It will work in non-grid areas and places having frequent power interruptions.

Geoinformatics

(Date of presentation: 07.08.2016)

Prasanna Kumar

We live in a very dynamic and advancing scientific and technological era and much aware about the efficacy of this in our day to day life. The technological advancement is regarded as a key driver for economic growth and sustainable development. Geo-informatics or geo-spatial technology over the years acquires distinction of being a key facilitator in solving spatial decision making problems.

The application have become more pervasive impacting everyday life from browsing Google images to hearing the siren of the 108-ambulance and the benefits it rendered. It has definitely caught the attention of masses. The technology shows proven capabilities in decision making areas effectively like E-governance, location based information support, sustainable resource management, better management of business processes, disaster management, etc. The applications are already recognized in the National level projects like Rajiv Gandhi National Drinking Water Technology Mission, National Natural Resources Census, National Watershed Development Mission, Re-structured Accelerated Power Development and Reform Programme (R-APDRP), Jawaharlal Nehru National Urban Renewal Mission (JNNURM), Rajiv Awas Yojna (RAY), etc In this context the Secretary General of Federation of Indian Chambers of Commerce and Industry (FICCI) has rightly said "As India endeavors to achieve its developmental goals, the multifaceted and specialized capabilities offered by geo-spatial technologies will play a defining role for information management in future with application of great social and national significance.

What is Geo-informatics:

The term consists of two words, Geo (Earth) and Informatics (The study of information processing). Broadly it can be said that

Geoinformatics deals with the use of information technologies for collection, analysis, storage, retrieval, representation and discrimination of information about the earth. According to Oledzki, 2004, it is "The art, science and technology dealing with the acquisition, storage, processing, production, presentation and discrimination of geoinformation.

Components of Geo-informatics:
Various components of geoinformatics are: **Computer Science:** A discipline comprising hardware and software. It is an automatic device to manage numerous and complex data in every field. **Geodesy:** It is the discipline that deals with the measurement and representation of the earth. It involves complicated three dimensional spherical geometry. **Cartography:** It is defined as the science and art of designing, constructing and producing maps or study of maps. Map is a drawing of the whole or part of the surface of the earth on a plane surface to a particular scale. **Photogrammetry:** The name is derived from Greek words: Photo-meaning light, gramma-means graphy/ drawing and metry meaning measurement. Thus Photogrammetry is defined as the art and science of taking measurements from photographs referred to be aerial (taken from an aircraft) or by remote sensing(taken from satellite).

Remote Sensing: Remote Sensing is the acquisition of data for deriving information about objects or materials (targets) located at the earth's surface or in its atmosphere by using sensors mounted on platforms located at a distance from the targets. Measurements are made in different spectral regions on interaction between the targets and Electro-Magnetic Radiation (EMR).

Remote sensing has maximum advantages. It provides a synoptic view of an area. The data collection is very cost effective and it can provide multispectral data which human eye fails to detect. In inaccessible area the data can be acquired through satellites. Historical datasets help in monitoring, trend analysis and futuristic studies.

First Indian RS satellite (IRS-1A) was flown in 1988. The IRS series of satellites further add sophisticated satellites and improved sensors. They are dedicated primarily to support the national economy in the area of agriculture, water resources, forestry, biodiversity, geology,

marine fisheries and coastal zone management fulfilling the dreams of Dr Vikram Sarabhai, the father of Indian Space programme. The Spatial resolution of pixel has been improved from 72m (ISR-IA/B) to 0.8m (CARTOSAT-2)

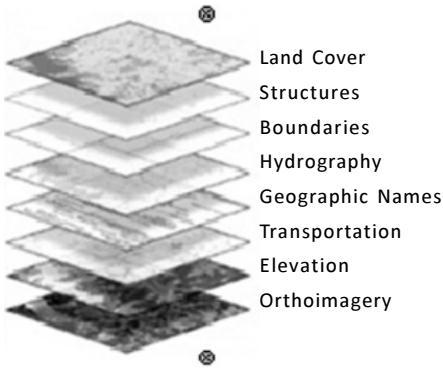
Global Positioning System (GPS)

With rapid advancement of space technology, a new navigational aid is available that works and gives better accuracy. It is called Global Positioning System popularly known as GPS. It is based on constellation of 24 satellites orbiting the earth at a very high altitude (commonly known as Global Navigation Satellite System, GNSS). The ranging technique is based on the measurement of time interval employed by a signal transmitted by an emitter (e.g. satellite radio signal) at a known location to receive at the user receiver. The distance from a known position of a satellite to the receiver end is equal to the velocity of transmitted signal multiplied by travel time of radio waves transmitted from the satellite to receive the receiver. Popular GNSS programme are NAVSTAR (Navigational System with Timing and Ranging Global Positioning System) of USA, GLONASS of Russia and Galileo of European Space Agency. For best accuracies, Differential GPS (DGPS) was developed. India is currently having its own GNSS called GAGAN (GPS Aided Geo-Augmented Navigation) developed by ISRO. The first GAGAN was successfully launched on May 21, 2011. Now there are seven such satellites which are dedicated for GNSS over India and adjacent countries. The positional set up (Latitudes, Longitudes, highest from mean sea level and time of observation) facilitated by GNSS are now widely used by the civilians. Examples include tracking system, navigation, intelligent transport system, weather forecasting, precise positioning, rescue operation, emergency services etc.

Geographic Information System (GIS)

We have discussed in the foregoing paragraph how the modern technologies are being used to gather data and possible applications in measuring, documenting, monitoring, analysis and planning different geo-environmental issues. In this context, Geographic Information System (GIS) is considered as an important tool in planning and decision making. It is extensively used on land use planning, cadastral data organization and linking, forestry, wildlife

management, infrastructure planning, environmental monitoring, disaster management support service, network planning and military surveillance etc. The GIS has been derived from three components viz. i) Geographic meaning related to earth surface ii) Information means geo-spatial data and iii) System means one information management machinery unit called computer which has capability to analyse such vast datasets and should have modules to compute, store and analyse data.



Geographic Information System

Applications of Geo-informatics:

Rapid advancement in Geo-informatics and massive use of mobiles in day to day life drive us towards a digital world where spatial or thematic knowledge is integrated in various applications and programmes summarized as follows.

Natural Resources Management and Ecosystem Studies

These studies cover aspects like (a) Land use / Land cover, (b) Drainage and water bodies, (c) Soil resources mapping, (d) Studies on terrestrial and aquatic vegetation cover and historical change, (e) Shoreline and CRZ mapping- identification areas of accretion and erosion along the coast. (f) Biodiversity estimation, (g) Species richness and distribution, (h) Migration of wildlife including elephant corridor mapping, (i) Desertification - land degradation studies and monitoring, (j) Wetland studies-natural and man-made wetlands mapping and database generation, (k) Water quality mapping and primary productivity studies, and (l) Identification of potential fishing zone.

Agriculture

(a) Crop identification and inventories, (b) Crop area / acreage estimation and production forecasting, (c) Cropping Pattern and cropping system analysis, (d) Crop stress detection.

Land use Planning and E-governance

(a) Land use/land cover mapping in different scale, (b) Rural and Urban planning and infrastructure monitoring, (c) Monitoring urban sprawl, (d) Analysis of urban expansion of different urban local bodies, (e) Urban infrastructure/ facilities mapping- exiting land use/ sewage treatment site analysis etc., (f) National Urban Information System (NUIS), (g) Digital 3-D city models, (h) Smart City (i) E-administration- improving internal workings of the public sector, (j) Land record management, (k) Real time data integration, (l) Building information model, (m) Property and encroachment assessment, (n) Industrial estate management, mapping industrial plots and infrastructure land bank creation using high resolution satellite data. The readers may visit Govt. of Odisha Industrial Land Bank Portal GOIPLUS for details.

Land Records Modernization

Government of India is implementing a project named National Land Records Modernization Programme (NLRMP) for modernizing and management of land records. The major components of the programme are computerization of all land records including mutations, digitization of maps and integration of textual and spatial data, survey/re-survey and updation of all survey and settlement records including creation of original cadastral records.

Disaster Management

Mapping of existing infrastructure, disaster prone areas, networks facilities etc. are needed at all stages of preparation, early warning, relief/ response and mitigation.

Environmental Management

Mapping of environmental sensitive areas, e.g. soil salinity, oil spills, deforestation, land subsidence etc.

Business

(a) Planning for maximum coverage of sale regions, (b) Identification of uncovered areas, (c) Site-suitability analysis for particular kind of business/store, (d) Planning optimum and short route of delivery, (e) Decision support system- reducing risks, and (f) Banking.

Social Science/ Health/ Others areas

(a) Integration of Socio-economic parameters with satellite data on

land use using GIS, (b) Studies on population growth, distribution and density, (c) Road and transport network and built-up area analysis, (d) Archaeological application- delineation of existing archaeological sites and its environs/delineation of anomalous area/ Palaeo channel study, and (e) Application in studying of vector borne diseases.

Odisha Space Applications Centre (ORSAC) is the nodal centre for applications of Geoinformatics in Odisha State. The Centre is for providing inputs to a number of government departments for various development planning activities and societal benefits. The major activities at present include projects related to Mining Joint Survey; Land Bank development for industrial development planning and compensatory afforestation; survey and mapping of urban land utilization; water source targeting and quality monitoring; cadastral map preparation for revenue administration; survey for forest diversion proposals; canal network spatial datasets for irrigation; input generation for Forest Working Plan preparation, plantation monitoring; spatial database generation of police infrastructure;, Rice Crop Acreage and yield estimation and state carriage database for transport etc. The Centre has proved its excellence in the country in the area of web-enabled data services for planning and governance; high-tech survey and micro-level resource mapping besides implementation of satellite communication programmes through the GRAMSAT and EDUSAT projects. The centre is now identified as an implementing agency for operation of the "**Odisha State Data Policy**" approved by Govt. of Odisha. It is also establishing "**Odisha Spatial Data Infrastructure**" for easy sharing of geo-spatial data and enhanced application of such geospatial data in development planning of the state.

