



Sustainable Development

A Multidisciplinary Approach

Research Committee
Jogamaya Devi College
Kolkata

Sustainable Development

– A Multidisciplinary Approach

Knowledge Based Volume [TWO]

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Kolkata
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Jogamaya Devi College

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Foreword

It is a matter of great satisfaction for the Research Committee of Jogamaya Devi College, Kolkata, that they are going to publish the second volume of the e- journal entitled "Sustainable Development: A Multidisciplinary Approach". The fact that the journal is being contributed by academicians closely associated with research on various aspects of environment and sustainable development, proves that it has been well taken by the academic community. The journal was conceived to have a multidisciplinary character, which has been borne out by the topics of articles selected in the first volume as well as the second, which is about to be published. The readers may appreciate the fact that the authors have chosen their subjects from areas which normally escape the attention of researchers. It may also encourage researchers, particularly those who are new entrants in the field, to choose their fields of work innovatively, disregarding the degrees and extent of impact.

Environment and Sustainable Development should not be matters of concern for the academic community alone. Rather, they should be very much within the sight of the national executives and policy makers. They include Members of the Parliament and State Assemblies to Ministries, Municipalities and Panchayat bodies. These groups should be invited to pay due attention to the realities, suggestions, and perhaps warnings, put forward in the papers. An e-journal may, perhaps, not be visible to these groups. It may be prudent to print a few copies of the papers and send them to appropriate people, who may not be academicians but would have a say in determining environmental policies. Researchers would definitely be encouraged to see active attention paid to their findings. It would also serve the purpose of documentation, much needed in the present era of benchmarking and accreditation.

It is hoped that the e-journal of Jogmaya Devi College will get publicity both within and outside the State as a forum for publishing quality research work on environment and sustainable development. The journal has taken upon itself a social responsibility. We seek cooperation of all the stakeholders so that this responsibility can be suitably discharged.

Pratip Kumar Chaudhuri
Chief Editor

From Principal's Desk

This is of immense pleasure to present the 2nd volume of annual multidisciplinary e-journal published by Jogamaya Devi College to its readers. My whole-hearted thanks go to the Research Committee of our college whose continuous and untiring effort throughout the year has made it possible to keep its deadline. I also give thanks to all the contributors and peer-reviewers for their consideration for the publication.

I hope the nature of the journal will invite more indigenous opinions in the form of research articles in future.

With thanks,

Dr. Srabani Sarkar
Principal

From the Board of Editors

When the Research Committee of Jogamaya Devi College, despite its enormous workload and highly constrained resources, undertook the arduous and seemingly daunting task of publishing in 2018 its first electronic volume titled *ENVIRONMENT: A MULTIDISCIPLINARY APPROACH*, many were apprehensive regarding the acceptance of such a conglomeration of specialized treatises on eclectic environmental issues to the readers. We sincerely thank the eminent academicians, faculties of colleges and universities, researchers and students for their encouraging feedback which inspired us to publish this second multidisciplinary volume; and also for their thoughtful suggestions that helped us to select its objective. While the previous volume presented a glimpse of ongoing researches on different aspects pertaining to the environment, this one intends to give an idea of the state-of-the-art studies on the various facets of sustainable economic progress.

While the necessities for the holistic researches aimed at identification of various environmental threats and their mitigations cannot be overemphasised, it should also be taken into account that the rapidly increasing human population round the globe calls for a steady and comprehensive socio-economic development that includes proportionate increase in agricultural production, industrialization, and urbanization. Sustainable development, as defined by Encyclopaedia Britannica, “is an approach to economic planning that attempts to foster economic growth while preserving the quality of the environment for future generations”. It is the need of the moment to find out innovative ways for socio-economic development without compromising the well-being of the physical and social environment, and researchers from diverse disciplines of natural sciences, social sciences, commerce and humanities must come forward to accomplish this multidimensional objective.

When the articles were invited for this volume last year, there was a highly favourable response from the teachers of our college as well as from the academicians affiliated to other institutions, and a large number of articles were received. But unfortunately we were compelled to discard many of those in accordance with the suggestions made by the highly esteemed reviewers. Some of the articles which could not be included here, although not conformable to the context of the present volume, feature promising works of research which we are sure shall find their rightful places in other publications. We will consider ourselves fortunate if we have the opportunity to publish the articles from these authors in the subsequent publications of Jogamaya Devi College.