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Dr Prasanna Kumar, born on 30th June 1961 is a Scientist from Odisha Space Applications Centre. Dr Kumar is a native of Bhuban in Dhenkanal District. He got his MSc Degree in Geology and PhD degree in Marine Sciences from Berhampur University, and the P.G.Diploma in Remote Sensing from IIRS, Dehradun. Some of the major professional trainings received by Dr Kumar include one on "Integrated Coastal Zone Management" at Asian Institute of Technology, Bangkok in 1993, one on "Microwave Remote Sensing Applications to coastal zone studies" at SAC, ISRO, Ahmedabad in 1989, and several other trainings in Geoinformatics, Environment and Disaster Management. Dr Kumar has around 42 research papers and 31 technical reports added to his involvement in various capacity building activities with membership of learned societies and accredited bodies.

Coastal Erosion at Puri during 1st and 2nd Week of August, 2016

(Date of presentation: 07.09..2016)

Girija Prasad Mohapatra

Preamble

Puri, the well known shrine on the east coast of India has witnessed severe coastal erosion during 1st and 2nd week of August. The erosion of the coast was near the place Swargadwara**,** and stretched for about 400 metres approximately. The width of the beach during December 2015 was 42 mts (tide period unknown) which is observed to be completely eroded.

The town, being the abode of Lord Jagannath, an important Hindu shrine with its silver sand beach, is the foremost important tourist place of Odisha. The coastal erosion thus attracted huge coverage in print and electronic media of the state.

In view of this ongoing coastal erosion a preliminary study and assessment was made by a team of Geoscientists of the Society of Geoscientists and Allied Scientists (SGAT), Bhubaneswar, comprising Dr Surendra Ku. Sarangi, Girija Prasad Mohapatra, Dr B.M.Faruque and Saheed Umar. The scientists carried out elaborate ground survey at the mouth of the river Mangala, the previous eroded site of 2007

Figure-I Coastal Erosion at Puri, near to the Beach Road at Swargadwara (17.08.2016; 16.20Hrs)

north of the present river mouth and the erosional site at and near Swargadwara, on 17th August, 2016.

Background Information

The shoreline at Puri is a linear one trending NE-SW, in parallelism with the trend of Eastern Ghat and Eastern Continental Margin of India. Puri and adjoining area is built over sand dunes, presumed to be of Holocene period. The wider sand dunes at the coast is prominent both on the southern and northern side of the temple town of Puri. The lake of 'Samanga' and 'Sar' on the western side of Puri are possible remnants of the erstwhile regressing sea during the Holocene.

The coast at Puri and its beaches are nourished by sand brought down from the south by longshore current. This littoral current and sediment movement takes place all along the coast in North Eastern direction during the southwest monsoon from March to October. The possible source of the sand could be Rushikulya, Bahuda, MahendraTanaya, Vamsadhara and Nagavalli apart from minor streams and rivulets and earlier deposited onshore coastal sediment.

The Coastal Erosion

The coast or the shoreline is the area or locale of interaction of land and sea. The interplay is between the dynamics of the coastal area such as waves, tides, currents, winds and the land including its geology. The geological factors are, nature of coastal rocks or sediments, sediment input and output in the area, the generalised slope of the foreshore etc. Coastal erosion takes place once a process or processes as above predominant over another.

Normally the coastal erosion could be anthropogenic or natural. The manmade causes are due to construction of offshore structures that obstructs the natural processes such as littoral current movement. The natural causes in a tectonically stable area occur invariably at the river-mouths. Specifically during the Indian monsoon when heavy discharge of water and sediment takes place at the rivermouth. This is evident at the mouth of the river Rushikulya, Devi and Mahanadi, Kushabhadra of Odisha. In addition, the natural causes could be due

to impingement of waves at the coast during, storms, low pressure in atmosphere, cyclones, tsunamis when the energy dissipation of the waves takes place at the shoreline.

Coastal Erosion at Puri

The points that need to be deliberated are-

a. Why there should be coastal erosion in a linearly trending shoreline such as Puri?

b. Whether any variation has taken place in the dynamics of interaction of land and sea at a specific time? That are changes in wave pattern, littoral currents, tides that impinge unusual force on the shoreline

c. Whether the longshore current or littoral current moving the sediment along the coastline was abutted? Invariably it's towards North Easterly direction during the ongoing season.

d. Whether the shoreface (adjacent offshore part of the beach) has undergone any morphological change, so that the waves concentrate or converge at the specific place? Any channel cut was there for causing surging waves to break near the shoreline at the place of Swargadwara area?

e. Any neotectonic subsidence or upheaval has occurred in the local area, off Swargadwara?

f. Does this phenomenon have any relevance with the climatic changes?

Observations and Analyses

It needs a detailed field studies to analyses and arrive at a meaningful conclusion for the coastal erosion that has been witnessed in the area once in 2007 and another time at 2016. The practical handicap is the offshore bathymetric, sediment data that would illustrate any morphological change that has occurred at the shoreface or on the offshore part immediate near to the beaches. Similarly the littoral movement of the sediment in different season hitherto of Puri coast

is unknown and the nature of wind and waves during the affected period (5th August to 15th August) is yet to be obtained.

From the field observations it is gathered that

i. There was abnormal heavy rainfall at Puri on 31st July and 1st August. On 31st it went in the order of 90 mm where as it was 70 mm on the following day. The water on the western side of the town including the Samanga Lake (non existent now) had to be drained through the Mangala River, immediate south of Puri town. This unusual water amount including heavy sediment load was transported through the Mangala River.

ii. Mangala River: This river was not flowing south of Puri Town and was flowing down south in 1930 (Figure-II), *in the year of 1970 there was an artificial canal that was dug to drain part of Mangla river but the river was still active. (Figure III)*

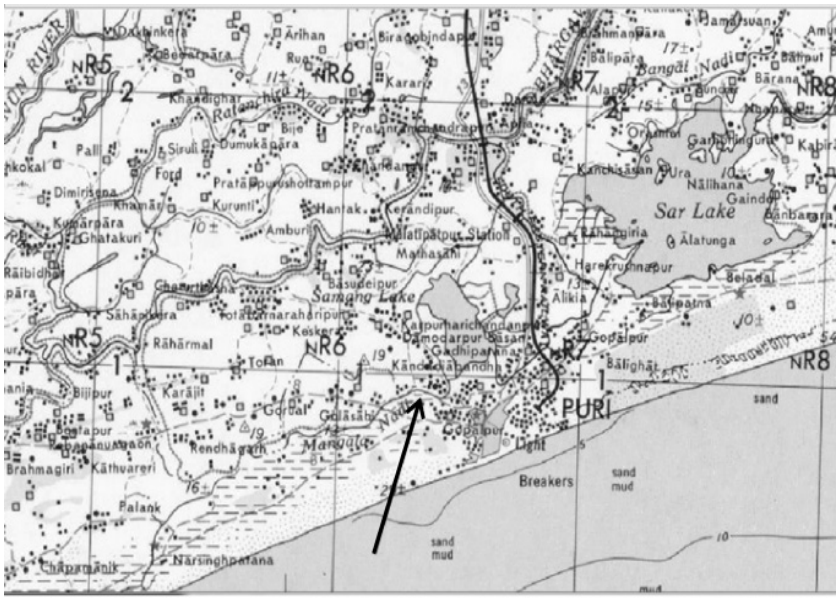


Figure-II, A topographical map of 1930, where the Mangala River was flowing to the Chilka Lake

Fig-III, The Survey of India toposheet, 1970, indicating the artificial canal dug. (Marked by arrow) But the Mangala River flows in its original course

iii. Subsequently the entire Mangla River was flowing through the artificial canal and the original flow was cutoff (Fig – IV).

iv. The so called canal has grown to the present dimension where the mouth is more than 200m width.

Fig-IV, Satellite Image December, 2015, Mangala River mouth migration has created a back water-body, towards NE side.

v. The flow of the river near its mouth was towards N85^{0}E-S85^{0}W, almost parallel to the shoreline. That indicates that another minor spit formation 20 m further offshore of the present shore line was in the offing. (Figure V)

Fig-V Photograph showing the growth of a newer spit near the mouth of River Mangala on 17-8-2016

vi. However this observation needs to be checked on the ground by close mapping on larger scale. Overall the formation of a river-mouth bar of Mangala Nadi in a mega-scale was confirmed. From the breakers of the waves, the aerial dimension of this microbar appeared to be of considerable area.

vii. The trend of the bar was observed to be getting more or less parallel to the shoreline. That indicate that the realignment of the shoreline to the existing wind/wave settings is on the offing and littoral movement of the sediment was attending its normalcy reducing the intensity of erosion at Swargadwara.

Summary

a. The coastal erosion at Swargadwara Puri was accentuated by torrential rain during last day of July and First week of August, followed by huge sediment and water debouching at the mouth of the river Mangala.

b. The sudden deposit of sediment at the mouth of river Mangala, formed an unusual mouth-bar and restricted the longshore sediment movement for the time being.

c. Mangala River is a manmade one as it did not exist prior to 1970? The artificial canal of 1970s and diversion of original Mangala River through this canal is attributed to the threat to beaches of Puri.

d. The blockage of sediment movement by the natural bar formation and possible higher waves during the low pressure over the Bay of Bengal during the first week of August resulted in the beach erosion at the Swargadwara.

e. However, the impingement of the waves at Swargadwara, nearly 3.8 km from Mangala River mouth, could be due to unusual morphological feature of the shoreface (up to 12 m water depth) in conjunction with higher waves due to low pressure and prevailing tide. The depth near the area of erosion could be relatively more resulting in the breakers near to the beach/ foreshore. This need to be studied in detail.

f. The erosion at the Swargadwara appears to be for the time being and the normalcy is expected to return once the weather is fair. However, in case of storms/cyclones or any unusual natural happening such as neo-tectonic movement etc, the erosion at the same or adjoining place may accentuate.

g. There may not be any other criteria such as neo-tectonic movement (earthquake related), or impact of climatic changes which could have resulted in this type of erosion.

h. This may be considered as localized not regional.

Recommendation

a. Subject to restoration of the beach by normal natural processes further erosion of the coast may be arrested by artificial means.

This can be done, with intention to reduce the impact of wave

energy that breaks very near to the shoreline. It is preferred to artificially recharge sand on the immediate southern side of Swargadwara.

The sands of equal size and specific gravity are preferred. If the situation aggravates, wooden logs may be used as barriers to the wave surge in an alignment parallel to the shoreline and filling sand bags at the shoreward side of these logs. Similar type of measures is taken at Ambati, Satabhaya.

b. A base data of the periodical changes of the beach and near-shore part of the offshore zone can be taken up to study the morphology of the shoreface (up to 10-12m Water depth) and sediment types and its seasonal variation.

c. A study can be taken up to decipher the longshore movement of the sediment in the littoral zone in different seasons, say SW monsoon and NE monsoon and fare weather period. The study has to be aided with satellite image.

d. The feasibility of restoration of Mangala River to its original course (prior to 1970s) may have to be studied.(in exigency, when there is abnormal rain or storms or cyclones)

e. A long-term plan is required in view of climatic change and rise of sea level by 2100 AD. The climate change not only will raise the sea level but frequency of storms and cyclones may increase which may have serious impact on the coast, particularly where the township is located.

Sri Girija Prasad Mohapatra
Former Additional Director General,
Geological Survey of India

Sri Girija Prasad Mohapatra completed MSc in Geology from Utakal University in 1975 and joined the Geological Survey of India in December 1977 at A.P. Circle, Hyderabad. His places of work encompassed the states of Andhra Pradesh, Tamil Nadu, Pondichery, Odisha, West Bengal, Jharakhand and Bihar, where he acquired a very wide range of professional experience in aspects like Geological Mapping and Mineral Investigation both inland and offshore, Mapping of sedimentary terrain, investigation for gold and base metals like lead and zinc, coastal zone monitoring, collaborative work with Space Application Centre, Ahmedabad, and he undertook quite a few special projects. At various times of his career, Shri Mohapatra held very responsible and coveted positions of Director for Marine Wing, Dy. Director General, Head of Eastern Region GSI at Kolkata and finally the Addl. Director General- GSI before superannuation from service in February 2014. Sri Mohapatra went on foreign deputations to Denmark, Houston in USA and South Korea. Shri Mohapatra has several scientific publications in national and international scientific journals, and he is a regular contributor of scientific articles to 'Science Horizon', a publication of Odisha Bignyan Academy.

Coastal Erosion in Odisha: Causes and Consequences with Special Reference to Puri Beach Erosion

(Date of presentation: 07.09.2016)

Devananda Beura

Abstract

The deltaic coast stretching from the Rushikulya river mouth in the south to the Subarnarekha river mouth in north witnesses erosion at various locations. In spite of accretions in certain zones, around 36.8% coastline is undergoing severe erosion. Out of 480 kilometre length coast line about 200 km is undergoing erosion, 205 km is undergoing accretion and 32 km coast remain stable. During the last two decades of period, severe to extreme beach erosion are experienced along some places like Satavaya, Pentha, Gopalpur, Puri, Konark-Chandrabhaga-Ramchandi beach etc. The Puri beach suffered the first event of severe beach erosion in 2007 between Lighthouse and Sterling Hotel beaches. After a gap of 9 years, in August 2016, such type of quick and severe erosion is seen at the Swarga Dwar beach. The paper intends to describe possible causes and consequences of beach erosion focusing to the recent Puri erosion.

Introduction

Beach erosion has emerged as a serious issue at the sea-land interfaces all over the world. All most all the coasts of the world suffer from erosion process due to various natural and anthropogenic causes. The Indian coastline on either side of the peninsula and islands is subjected to varied coastal processes that make the coast vulnerable to erosion. One study shows that 3829 km (45.5%) of the coast is under erosion, 3004 km (35.7%) is getting accreted, while 1581 km (18.8%) of the coast is more or less stable in nature (Fig-1). The Odisha coast having 480 km stretch is presently undergoing serious erosion at several locations, which is about 36.8% of the total coastline. Erosion, accretion takes place in the coast line comprising

about 200 km and 205 km respectively, while a length of about 32 km coast remains stable (Fig-2). Zones of erosion are more pronounced at Gopalpur Port, Puri beach, Konark-Chandrabhaga-Ramchandi beach, Astaranga towards Devi river mouth, Paradip-Jatadhar Muhan and South of Dhamra Port. Mostly the river mouths along Odisha coast are highly prone to erosion. Satabhaya/Pentha village in Kendrapara district has been creating great concern since 2004 due to severe coastal erosion and shifting of settlement. The consequences of coastal erosion are manifold in nature among which the resultant loss of coastal infrastructure and important natural habitats such as beaches, dunes, and mangroves are prominent. It also squeezes the distance between land and ocean, thereby increasing the risk on live and livelihood of population.

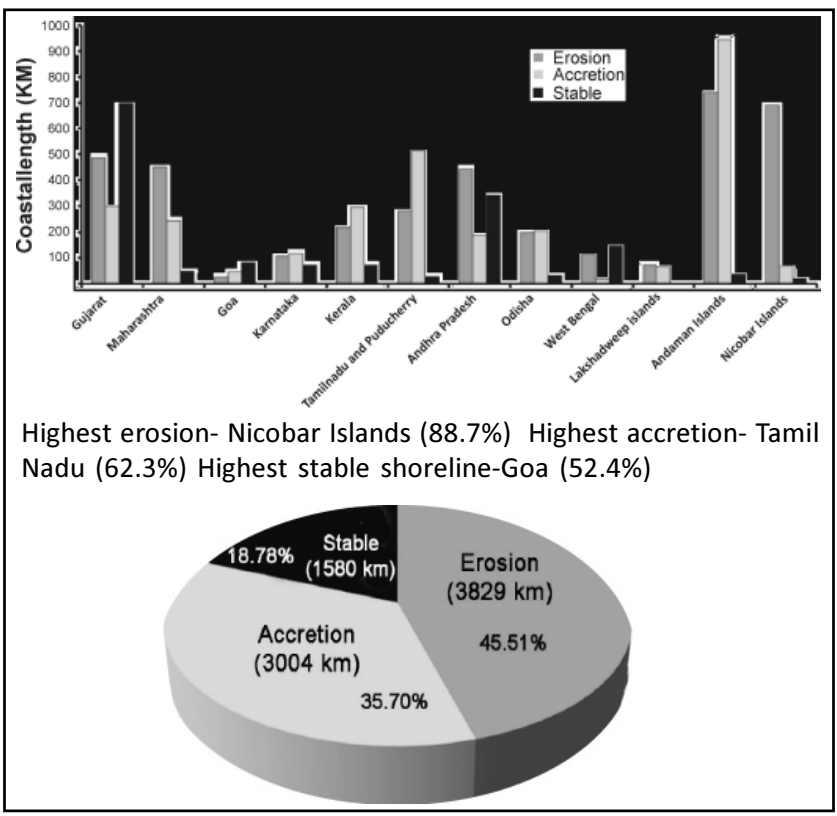
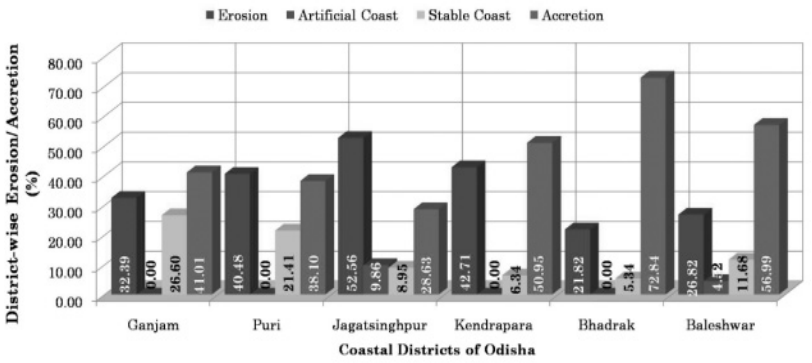


Fig-1 Indian Coast undergoing erosion, accretion and stableness in different coastal states/UTs (Modified after Rajawat et. al., 2015)



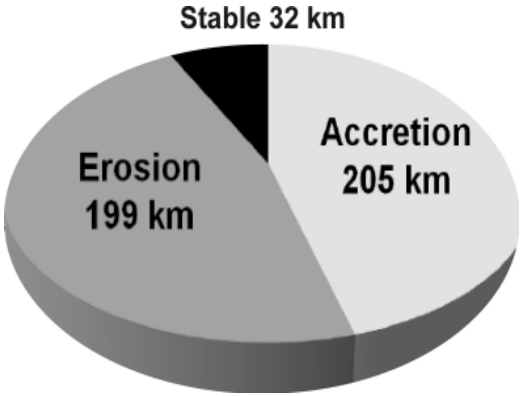


Fig-2 Odisha Coast undergoing erosion, accretion and stableness in different coastal districts (NCSCM, MoEF, 2011)

Puri (19° 47'N; 85° 50' E), the famous pilgrim town and point of tourists' attraction lies almost at the centre of the coastal tract of Odisha. It has a wide and gentle sloping beach of nearly for 7 km length, which has been undergoing continuous erosion process. Though the slow erosion process was not an eye catching phenomenon till 2007, but onshore damage was not scarce. The first event of severe and quick beach erosion was reported on 25 September 2007 in Puri beach on the southern side of Swarag Dwar/ Light house beach, where catastrophic erosion leading to landslide along a stretch of 2 km was observed. There was almost 3 meters vertical cut along the beach side of the road. After a gap of nine years very localized but sever beach erosion started in the 1st week of August 2016 at Swarga Dwar. The high rise tide and gigantic waves touched the coast just 10 feet away scouring 10 feet deep (Fig-3).The quick but quantum erosion got weakened within the next week.