The first article of this volume, titled *MICRO-INSURANCE' – AN IMPORTANT TOOL OF ACHIEVING SUSTAINABLE DEVELOPMENT GOALS*, contributed by Anita Chowdhury focuses on the immense potentialities of micro-insurance to address sustainable development goals, which may facilitate elimination of poverty and hunger, achievement of good health and well-being, promotion of gender equality and even mitigation of climate change issues.

In the second article titled *CLAY MINERALS IN THE PROTECTION OF SOIL ENVIRONMENT FROM THE IMPACTS OF INDUSTRIAL AGRICULTURE – A REVIEW*, Bhaskar Ghosh and Dr. Swapna Mukherjee explain the efficacy of the natural clay minerals and their derivatives as the adsorbents of a wide range of soil contaminants, providing a simple and cost effective solution to the soil degradation caused by insecticides, fungicides, herbicides etc. without decreasing the agricultural production.

In the article entitled '*BANGLA PATHYAPUSTAK O CHAPAKHANAR PRATHAM PANCH DASHAK*', Dr. Broti Gayen has revisited the initial five decades of the concurrent association of the press and the Bengali text books which gradually popularized the mass-education in vernacular language.

The article titled *A STUDY OF VASCULAR PLANTS ON CONCRETE HOUSES IN KOLKATA*, attributed to Deblina Hati, Dr. Subharthi Pal, Dr. Poulami Adhikary and Dr. Pushan Chakraborty, presents an insight to the vascular plants that grow naturally in the concrete of old buildings and heritage houses in Kolkata. They have also described the effectiveness and the expenses of various methods for cleaning those plants.

Dr. Lekha Mukhopadhyay furnishes the facts and figures in her article titled '*SUSTAINABLE DEVELOPMENT STRATEGY AND SUSTAINABLE DE-GROWTH STRATEGIES – HOW FAR DO THEY DIFFER IN REALITY?*' to examine the practical worthiness of Sprangenberg's de-growth criteria for environmental sustainability over the sustainable development strategies done in the context of mining related growth discourse of Jaintia Hills District, Meghalaya, India.

In the article titled '*SHRINKING HERITAGE MANGROVE ECOSYSTEM OF INDIAN SUNDARBANS AND EFFECT ON COASTAL CRABS: CONSERVATION AND SUSTAINABLE MANAGEMENT ISSUES*', Dr. Ranu Naskar makes us aware of the brachyuran mud crab which plays a crucial role in maintaining the ecology. She further explains how the lives of these crabs are at stake due to the rapid degradation of Sundarbans mangrove, which demands immediate and sound management strategies involving local beneficiaries, stakeholders and governments.

As the above description shows, this volume is multidisciplinary in its true sense, and in accordance

with our endeavour to help the readers from diverse disciplines to understand the objectives, outcomes and conclusions of these studies, lucid and easily comprehensible abstracts are given at the beginning of all the articles. We hope this will facilitate trans-disciplinary appreciation and utilization of their works. The researchers and students of one discipline, engaged in the study of a particular facet of sustainable development, can have some preliminary ideas of the ongoing investigations in other disciplines, which may help to enrich their own studies and diversify their fields of investigations in future.

Publication of this volume within the stipulated time necessitated a lot of efforts from all those involved. We gratefully acknowledge the generous assistance of the members of Research Committee, Jogamaya Devi College, during various stages of the work. We also express our gratitude to Dr. Rahi Soren, presently affiliated to the School of Oceanographic Studies, Jadavpur University, who diligently carried out the duties as a member of the editorial board till February, 2019. Finally, our sincere thanks to all the teachers and staff of Jogamaya Devi College for their continuous encouragements and valued suggestions, which facilitated the successful completion of the work.

Members of the Editorial Board

“Micro-Insurance” - An Important Tool of Achieving Sustainable Development Goals

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Abstract: In the 14th international micro-insurance conference entitled “Inclusive Insurance for Emerging Markets”, held on 6th November, 2018, it has been stated that billions of uninsured individuals, families and small businesses are exposed to various risks pertaining to life, health, social and environmental issues etc. The immense possibilities of micro-insurance for addressing sustainable development goals have been pointed out in the conference, and it has been suggested that micro-insurance is already contributing to achieve different UN sustainable development goals like elimination of poverty and hunger, achievement of good health and well-being, promotion of gender equality and alleviation of climate changes. Micro-insurance safeguards resilience and risk managing abilities for millions of consumers who are exposed to various risks.