Fig-3: (A) Puri beach erosion in 2007 near Baliapanda
(B) Beach erosion in 2016 near Swarga Dwar

Causes of Erosion

Coastal erosion is the natural or anthropogenic process in which there occurs the loss of land or the removal of beach or dune sediments by wind, wave action, tidal currents, wave currents or drainage and various developmental activities along the coast. Coastal erosion may be long- term induced by wave generated by winds, storms and unusual weather condition. or merely temporary redistribution of sediments. Short term coastal erosion is caused by storm surge, monsoonal high wave and tsunami. Erosion at one place may result in accretion in nearby region. Factors that affect the coastal erosion are wind-wave direction, tidal range, geomorphological setting, groundwater fluctuations, sea level changes and climatic/ meteorological conditions. Anthropogenic pressures including the inevitable development activities along the coast and in the catchment areas of the rivers, land subsidence due to groundwater pumping, Construction of levees, embankments, diversion of water courses due to digging of irrigation canals, changes in land-use patterns, increasing urbanization, increasing domestic consumption of water, increasing use of water in industries have induced changes in the equilibrium of the sediment transport which cause undesirable accretion and erosion along the coast. The causes and consequences of the coastal erosion processes shown in the following schematic diagram (Fig-4).

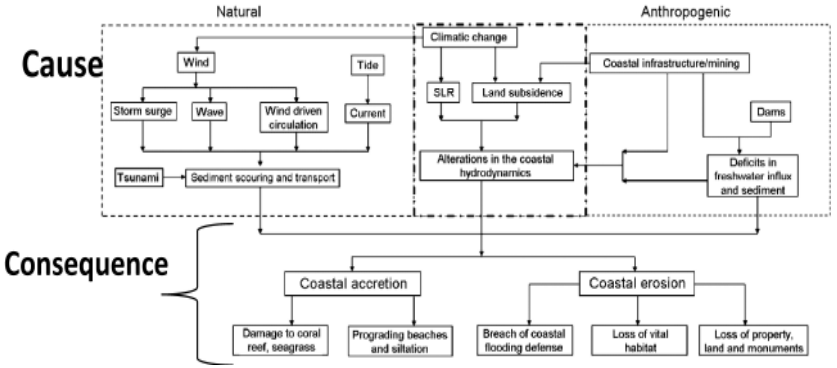


Fig-4: Schematic diagram showing causes and consequences of coastal erosion

Puri Beach Erosion

At Puri coast, the sediments move onshore-offshore and along shore as either bed load or suspended load under the action of waves and currents. Movement of sediments perpendicular to shoreline (onshore-offshore) is responsible for short-term beach changes at small pockets. Movement of sediments along the shore is important in causing major long-term changes of the coastal zone. High tides and strong waves dash the coast in monsoon season frequently that facilitate erosion. The washed out sediments are dragged both by littoral current and off shore transport. If the on shore transport is weak and supply of sediment load is hindered at any point on coast, the erosion is triggered there.

Wind driven waves are the most important parameter that transform or modify the beach characteristics through erosion. Wind direction, particularly long-shore winds initiate near shore currents and thereby littoral drift (Fig-5). Wind velocity intensifies all its impact, and strong onshore and offshore winds contribute to sub-aqueous sediment transport through down welling and upwelling currents. Wind direction along Puri coast remains within the range of 7^0 to 31^0 that strikes at high angle to the coast (Behera et al., 2013). This may stimulate the shoreline sediment movement leading to short term but severe beach erosion.

Over the years, the coastal Odisha has been getting jerks continuously and frequently by Bay-surrounding landmass and submarine earthquakes, although the origin in coastal tract is rare. That indicates the neotectonic activities are going on in Bay of Bengal. It has reduced the length of continental shelf and increased the slope abruptly, which is evidenced by squeezing of fathomline and magnetic anomaly data (Fig-5, 6). This condition helps the current to empower in dragging sediments from beach for which erosion process is intensified at Puri coast.

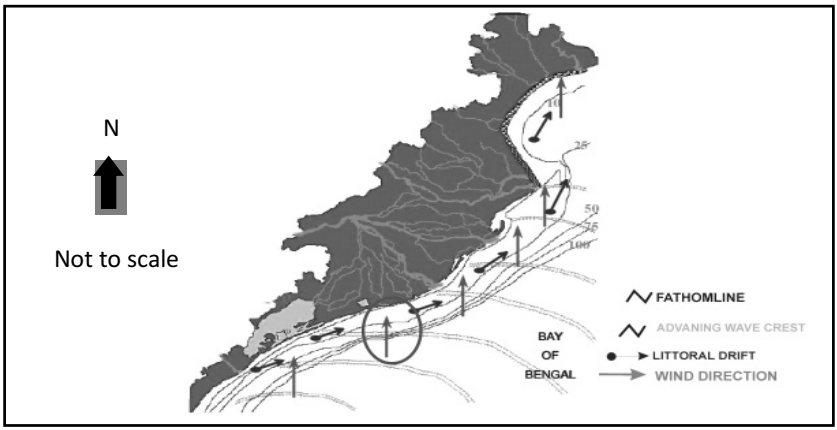


Fig- 5 Wind direction strikes at high angle to Puri coast and abrupt depth zone in continental shelf indicated by closely spaced fathom line.

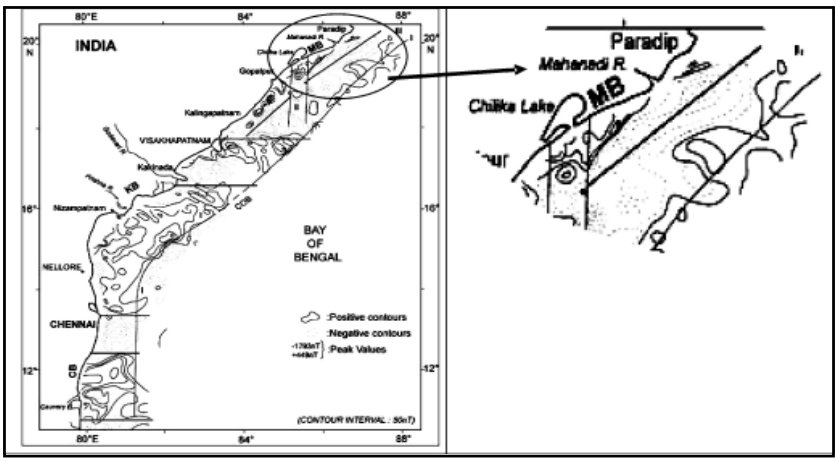


Fig-6 Magnetic anomaly map of the Eastern Continental Margin of India (ECMI) showing Puri coastal margin (Murthy, et al., 1993)

The Mangala, a small tributary of the Bhargavi River falls in the sea near Sterling resort about 2 km west of Swarga Dwar. The natural Mangala mouth has been buried by sand bars and disconnected from sea (Fig-7). It has changed its course little towards east and outpours to sea in a new mouth. As a result, River loads are obstacled at sand bars at original mouth and supply of sediments to sea is getting drastically reduced. The straight fall of river in sea perpendicularly would have imparted high sea-ward inflow energy and absorbed tidal ingress into the hinter river. But by failing these activities, the Mangala river has influenced the onshore current dynamics, particularly the littoral drift is activated. So a quick erosion process is in progress for which the mouth configuration conflict is partially responsible. The Mangala factor for Puri erosion is shown in the schematic diagram (Fig-8)

Fig-7: (A) Mouth of the Mangala river closed by sand bars
(B) River is diverted to east and open new mouth

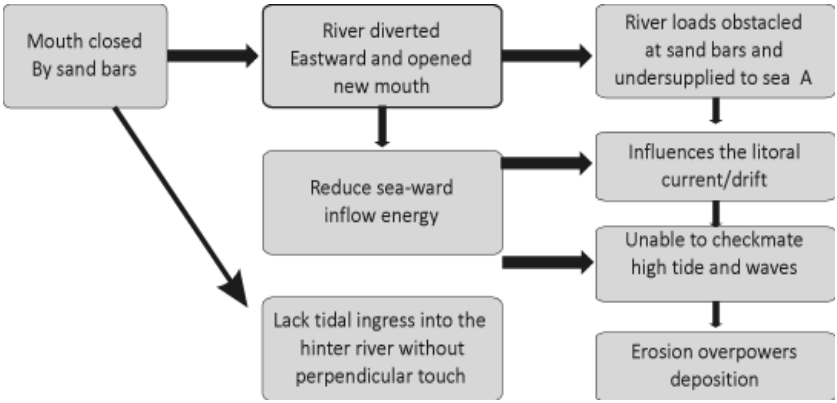


Fig-8 Schematic diagram of Mangala factor on Puri beach erosion

Conclusion

Puri beach erosion in general is due to the high waves and strong littoral currents induced by crustal disturbances in sea floors. Disparity in water flow at river mouths and supply of sediments also impact the current dynamics. Aggressive erosion at much localised points may be due to elevation anomaly in slope of continental shelf. But they are temporary in nature as it is found in Baliapanda in 2007; the situation is recovered by potential accretion. Opening of Mangala mouth will facilitate the tidal ingress into the river so that it may annul the local energetic waves and current. The beach along Puri town is infringed by infrastructure and a slightest tidal inundation and temporary erosion creates panic to people. A minimum buffer zone should be left out adjoining the beach for safe normal tidal activity of sea. Natural barriers like mangroves and Casuarina forests at the buffer zone may be more effective than the implant of geosynthetic tubes, gabion boxes/ mattress against beach erosion.

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Prof. Devananda Beura, after completing his MSc, MPhil, PhD degrees from the P.G. Department of Geology, Utkal University, joined in the same department in 2004 as lecturer. Presently he is serving as Associate Professor there. Having acquired bright academic career, he has deep involvement in teaching and research in geosciences, and interdisciplinary areas. Apart from this, he regularly writes columns in different Odia and English newspapers and is known as a noted columnist in the state. He is actively participating in various interdisciplinary studies and environmental researches. In popularising science, he has written 4 books in Odia. To his credit he has published more than 50 research papers in national and international journals and about 100 popular articles. He has also authored one text book, one research book and two edited volumes. He is associated with a number of professional bodies, social organisations and particularly with research journals as editors or editorial board member.

Water Conservation and Management for Sustainable Future

(OES- release on World Water Day- 22 March 2016)

The Orissa Environmental Society organized a seminar on 'Water Conservation and Management for Sustainable Future' on March 22, 2016 to mark the occasion of World Water Day. The theme of World Water Day 2016 was 'Water and Jobs'. Sj. Prafulla Kumar Mallik, Hon'ble Minister of Steel and Mines, Government of Odisha addressed the Inaugural Session as the Chief Guest. The inaugural session was followed by a panel discussion and an interactive session. The seminar was attended by scholars, experts and engineers on water resources, earth scientists, academicians, agriculture scientists, farmers from remote areas and social workers.

Water is a precious natural resource, essential for survival of mankind as well as the living organisms. Of all water available on the Earth only one per cent is usable i.e the sweet water, and the rest 99 percent is unusable. Out of the one percent usable water 99 per cent is in the form of ground water. A meager 0.86 percent is in the lakes and 0.02 percent is in the rivers. The rain water is stored in the rivers, streams, lakes, reservoirs and ponds. Most of the water in the ground comes from precipitation that infiltrates downward from the land surface. The usable surface water resource in Odisha is 70 billion cubic meter against India's 690 billion cubic meter; while the ground water resource is 21 billion cubic meter against India's 432 billion cubic meter. About 60% of the Odisha's agricultural land is rain-fed; hence, the yield performance of the crops is dependent on the quantity of rainfall. Agriculture contributes to about 30 per cent towards the State's Gross Domestic Product; but however it engages about 60 per cent of the State's workforce in Odisha.

The major contribution of surface water and ground water is for irrigation and agriculture. Potable water has become a matter of concern in most part of the State. Water has to be conserved and judiciously managed for the present and posterity. As per international standard, water availability of less than 1,000 cubic meters per person per year is regarded as a scarcity condition. Water availability in India in 2011 was recorded at 1,545 cubic meter per person per year, which is drop of nearly 500 cubic meter from 2000-2011, with wide regional variations. While public investments have largely focused on surface water in the past, ground water remains a major resource for drinking and irrigation in India. 85 per cent of the drinking water supply in rural India is met through ground water sources, and around 84 per cent of the total addition to the net irrigated area has come from groundwater over the last four decades. Excessive reliance on this source of water has created a situation of over-exploitation of resources in many areas of the country.

The water demand is increasing to meet the need of the burgeoning population and demand of more food production. Besides, the indirect and major contribution of water is in maintenance of thermal and ecological balance. The water demand for mining and industrial activities in the State is also increasing. Such activities also subscribe to pollution of rivers and water bodies. The Motto of Odisha State Water Policy is 'Conserve and Sustainable Use'. The water allocation priorities according to the State Water Policy 2007 are- drinking and domestic use, ecology, irrigation, agriculture, hydropower, agro-industries and non-agro industries, navigation and other uses related to the activities including fisheries.

The collective wisdom of the seminar was in favour of giving priority to conservation and management of fresh or sweet water. The following are the observations of the seminar that addresses to long term conservation and management of our precious water resources for a sustainable future.

01. Being essential for life, water is a common good, the access to which must be maintained for all. But, it appears that water might

become a market good, and thus would be made unavailable for the people, more particularly to the poor, in future.

02. The river is a very active ecological entity, which supports a large number of activities that includes recharging of aquifers that provide drinking water and other needs of the community, supports floral and faunal biodiversity unique to each habitat, and empties silt into the sea. Odisha State has the privilege of many rivers and streams.

The major rivers among those are Mahanadi, Brahmani, Baitarani, Rushikulya, Vansadhara, Nagavali, Kolab, Indravati, Bahuda, Subarnarekha, Burhabalanga. The farmers and people in general depend on these rivers for irrigation, drinking, domestic use, and domestic animals.

03. Water scarcity is going to be more acute due to weather aberrations. Water management has now become an ethically sensitive issue. It should best be managed by its users at the level of the river basin. In absence of appropriate watershed management, the silt escapes from the catchment area faster and deposits on the river bed making the river shallow leading to loss of capacity to retain more water. Once there is flood, water flashes out of the river, and the perennial river gradually turns to be seasonal river. The hill areas are denuded due to shifting farming, mining, industries and other land use practices. The water holding capacity of the rivers needs to be enhanced by removing silt from the river beds. Appropriate land management and land use for agriculture, horticulture and such other activities would be long term management of watersheds and water retention. Scientific watershed management with adequate vegetation cover and tree plantation will arrest siltation of river beds and also generate job opportunity for the rural farmers.

04. Lakes, reservoirs, ponds, pools are the fresh water bodies that store rain water. These water bodies are losing their water storage capacity due to inadequate rain, siltation and weed infestation. Therefore, revival of natural water bodies are badly necessary.

The water bodies need to be desilted to harvest and store more rain water. And more new water bodies are to be created. Water bodies are essential for drinking water, irrigation, pisciculture and various other purposes.

05. Ground water level of urban and rural areas has been reducing sharply. About 60 per cent of tube wells are not functioning. Aquifers and rainwater harvesting structures, and forest cover have to be increased in order to maintain the ground water level. The ground water is also to be kept free from contamination, more particularly in mines and industries areas.

06. The Union Ministry of Water Resources observed that, in the past, structures like dams and barrages were designed without factoring in e-flow. In the process, not only have the rivers become fragmented, but most of the floral and faunal species have become extinct. There are certain stretches where a river has become completely dry. It needs to be recognized that the environmental flow (e-flow) is a necessity for the survival of a river, for it to perform its ecological functions and also to ensure that the cultural dependence a community has on the river is maintained.

07. Almost all the rivers bear the burden of river valley dam projects. Dams are constructed on the rivers in order to control flood, store water, harvest rain water, generate electricity, and meet the need of irrigation and drinking water. Removing silt is as expensive as constructing new dams, experts observed. A report by South Asia Network on Dams, Rivers and People (SANDRP) states that we are losing at least 1.95 BCM storage capacity (all over India) through siltation every year, valued at about Rs. 2,017 crore at replacement cost. The losses are alarming and the consequences are far reaching. Therefore, adequate environment and soil conservation measures need to be taken to maintain the life of dams.

08. The State has not risen to the occasion of appreciable irrigation facility; therefore, monsoon rain is the major source of water for

crops. The fertile land, skill of farmers have been underutilized due to lack of irrigation facility, even though the State has enough water potentiality in its rivers, reservoirs, ponds and other fresh water resources. Irrigation intensity in the state, as of 2006-07, was 31 per cent in comparison to the all India average of 44 per cent. Even irrigated agriculture is threatened by drought as stored water supplies are depleted. 80 per cent of water of our rivers is drained into the sea without utilization. A major part of this water could be harvested and utilized during lean period.

09. The Angul, Talcher, Dhenkanal, Sukinda, Joda-Barbil, Kalinganagar, (Jajpur), Jharsuguda, Ib Valley, Paradeep, Damonjodi, Rayagada are some of the areas where mining and industrial activities are active. To cite an example, in Sukinda area the individual projects have installed effluent treatment plants to reduce discharge of hexavalent Chromium. Yet the Damsala river flowing in the area has high concentration of hexavalent chromium which is quite harmful to human beings as well as flora and fauna. In order to solve the problem of water pollution the point and non-point source of water pollution needs to be addressed. Source prevention and treatment is ideal than the end-of-pipe treatment. The efforts at the government level are not enough to address this important issue. There should be people's participation in containing pollution of water caused due to industrial discharges as well as dumping of municipal solid waste and sewage. In this case regional approach of environmental management is an effective solution to reduce pollution and enhance land and water ecology through scientific restoration.

10. The responsibility of plantation on the over-burden and barren hills lies on the mines and industries. Huge quantity of water can be harvested in the abandoned mines during rainy season with much less efforts. With measures to make this water free from contamination, it can be used for irrigation.

11. The ground water potential is high but the distribution is uneven. However, the ground water is more reliable storage option in

times of drought, as it is not lost through evaporation. Both in urban and rural areas the ground water is more dependable as assured source of water, more particularly when drought condition prevails. High rise buildings in the urban habitations draw excess groundwater. Urban water supply can benefit more at lower costs and greater reliability from developing better water management techniques such as rain water harvesting, conserving and developing aquifers, protecting local water bodies and rivers, treating and recycling sewage and recharging ground water.