Keywords: Micro-insurance, sustainable development, sustainable developmental goals (SDGs), economic growth, social and economic development.

I. INTRODUCTION

Sustainable development can be defined as the organizing principle for meeting human development goals, while at the same time sustaining the ability of natural systems to provide the natural resources and ecosystem services upon which the economy and society depend. This can be achieved when development satisfies the needs of the present without compromising or hampering the environment and resources for the future generations.

The concept of sustainable development is originated from sustainable forest management and twentieth century environmental concerns. The modern concept of sustainable development is derived from the 1987 Brundtland Report. As the concept developed, It has encompassed other areas of concern like economic development, social development, and environmental protection for future generations.

The Brundtland Commission report of 1987, entitled “Our common Future”, has the following mandates: “(1) re-examine the critical issues of environment and development and to formulate innovative, concrete and realistic action proposals to deal with them; (2) strengthen international cooperation on environment and development and assess and propose new forms of cooperation that can break out of existing patterns and influence policies and events in the direction of needed change; and (3) raise the level of understanding and commitment to action on the part of individuals, voluntary organizations, business, institutes, and governments” (1987:347).

In addition, the commission highlighted “the areas of population, food security, the loss of species and genetic resources, energy, industry and human settlements-realizing that all of these are connected and cannot be treated in isolation one from another” (1987:27).

Brundtland Commission report recognises that sustainable development necessitates the development of human resource by means of poverty reduction, gender equality and wealth redistribution. This report stated that human resource development was crucial to formulating strategies for environmental conservation, and there were environmental-limits to economic growth in industrialised and industrialising societies. For such societies, the report emphasized on “the analysis, the broad remedies, and the recommendations for a sustainable course of development” (1987:16).”

The report also deals with sustainable development and the change of politics needed for achieving it. The definition of this term in the report is quite well known and often cited:

“Sustainable development is development that meets the need of the present without compromising the ability of future generations to meet their own needs”.

Sustainable development goals: The sustainable development goals aim to achieve a better and more sustainable future for all. The 2030 Agenda for sustainable development, adopted by all United Nations Member States in 2015, provides a shared blueprint for peace and prosperity for people and the planet, now and into future. There are 17 Sustainable development goals (SDGs), which are to be taken on urgent basis for actions by all countries – developed and developing – in a global partnership. The SDGs are discussed below:

GOAL 1: End Poverty in all its Forms Everywhere: Human societies should generate necessary resources to ensure sustainable livelihoods for all. Lack of source of income brings about poverty, which is manifested in hunger and malnutrition, limited access to education and other basic services, social discrimination, as well as the lack of participation or even exclusion of financially backward sections of the society in decision making.

Economic growth must follow the necessary steps to provide sustainable jobs and promote equality. Social protection systems need to be implemented to alleviate the suffering of disaster-prone countries and provide support in the face of great economic risks.

GOAL 2: Zero Hunger: It is time to reconsider how we grow our food, and share and consume it. Nutritious food and sources of decent income can be provided to all through proper implementation of agriculture, forestry and fisheries. That will also support rural development and protects the environment.

GOAL 3: Ensure Healthy Lives and Promote Well-Being for all at all Ages: Ensuring healthy lives and promoting the well-beings for people of all ages is essential to sustainable development in all over the world. Reduction in mortality rate of children and premature deaths due to incommunicable disease are essential for sustainable developments. Many more efforts are needed to fully eradicate a wide range of diseases and address many different persistent and emerging health issues. By focussing on providing more efficient funding on health system, improved sanitation and hygiene, significant progress can be made to save the lives of millions in the whole world.

GOAL 4: Quality Education: For creating sustainable development, obtaining a quality education for all is the foundation for all societies. For improving quality of life, access to inclusive education can help with the tools required to develop innovative solutions to the world's greatest problems.