Ground water occurring in the unconsolidated sediments underlying the coastal areas constitutes about 25 per cent of Odisha's geographical area. The major problem here is the occurrence of the saline groundwater in juxtaposition with the fresh ground water. Once saline groundwater, which is below the fresh groundwater, comes to upper horizon there will be no room for fresh groundwater. Caution in indiscriminate pumping out of fresh groundwater is advised, since there is risk of saline water occupying the void left by fresh groundwater. The importance of resource identification and allocation on area and sector specific basis need not be over emphasized. The main challenge is the sustainable development of the ground water catering to the needs of the domestic, agricultural and the fast upcoming industrial sector.

12. Coastal Odisha constitutes about 25 percent of the total area of the state. The area is built up by the sediments deposited by the rivers like the Mahanadi, Brahmani, Baitarani, and Subarnarekha mainly. There is problem of scanty among plenty of water in the coastal areas. The ground water as well as surface water is prone to salinity. Therefore, the coastal areas need separate treatment. Prevention of water pollution in coastal water for protecting coastal biodiversity should be the main thrust to implement the environmental safeguards as coastal population in general entirely depends on the coastal productivity. The potable water availability in coastal areas is also low. Sustainable development of ground water in the coastal areas demands a sound

management practice. The ground water development and management plan has to be tailor-made to suit to the local conditions in each of the areas.

It needs to be recognized that

- The water resource is going to be a scarce essential commodity because of the problem of climate change and increasing intensity of global warming; and
- The water bodies play the pivotal role in maintenance of thermal balance and ecological balance of local areas.

With this background on the status of usable water the following actions are recommended for equitable sharing and sustainable use.

- Water allocation priority as provisioned in the State Water Policy 2007 shall be strictly adhered to.
- Village ponds need to be maintained sustainably which requires periodical renovation. These ponds serve the purpose of drinking and other domestic uses. Pisciculture may be allowed in the ponds which is profitable but it should be organic under the management control of the Panchayatraj Institutions. Application of fertilizer, pesticide and food additives should not be allowed.
- The local communities in the river basins are the custodians of water as natural resource. Their right for its management, and use for the purpose of drinking, domestic use, irrigation, agriculture, without affecting the e-flow needs to be honoured. The government may play the facilitating role in this regard.
- In all river basins, small or large, e-flow of water may be studied. While permitting activities on water use it is to be examined if such activities affect the e-flow (environmental and ecological flow).
- Over drawing of ground water runs the risk of contamination. The problem is more acute in the coastal areas on the Bay of Bengal coast. By enhancing surface water storage capacity dependence on ground water can be reduced.

- Installation of solar panels requires vast areas of land. Such projects may be encouraged over the water bodies so that one need not search for land. This will also meet the requirement of lighting in the area.
- Real estate developers, commercial farms, mines, industries and such kind of other projects may be asked to rely on their own captive water harvesting structures preferably instead of drawing water from the rivers, lakes, reservoirs, ponds, and ground water.
- Adequate tree plantation around the water bodies and river basins may be encouraged to maintain the water cycle and the level of surface water as well as ground water level.
- Watershed management with green cover and soil conservation measures will help prevent siltation in the water reservoirs, lakes, ponds, rivers and streams. This will enhance water storage life of water bodies and prevent accumulation of earth on the river beds. Most of the river beds are now shallow and suffer from flash floods whenever there is intensive rain.
- The aims and objectives of the National Water Policy 2012 and State Water Policy need to be discussed at farmer and consumer levels.
- Intensive education and awareness activities among educational institutions and communities for wise, judicious and need-based use of water will help a long way towards conservation and efficient management of water as the precious natural resource.

Awards and Felicitations

Prasanna Kumar Dash Memorial Lecture

Year	Guest Speaker
2015	Shri Priyanath Padhi, Former Principal Chief Conservator of Forests, Odisha
2014	Prof. Dr-Ing. Omkar Nath Mohanty, Director, Technology and Academic Initiative, RSB Metaltech, RSB Group
2013	Dr Trilochan Mohapatra, Director, Central Rice Research Institute, Cuttack
2012	Shri Bijay Kumar Patnaik, Former Principal Chief Conservator of Forests & Chief Wildlife Warden, UP

Lifetime Achievement Award

Year	Awardee
2015	Prof. Satyananda Acharya, Former Vice Chancellor, Utkal University
2014	Prof. Rebati Charan Das, Former Vice Chancellor, Berhampur University
2013	Dr Chitta Ranjan Mohapatra, Former Principal Chief Conservator of Forests (WL) and Chief Widlife Warden, Odisha
2012	Prof. Madhab Chandra Dash, Former Vice-Chancellor, Sambalpur University

Environmentalist of the Year

(Smt. Parbati Mishra Memorial Award)

Year	Awardee
2016	Dr Sudhakar Kar, Former Sr. Research Officer, Forest Department (Wildlife Wing), Govt. of Odisha
2015	Dr Lala Aswini Kumar Singh, Former Sr. Research Officer, Forest Department (Wildlife Wing), Govt. of Odisha
2014	Dr Chandra Sekhar Kar, Former Sr. Research Officer, Forest Department (Wildlife Wing), Govt. of Odisha (posthumous award)
2013	Dr Bibhudhendra Pratap Das, President, Odisha Krushak Maha Sangha
2012	Dr Sudarsan Sasmal, Former Principal Scientist, Central Rice Research Institute, Cuttack
2011	Mr. Prafulla Kumar Dhal, Director, Biswa Research and Innovation Centre
2010	Mr. Biswajit Mohanty, Wildlife Society of Orissa

B.C.Panda Award

For Environment and Science Communication

Year	Awardee
2015	**Dr Chitta Ranjan Mishra**, Former GM, NALCO
2015	**Dr Bijay Ketan Patnaik**, Former PCCF (Wildlife), Odisha

OES Activities

Interviews of the Year

Dr S. N. Patro – Pioneer, 7 June 2016

(Interviewed by Sugyan Choudhury)

Let State Government soon facilitate Mahendragiri biosphere reserve

Professor **Sundara Narayana Patro** is not only an academician of repute but also a trendsetter environmentalist. As a botanist, he dissected plants and flowers and found them pulsating with life and while in his garden and in the lap of nature, he felt the vivid intimations of immortality and so he was full in love with nature's flora and fauna including its biodiversity. The Orissa Environmental Society (OES) was his brainchild that took its inception in 1982 spreading awareness of environment. He has authored more than 30 books on natural habitat, biodiversity, environment, science, etc. He has bagged the Biju Patnaik Award for Wildlife Conservation 2009 and the Prakruti Bandhu Puraskar 2015 of the State Government. As a precursor of environmental enlightenment, he believes that man should maintain the desired chemistry of relationship with nature for his need and not for his greed. In an interview to *The Pioneer*, Dr Patro shared his views with **Sugyan Choudhury** at the OES headquarters in Bhubaneswar.

Professor Sundara Narayan Patro

What's the significance of the World Environment Day?

The day, as the name suggests, concerns the preservation and protection of global environment. In 1972, the first world convention of its time was held in Stockholm of Sweden. This is where 170 nations discussed on the issues relating to the emerging problems and predicaments of environment of the globe. In 1992, another world convention took place in Rio de Janeiro, Brazil, where 192 nations participated. This is known as the Earth Summit. All the nations felt deeply concerned for the global environment for which many action plans were chalked out known as Agenda-21. Finally in 2015, another

World Summit in Paris was held. Here, 196 countries formed solidarity expressing their determination to follow the rules and reduce the greenhouse gases like carbon dioxide, nitrogen oxide, sulphur dioxide, methane, chloroflouro carbon, water vapour etc. India also agreed to reduce its national GDP by 33 per cent to reduce the greenhouse gases. Besides, all nations including India agreed to generate power up to 40 per cent of the total power consumed from nonconventional energy sources like solar energy and from other renewable energy sources. Besides, the nations agreed to provide forest cover by planting trees so as to absorb 2.52 billion tonnes to 3 billion tonnes of carbon dioxide from earth's atmosphere. They also agreed for zero tolerance to illegal trading of wildlife.

What's illegal trading and loss of wildlife?

Can you cite an example?

This is occurring in many countries including Africa, India. Take a case in Odisha. On replying to a question, the Forest and Environment Minister said in the State Assembly that there was loss of lives of 193 elephants in our State between 2013 and 2016. He also further confirmed that 41 elephants died due to poisoning, poaching and electrocution. You will be again surprised to know the Wildlife Cell of the Crime Branch police recently arrested nine persons including a hardened poacher from whose house eight tusks were seized in Boudh district. Thus, many valuable creatures like pachyderms, tigers, leopards and wild deer have been killed leading to large-scale depletion of the endangered species. I want to tell you that the 1972 convention prohibited poaching of 1,800 species of wildlife.

What's the difference between the conventions of 1972, 1992 and the recent Paris convention of 2015?

While the 1972 convention set the ball of international discussion on environmental awareness rolling, the 1992 convention further confirmed it with many agenda. But the decisions of the earlier two conventions were not binding upon nations. But in 2015, the decisions in Paris became a legal document and it was binding upon each and every nation for strictly adhering to the agenda.

What are the achievements of your organization so far?

Our Orissa Environmental Society was a figment of my imagination that took its birth in 1982. It has achieved many things, and it has still miles to cover. Its major significant achievement is declaration of the Similipal sanctuary and forest as a biosphere reserve in 1994, which happened after our society's prolonged efforts. This is one of the 18th reserves of India and the first of its kind in Odisha. Our second achievement is in the Talcher-Anugul region, which is one of the 23 hotspots in India as identified by the Central Pollution Control Board. Our society conducted a detailed research under the Indo-Norwegian cooperation of which incidentally I was the principal coordinator. After a deep study, we found that the water of the area contained more than the permissible limits of fluoride, which is dangerous for health. Basing on

our findings, Rs. 8 crore was sanctioned and the people of nearby 14 villages are provided with fluoride-free water. The Indian Science Congress Association had its chapter here in our society in 1996 that helped in promotion and propagation of scientific awareness on environment. I was its first convener.

What are the further plans on your agenda on similar lines?

You will be glad to know that our Society is now bent on putting all its efforts to see that the Mahendragiri region is declared as a biosphere reserve. Compared to Similipal, Mahendragiri of Odisha is more ancient endowed with rich biodiversity. Mythologically, historically, culturally, biodiversity-wise, it is more enriched than Similipal and richer than any other reserve of the country. The Indian Institute of Wildlife had conducted a survey and advised the State Government to take initially a 50-sqkm area as biosphere reserve and then to develop it to 5,000 sqkm. The Government has been told to do so since 1998, but nothing has been done so far. In 2011, the Government had formed an expert appraisal committee to give its opinion. The committee too recommended in the positive. I have also submitted many research findings on behalf of our Society to facilitate the noble cause. But all these are being dumped in the cold storage of the Secretariat. That should be our State's dream project too that will bring laurels not only to the State but also to the country.

How do you feel about the reckless felling of trees in the name of development?

I shall tell you an incident relating to a tree at the Bhabha Atomic Research Centre campus, Mumbai. Dr Homi Bhabha was busy in his research. Someone informed him the solitary mango tree in front of his laboratory was needed to be mowed down for facilitating the road inside the research centre. Dr Bhabha came out of his laboratory and examined the spot and immediately directed the engineer that the tree ought not to give way to the road, but the road should give way to the tree. The engineer at once understood his mind and ensured that the road go in a different way leaving the tree intact. You can understand that the Tree Act in the model USA and even in the model of New Delhi should be introduced here in Odisha as well as throughout the country besides preserving and protecting our flora and fauna.

What's your message to the future generation?

The future generation should depend on nature for their need but not for their greed. They should follow Gandhiji, who loved nature without ever wishing its wanton destruction in the name of development.

Dr Lala A K Singh - ORISSA POST, 8 Sep 2016

(Interview by Orissa POST)

'We need to be TOLERANT'

It has been said that if one doesn't have the passion for wildlife one will never be able to understand how animals, be it of any variety or species, feel and think.

Dr Lala AK Singh *has been one of the doyens of Orissa in wildlife conservation, especially tiger. His scientific papers have been published in various international publications including WWF magazines and journals.*

Orissa POST *caught up with the 'young' 64-year-old wildlife expert. Excerpts…*

The recent tiger population in the country has been pegged at a little over 2,200 approximately. Can you say that it is correct figure?

I don't know how to explain this to you. Tiger census was started way back in 1972 and then the figure was approximately 1,800. Those were the days when pugmark used to be counted. It is the most scientific method, you can't find out the exact population of the tiger unless you dirty your pants.

So you have doubts about the figure?

I wouldn't directly say 'yes' or 'no'. I would say that a tiger doesn't walk in the air, so instead of high-tech methods like the trap camera etc, one has to get down and identify the pugmarks. The pugmarks identify the male, female and cubs. But pugmarks census was last done 12 years ago.

Look, it is a well-known fact that the human population increases by 20% every decade. So that means deforestation is taking place at a rapid pace. If that happens, how can we say that growth in tiger number is happening? But even then I would like add that good work is being done in trying to increase the tiger populace.

How do we reduce the man-tiger conflict that is hampering their growth?

First of all, I wouldn't call it conflict, I would call it man-animal interface. Actually we are not tolerant to any animal species. That is why the face off is happening. Even if you study the case of elephants, you will see this same stand-off. More and more elephants are straying into our habitats because their areas are being taken over by human beings. So for food, they are trespassing into our lives. Similar is the case with the tiger. It lives within a particular

territory and is dependent on its food in that area. If we try to take over the area, there will be conflicts. Human beings are diverting tiger territory for other kinds of use. We should be more tolerant and develop land scientifically so that both can survive. We can't have a world without tigers. It will create ecological imbalance.

The Orissa government has recently said that there are 40 tigers in the state. Your observations.

Look, I will go back to my earlier answer…..I don't go by virtual figures. There has to be 40 different pugmarks then. Just trap cameras won't suffice.

How do melanistic tigers happen? Have you in your career seen any melanistic tigers?

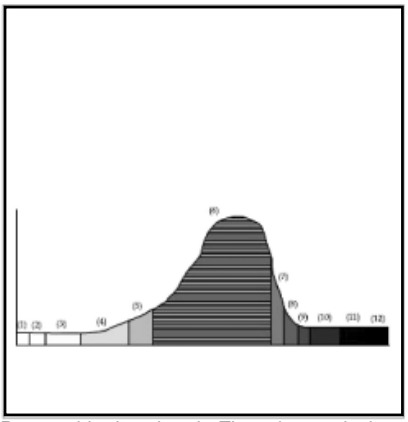
I will start with the second part of your question first. I first saw a 'black' tigress in 1993 which was killed at Podagad village in the western periphery of Similipal. It proved that melanistic tigers existed in Orissa. One was also seen at the Satkosia forest reserve in Dhenkanal district. And later on, I have on a number of occasions, seen melanistic tigers.

Now returning to your question as to how it happens. There are 14 different variants in tiger colours (12 shown in graph). Normally a tiger's coat displays a combination of three colours – white, yellow and black. The background colour of the body is controlled by a set of 'agouti' genes and their alleles. "Tabby" genes and their alleles control the stripes. Built within the two series (background and stripe) some genes determine the location and quantum of expression of three main skin colours – white, yellow and black. The absence of any of these colours creates variants. So when the yellow is minimal it can lead to white tigers. Similarly dominant black genes will produce melanistic tigers.

But then I must add one thing here. Melanistic tigers are nature's aberrations and they will ultimately cease to exist. They are not normal and nature does not like anything abnormal.

So ultimately does this picture look rosy for the tigers?

I would say this much. People are aware now that we need tigers to maintain the ecological balance. That is indeed a huge step forward.



Range of body colour in Tiger: from stripeless white (1), white (2,3,4), golden (5), shades on normal (6), rufous (7), brown (8,9), melanistic (10), blue (11) to black (12). From "Born Black" by L. A. K. Singh (1999), World Wide Fund for Nature- India, New Delhi.

Annual Reports

2014-15 REPORT (Upto October 2015)

Lectures and Discussions on Science and Environment

26.10.2014:
The 33rd Foundation Day Function was observed with Talk on 'Utilization of Effluents from Integrated, Steel Plants- Some Examples' by Prof. (Dr) **Omkar Nath Mohanty**, Director, Technology & Academic Initiative, RSB Group, Pune. The Chief Guest at the function was Prof. (Dr) **Siba Prasad Adhikary**, Hon'ble Vice Chancellor, Fakir Mohan University, Balasore. Lifetime Achievement Award was presented to Prof. **Rebati Charan Das**, Former Vice Chancellor, Berhampur University and Chairman, Odisha State Pollution Control Board

02.12.2014:
Pollution Control Day. There was an Interaction Meet on 'Current Issues of Environment and Development in Odisha State'. Sj. **Subhrakant Panda**, MD, IMFA, who was the Chief Guest at the function and he was felicitated.

11.01.2015:
Popular talk on 'India's Space Mission', by Dr **Ashok Kumar Rath**, Prof. in Civil Engineering, KIIT University and Former Scientist, ISRO.

01.02.2015:
Popular talk and participatory discussion was held on 'Tiger Conservation and Current Census Issues' with Dr **Lala Aswini Kumar Singh** as the Chief Discussant.

01.03.2015:
Popular talk on 'Tiger Conservation in Central India Landscape' by Dr Debabrata Swain, Inspector General, National Tiger Conservation Authority (NTCA), Nagpur Region, Nagpur

07.04.2015:
World Health Day 2015 observed with theme "Food Safety (From Farm to Plate, Make Food Safe)". The Guest of Honour was Dr **Banambar Ray**, Head, Critical Care Medicine, Apollo Hospitals, and the Guest of Honour was Sj. **Krishna Chandra Mishra**, Founder, eKutir; and Co-Founder Veggie Kart and Veggie Health Sollutions (USA). The Chief Guest was Sj. **Sahadeva Sahoo**, Former Chief Secretary, Odisha, and President ACAS.

03.05.2015:
Popular talk on 'Environmental Protection and Green Laws in India' by Mr. **Bibhu Prasad Tripathy**, Senior Advocate, Odisha High Court, who is also the General Secretary, Progressive Lawyers' Association, and Member, State Bar Council, Bhubaneswar

05.06.2015:
World Environment Day 2015 was observed with popular talk on 'Seven Billion Dreams. One Planet. Consume with Care'. The Chief Speaker was Dr **Madhumita Das**, Professor of Geology, Utkal University. Addresses were also by the Chief Guest Sj. **Arun Misra**, Vice President, Project Gopalpur and Managing Director, Tata Steel SEZ Ltd. The Panellists included Dr **Sangram Keshari Nayak**, Former Principal Scientist, CRRI, Cuttack; Prof. **Lalita Mohan Garnayak**, Dean, College of Agriculture, OUAT; Prof. **Md. Hussain**, Dean, College of Forestry, OUAT, and Mr. **Pranab Ranjan Choudhury**, NRMC Pvt. Ltd.

05.07.2015:
The 66th Van Mahotsav 2015 was observed in collaboration with Khordha Forest Division at Khordha.. Activities included Plantation of saplings and public meeting.