GOAL 5: Achieve Gender Equality and Empower all Women and Girls: Gender equality is one of the most important fundamental human rights. It is also necessary foundation for a peaceful, prosperous and sustainable world. Providing women and girls with equal access to education, health care, decent work and representation in political and economic decision making process will contribute to sustainable economies which will benefit societies and humanity at large.

GOAL6: Ensure Access to Clean Water and Sanitation to all: Clean, accessible water for all is an important goal to achieve sustainable development. Due to bad economics or poor infrastructure, millions of people including children die every year from diseases associated with inadequate water supply, sanitation and hygiene all over the world, especially in developing countries.

GOAL 7: Ensure Access to Affordable, Reliable, Sustainable and Modern Energy: Production of environment-friendly energy in sufficient quantity is a major challenge the world faces today. It is crucial for food production, livelihood, security, and also for climate change issues. Access to energy for all is essential for achieving sustainable development, and correlated with the other sustainable development goals.

GOAL 8: Promote Inclusive and Sustainable Economic Growth, Employment and Decent Work for All: Sustainable economic growth will be possible in such societies which are able to create the conditions that allow people to have quality jobs that stimulate the economy while not harming the environment. Job opportunities and decent working conditions are also required for the whole working population for achieving sustainable development.

GOAL 9: Build Resilient Infrastructure, Promote Sustainable Industrialization and Foster Innovation: Investment in infrastructure, transport, irrigation, energy and information and communication technology are crucial in every country to achieve sustainable development and to empower communities in many countries. It is a process which requires long time. Growth in productivity and incomes, and improvements in health and education outcomes require investment in infrastructure for both developing and developed countries.

GOAL 10: Reduce Inequalities Within and Among Countries: The international community has made significant strides towards lifting people of their country out of poverty. To reduce inequality, policies should be universal in principle. While formulating policies, every country should pay attention to the needs of disadvantaged and marginalized populations. For achieving this goal, there needs to be an increase in duty-free treatment and continuation of favouring exports from developing countries.

GOAL 11: Make Cities Inclusive, Safe, Resilient and Sustainable: Cities are hubs for ideas, commerce, culture, science, productivity, social development and much more. At their best, cities have enabled people to advance socially and economically. For achieving sustainable development, cities must be

safe in all form. It should be organized in such a way in which cities provide opportunities for all, with access to basic services, energy, housing, transportation etc.

GOAL 12: *Ensure Responsible Consumption and Production Patterns*: sustainable consumption and production are required for promoting resources and energy efficiency, sustainable infrastructure. For achieving sustainable development, it is necessary for providing access to basic services, green and decent jobs and a better quality of life for all. Its implementation helps to achieve overall development plans, reduce future economic, environmental and social costs, strengthen economic competitiveness and reduce poverty.

GOAL 13: *Take Urgent Action to Combat Climate Change and its Impacts*: Climate change is now affecting every country on every continent. The poorest and most vulnerable people of the poor and developing countries are being affected the most. Affordable, scalable solutions are available to enable countries to leapfrog to cleaner, more resilient economies in order to achieve sustainable development.

GOAL 14: *Conserve and Use the Oceans, Seas and Marine Resources Sustainably*: The oceans and seas are the sources a substantial part of our food and also of meteoric water, which in turn is the chief provider of our drinking water. They also have significant impacts on the local and regional weather and climate; and in the conservation of environmental resources like atmospheric gases. The oceans and seas are therefore considered as essential global resources, and their conservation and careful management are thus the key factors for sustainable development.

Goal 15: *Sustainably Manage Forests, Combat Desertification, Stop and Reverse Land Degradation. Stop Biodiversity Loss*: Climate change is a major challenge to sustainable development and has affected the lives and livelihoods of millions of people, impeding their fight against poverty. Deforestation and desertification caused by human activities are two major reasons for climate changes and global warming. For sustainable development, efforts should therefore be taken to manage forests and combat desertification.

GOAL 16: *Promote Just, Peaceful and Inclusive Societies*: The threats of international homicide, violence against children, human trafficking and sexual violence are important negative factors which are to be controlled strongly for mankind. It is necessary to promote peaceful and inclusive societies for sustainable development. They pave the way for the provision of access to justice for all and for building effective, accountable institutions at all levels.