Popular talks on 'Plant One: Protect One' were delivered by a number of Guests including Mr. **Akshaya Kumar Patnaik**, DFO, Khordha Forest Division, the Guest of Honour, Mr. **Sudhakar Mohapatra**, Former CCF, Odisha, the Chief Guest Mr. **Bijay Ketan Patnaik,** Former, PCCF (WL), Odisha.

02.08.2015:
Popular talk on 'District Mineral Foundation' by Mr. B. K. Mohanty**,** Former Director of Mines, Govt. of Odisha

06.09.2015:
Popular talk on 'Soil Health: Present Scenario and Future Vision in Odisha' by Guest- Dr **K. K. Rout**, Professor, Soil Science, OUAT

05.10.2015:
The Wildlife Week and a Day for Elephant Theme: 'Wildlife Conservation – Priorities Ahead' were observed with Save Elephant Foundation Trust (SEFT). The Guests were Mr. **S S Srivastava**, IFS, PCCF (Wildlife), Odisha; Dr **Debabrata Swain**, IFS, IG, NTCA, Central Region, Nagpur, and Mr. **Saroj Kumar Patnaik**, IFS, Former PCCF (Wildlife), Odisha.

Annual Reports

2015-16 REPORT (upto October 2016)

Lectures and Discussions on Science and Environment

25.10.2015:
The 34th Foundation Day Function was observed with Prasanna Dash Memorial Lecture by the Guest Speaker, Shri **Priyanath Padhi**, Former PCCF, Odisha on the topic 'Conservation of Environment and the Poor: A Social Dimension'. Chief Guest, Sj Sudhansu Bhushan Mishra, Former Chief Secretary, Odisha Presentation of the 'Lifetime Achievement Award' to Prof. **Satyananda Acharya**, Former Vice Chancellor, Utkal University (Citation read out by Dr **B. M. Faruque**, Vice President) Presentation of the 'Dr BC Panda Award for Environment and Science Communication' jointly to Dr **Chitta Ranjan Mishra**, Former GM, NALCO and to Dr **Bijay Ketan Patnaik**, Former PCCF (Wildlife), Odisha (Citations read out by Dr **Rekha Das**, Secretary; and Dr **Lala A.K Singh**, EC Member)

01.11.2015:
National Environment Awareness Campaign (NEAC) 2014-2015 was observed with popular talks on Combating Desertification, land Degredation and drought. A booklet "Jayadeva Vatika"was released on the occasion. Representations were from Centre for Environmental Studies (CES), Khandagiri Anchalika Bikash Parishad (KABP), Jaydeb Walkers Club (JWC), Jaydeb Batika Yoga Sadhana Kendra (JBYSK), Ministry of Environment and Forests (MoEF), Odisha Forest Development Corporation (OFDC) and Lions Club, Bhubaneswar. The Guests included Mr. **Rudramani Sahoo**, D.M., OFDC Prof. **Sailabala Padhi**, Director, CES Mr. **Gadadhara Mahapatra**, Trustee, Jayadeb Foundation Trust Mr. **Ramesh Chndra Sethi**, G M., OFDC

24.11.2015:
Heritage Week was observed at Khandagiri-Udayagiri Twin Hills in joint collaboration with Khandagiri Anchalika Bikash Parishad (KABP) and Archaeologica Survey of India (ASI). OES-Guests included Sj. **Ashok Chandra Panda**, Hon'ble Minister, Culture and Tourism, and Dr **P.K.Patshani**, Hon'ble MP

06.12.2015:
Popular talk on 'Human-Environment Relationship, Its Synergies in Ganga Basin - A Coincidence or Consequence' was delivered by Guest Speaker Dr **Krishna Chandra Sahu**, Former Prof. IIT-Mumbai

29.12.2015:
UGC Seminar on Industrial Pollution Hazards and Mitigation was organized by Hindole College, Dhenkanal District. Hindole College. The Chief Guest was Prof. **Prafulla Kumar Jena**, Former Director General, IMMT, the Guest of Honour was Prof. **Madhab Chadra Dash**, Former Vice Chancellor, Sambalpur University & Chairman, Odisha State Pollution Control Board. OES collaborated the seminar.

03.01.2016:
Popular talk on 'Climate Change and the Paris Deal' was delivered by Guest Speaker Prof. **Madhab Chandra Dash**, Former Vice Chancellor, Sambalpur University

13.01.2016:
Felicitation Function was organized under the joint auspices of Orissa Environmental Society and Society of Geoscientists & Allied Technologists (SGAT). Felicitation was given to Dr **Achyuta Samanta**, Founder of KIIS and KIIT University; and Dr **P.P.Mathur**, Vice Chancellor of KIIT University on being elected as the General President and General Secretary of the Indian Science Congress Association

07.02.2016:
Popular talk on 'Rice – a climate resilient crop' was given by Guest Speaker Dr **Bhaskar Chandra Patra**, Principal Scientist ICAR-National Rice Research Institute Cuttack-753006, Odisha, India

06.03.2016:
Popular talk on 'Faunal Diversity of Rice Field and a few Environmental Concerns' were given by Guest Speaker Dr **Kshira Sagar Behera**, Former Principal Scientist National Rice Research Institute (CRRI), Cuttack.

22.03.2016:
World Water Day 2016 was observed with the Theme 'Water and Jobs'. The Odisha Krushaka Samaja Eco Friends collaboirated in the programme. Chief Guest Sri **Prafulla Kumar Mallik**, Hon'ble Minister, Steel & Mines, Govt. of Odisha addressed the members and other guests.

03.04.2016:
Popular talk on 'Strategies for Enhancing Pulse Production in Odisha' was delivered by Guest Speaker Prof. **Lalita Mohan Garnayak**, Dean, College of Agriculture, OUAT, Bhubaneswar

22.04.2016:
Earth Day 2016 was observed with the Theme 'Trees for the Earth'. OES, Hi-Tech College of Engineering (HTCE) and Ever Green Forum (EGF) collaborated in the programme.Guests Dr **S.N.Patnaik**, Principal, Hi-Tech College of Engineering, Er. **Prakash Chandra Jena**, EVER GREEN FORUM, Dr **Jayakrushna Panigrahi**, Secretary, OES, Mr. **Kishore Nayak**,

Former Principal, Biju Patnaik College, BBSR, Mr. **Prasant Kumar Mishra**, DFO, City Forest Division, BBSR, Dr **S.N.Patro**, President, OES, Dr **Pradeep Kumar Patnaik**, Regional Director, NSS

01.05.2016:

Popular talk on 'Conservation and Management of Wetlands – A Case Study of Chilika Lake' was delivered by Dr **Jaya Krushna Panigrahi**, Head, Dept. of Zoology Sri Jayadev College of Ed. & Tech., Bhubaneswar; and Secretary, Orissa Environmental Society

05.06.2016:

World Environment Day 2016 was observed with popular talk on 'Zero Tolerance for the Illegal Wildlife Trade' in collaboration with SGAT. The Guest of Honour was Dr **Bijay Ketan Patnaik**, IFS (Retd.), Former PCCF (Wildlife) and Chief Wildlife Warden, Odisha. The Chief Guest was **Dr Aurobindo Behera**, IAS (Retd.) Former Member, Board of Revenue, Odisha. Smt. Parbati Mishra Memorial 'Environmentalist of the Year Award' was presented to Dr **Sudhakar Kar**, Wildlife Scientist & Researcher.

03.07.2016:

67th Banamahotsav was observed with plantation and discussions in the sprawling campus of the Divisional Forest Office of Khurdha. Sri **Manoj Kumar Mohapatra**, Divisional Forest Officer coordinated the programme. Prof. **N. K. Mahalik** and Dr **A. K. Pattanayak**, DFO were the guests.

07.08.2016:

Popular talk on Geoinformatics was delivered by Dr **Prasanna Kumar**, Scientist, Odisha Space Applications Centre (ORSAC).

04.09.2016:

Popular talk on Coastal Erosion in Odisha: Causes and Consequences was delivered by Guest Speakers Mr. **Girija Prasad Mohapatra**, Former Additional DG, Geological Survey of India, and Dr **Debanand Beura**, Associate Professor, Dept. of Geology, Utkal University.

02.10.2016:
The Wildlife Week and a Day for Elephant Theme: 'The future of wildlife is in our hands' were observed with Save Elephant Foundation Trust (SEFT). The Guests were Mr. **Sidhanta Das**, IFS, PCCF (Wildlife), Odisha; Dr **Debabrata Swain**, IFS, IG, NTCA, Central Region, Nagpur, and Mr. **Saroj Kumar Patnaik**, IFS, Former PCCF (Wildlife), Odisha. A training programme was continued in the afternoon for participants which included a number of Honorary Wildlife Wardens.

Some of the organizations which have actively collaborated in programmes of Orissa Environmental Society are the following.

ASI- Archaeological Survey of India

CES - Centre for Environmental Studies

CFD- City Forest Division

EGF -Ever Green Forum

HTCE- Hi-Tech College of Engineering

ISCA: BC - Indian Science Congress Association, Bhubaneswar Chapter

JBYSK-Jayadeb Batika Yoga Sadhan Kendra

JWC - Jayadeb Walkers Club

KABP - Khandagiri Anchalika Bikash Parisad

LC – Lions Club, Bhubaneswar

MoEF - Ministry of Environment & Forests, Govt. of India

NEAC - National Environment Awareness Campaign

OFDC- Odisha Forest Development Corporation

ORSAC- Orissa Remote Sensing Application Centre

RMNH - Regional Museum of Natural History

SEFT- Save Elephant Foundation Trust

SGAT – Society of Geoscientists and Allied Technologists

Patrons

01. Tamotia (Dr) Shailendra Kumar,
Hon. Dean- cum- Director Genaral
and Vice Chairman, Bharatiya Vidya Bhavan, Bhubaneswar Kendra
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