GOAL 17: *Revitalize the Global Partnership for Sustainable Development*: A successful sustainable development agenda requires partnership between governments, the private sectors and civil society. These inclusive partnerships built upon principles and values, a shared vision, and shared goals that place people and the planet at the centre, are needed at the global, national, regional and local level.

Now our aim is to establish micro insurance as an important tool to achieve sustainable goals:

Micro-insurance is insurance with low premiums and low caps\coverage. Microinsurance may be offered for a wide variety of risks for low income people. These include both health risks (illness, injury, or death) and property risks (damage or loss) and extreme weather, climate and agricultural

hazards. A wide variety of Microinsurance products exist to address these risks, including life insurance, health insurance, crop insurance, livestock\cattle insurance, insurance for theft or fire, death insurance, disability insurance, insurance for natural disasters etc.

The objective of this paper is to provide an overview of the contribution of Microinsurance to specific SDGs and their targets. The paper highlights the crucial role that Microinsurance plays as a tool to achieve sustainable development goals beyond financial sector development. The other development agendas considered include: social protection; food security; agricultural, rural and urban development; gender equality and women's empowerment; micro, small and medium enterprise (MSME) development and climate change.

The protection of human beings and assets is a key component of sustainable development. Insurance as a risk protection mechanism can support many of the SDGs, some directly and others indirectly. Insurance will directly facilitate six SDGs and are also important to the completion of five other SDGs indirectly.

Micro insurance as a primary level contributor to Six SDGs:

As a primary level contributor, the impact of micro-insurance to the SDGs is direct and obvious. Drawing on this definition, insurance mechanisms help to achieve the following six SDGs by providing some form of risk protection to low-income individuals.

- GOAL 1: No Poverty
- GOAL 2: Zero Hunger
- GOAL 3: Good Health And Well-Being
- GOAL 5: Gender Equality
- GOAL 8: Decent Work And Economic Growth
- GOAL 13: Climate Action

GOAL 1: No Poverty: Micro insurance provides a safety measure for those using it. It prevents individual and families from falling (back) into poverty after experiencing a shock. Research suggests that when a shock occurs, families without insurance often liquidate their savings, take loans from friends and family, borrow at high interest rates, reduce family consumption, disinvest in education and sometimes must sell productive assets at a discount. All of these coping strategies reduce their resilience to future shocks. Through its basic function, insurance reduces the vulnerability of people. It helps to build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate related extreme events and other economic, social and environmental shocks and disasters. Without insurance, low and even middle income people can fall (back) into poverty once a severe shock strikes. Insurance helps to prevent people from becoming poor due to an unforeseen event leading to financial and social hardship.

GOAL 2: Zero Hunger: The support of agricultural productivity is a key element of eradicating hunger, to which many development efforts are aimed. Such efforts are focused on how to support the agricultural sector in ensuring food security. Crop risk poses a very serious threat for the low-income households dependent on agriculture. The insurance of crop and livestock can therefore improve the

situation. Specific insurance products could contribute to strengthening the agricultural sector by providing better opportunities for farmers to manage their risks. Poor agricultural families are managing their risks by increasing and diversifying their investments into agricultural activities, positively impacting production, sustainability, food security and employment. Insurance helps people to respond and adapt to natural catastrophes, which can plunge them into greater poverty. According to the World Food Programme (WFP), disasters disproportionately affect the poorest communities and significantly increase hunger and malnutrition. Appropriate micro insurance can mitigate hunger and it can enhance the resilience of vulnerable people to confront the nutritional effects of natural disasters and climate change.

GOAL 3: Ensure Healthy Lives And Promote Well- Being For All At All Ages: Poor health is one of the key obstacles of social and economic development. In the absence of effective universal health coverage schemes in developing countries and emerging economies, low income populations used to struggle to pay for their health care expenses. In the absence of effective health insurance, health care cost usually forces these affected vulnerable people and their families into deeper poverty. Insurance and social protection can play complementary roles to cover a range of household expenses. Health care financing for the population by a social protection system can be complemented by insurance products. Health insurance products cover costs excluded from the social protection health care plan. Micro insurance health products can cover smaller type of these health care costs. Insurance can improve health-care seeking behaviour. People having health insurance are more likely to have regular health check-ups and can avail medical treatments whenever required. This can provide better health assistances and contributes substantially to the well-beings of the common people.

GOAL 5: Gender Equality: There are gender differences in risks faced by men and women. These differences are faced by both biological and socio-cultural factors. Women may face different risks as compared to men at the time of pregnancy and child birth. Women may also face risks associated with biological health risks during different stages of their life cycle.

Women generally are more vulnerable than men to a range of risks based on the socially constructed gender rules. Because of these risks and challenges, women have a greater need of insurance, which can help them to reduce their financial reliance on others. This independence can contribute to their economic empowerment, and protect them from the devastating effects of gender-related reproductive health risks. Micro-Insurance also offers protection for women working in the informal sector, who often fall outside the reach of public social protection schemes.

GOAL 8: Decent Work And Economic Growth: To reach inclusive and sustainable economic growth and employment, it is necessary to create an environment for enterprises of different sizes, especially the smaller ones. Small enterprises need support to increase their productions. Medium-sized enterprises require support to grow into larger sized enterprises. For growing into large scale industry, a medium scale industry should obtain external financial supports to invest in machinery, to perform marketing, to adopt environmental and social standards, and to train their personnel. Micro-insurance protects the assets from damage, fire, natural disaster or any kind of loss. Thus insurance is unlocking loans and other funds for investments by MSMEs. By availing the benefits of insurance, the private funds of MSMEs are free for productive investment. Micro-insurance supports the development of

MSMEs by protecting them from losses due to risks related to business, natural disasters or other catastrophes.

GOAL 13: Climate Change: Due to the advent of climate change, natural disasters are expected to occur more frequently in future. Climate change threatens the development efforts of entire regions, negatively affecting families, business establishments, communities and entire countries. Developing countries are likely to be more affected by the impacts of climate changes. Disaster insurances are innovated to mitigate the risks associated to climate change. Insurance mitigates the effects of extreme weather events, which are strengthening climate change resilience. Many insurance products are directed towards mitigating the negative financial consequences of disasters and natural catastrophes for the population. Disaster insurance, weather insurance etc. are focusing on the agricultural sector since weather fluctuations are a major risk for agricultural productivity.

Microinsurance as a secondary level contributor to five SDGs:

Where insurance is a secondary level contributor to SDGS, the relevance of insurance and its effect on respective SDGs is indirect and less obvious than to the primary level SDGs mentioned above. However insurance is still relevant to the following five SDGs:

- GOAL 4: Quality Education
- GOAL9: Industry, Innovation and Infrastructure
- GOAL 10: Reduced Inequality
- GOAL 11: Sustainable Cities and Communities
- GOAL 17: Partnerships for The Goals

GOAL 4: Quality Education: Insurance can help families to maintain access to education. Once a shock happens to the family or business, poor families often cannot continue to invest in the education of their children. Different types of insurance plans can help to flow cash for the family and ensure that children's education is not hampered. Some insurance products are offering an educational savings component, which has recognized the demand of low income populations to have funds available to pay for their children's education.

GOAL 9: Industry, Innovation and Infrastructure: Insurance protects investments for both small and large firms, and also for governments. As stated earlier, small enterprises need supports to increase their productions, while medium sized enterprises need supports for their growth. The growth of enterprises increases the willingness of banks to disburse loans to them, and insurance can help foster innovation through covers that limit the risk of innovation.

GOAL 10: Reduce Inequality Within and Among Countries: Governments are trying to reduce social inequalities by providing social protection for the poorest of the poor. Microinsurance targets those low- income families and protects those who are not bankable and would not have access to any formal protection by normal insurance schemes. Insurance can help to mitigate the development differences of a group of countries.

GOAL 11: Sustainable Cities and Communities: Insurance makes human settlements more resilient. Different micro-insurance products help to retain investments of individuals, business, local and

national governments. Economic disparities among different communities can be exacerbated by a lack of insurance pushing people further into poverty. Micro-insurance is an important approach to mitigate the financial differences among different communities. Effective resilience requires some external risk diversification which is possible through insurance.

GOAL 17: Partnerships for the Goals: It is very important to include micro-insurance within the global development agenda, which involves the integration of insurance within the engagement of stakeholder countries. Micro-insurance practices will be most effective for achieving sustainable development goals when it is engaged in the global partnership involving different countries.

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Clay Minerals in the Protection of Soil Environment from the Impacts of Industrial Agriculture – A Review

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***Abstract:** The soil environment in an eco-system is the function of several interrelated physical, chemical and biological parameters. The gradually increasing industrialization of agriculture, involving widespread application of weed-killing herbicides, chemical fertilizers, pesticides, fungicides etc. leads to undesirable variation in soil organic carbon, nitrogen content, pH and moisture; and introduce substances which can adversely affect the soil microbial activity. Long-term application of these chemicals also destroys the soil-dwelling organisms and microorganisms that favourably affect the soil properties. The natural clay minerals and their derivatives may be used as highly effective adsorbents of a wide range of metals, inorganic and organic contaminants, and pathogens. The clay minerals with 2:1-structural types are good adsorbents for highly polar cationic contaminants, principally owing to their small particle-size, very large specific surface areas and their hydrophilic, negatively-charged surfaces. Their derivatives like natural hydrotalcites and the synthetically produced layered double hydroxides can adsorb anionic pesticides due to the presence of exchangeable anions in their interlayer spaces, thus having complementary adsorptive properties of clay minerals. By some simple ion-exchange reactions, the clays can adsorb hydrophobic, non-polar organic compounds. The easy availability and cost-effectiveness of these materials increase their applicability in this context.*

Keywords: Industrial agriculture, soil health, clay minerals, clay derivatives.

I. INTRODUCTION

The explosion of the human population over the last few decades has multiplied the demand for all sorts of agricultural products, which brought about rapid industrialization of agriculture in different parts of the world. The agricultural communities in the Indian subcontinent, China and other places of south-east Asia had to abandon their age-old traditional methods of farming and are forced in the widespread usage of chemical fertilizers, herbicides, insecticides, fungicides etc. While the harmful effects of these substances on human health and their remedial measures have been the subject of extensive scientific investigations for a long time, their adverse impacts on the soil environment are much less highlighted. Prolonged application of these chemicals may cause irreparable damage to the soil and render it useless for agricultural activities in the future. Switching over to environment-friendly organic farming is not yet a feasible alternative, as these low-yielding methods cannot sustain the ever-increasing demand of agricultural products. The only way out, for the time being, is possibly to identify the harmful impacts of the chemicals on the soil and to look for

appropriate alleviation for each of them. This contribution reviews the present researches on the impacts of modern-day agricultural practices on the physical, chemical and biological aspects of the soil environment, and discusses the potential application of clay minerals for the recovery of soil to sustain future agricultural activities.

II. THE SOIL HEALTH AND THE IMPACTS OF INDUSTRIAL AGRICULTURE ON IT

Soil quality has been defined by the Soil Science Society of America Ad hoc Committee on soil quality (S-581) as ‘the capacity of a specific kind of soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation’ (Karlen et al., 1997). Soil health, on the other hand, refers to the capacity of a specific type of soil to sustain plant and animal productivity, uphold or augment water and air quality, and promote plant and animal health (after Doran and Zeiss, 2000). Many authors prefer this term over soil quality because it represents soil as a living, dynamic system which perpetually interacts with a host of inorganic objects as well as a diversity of living organisms. In spite of continued efforts of soil scientists and ecologists since the early 1990s, there is not yet any feasible empirical way to quantitatively express or ‘measure’ the soil quality. The following factors, however, are universally accepted as the soil quality indicators.

1. The permeability of the soil, whereby it facilitates water flow through the environment.
2. The degree to which the soil can assimilate organic wastes and absorb or neutralize different types of contaminants, thus acting as a buffer that protects an eco-system from potentially harmful components.
3. The extent to which soil can sustain the organisms – plants, animals and microbes – and promote their nourishment and growth.

The above factors, in turn, are determined by a number of interdependent physical, chemical and biological parameters. Larson and Pierce (1991) suggested soil texture, structure, strength; plant available water capacity; and maximum rooting depth of plants as the physical indicators of soil health; and nutrient availability, total organic C, labile organic C, pH, and electrolytic conductivity as chemical parameters. Papendick (1991) suggested pH, salinity, cation exchange capacity, organic matter, and site-specific toxicities such as heavy metals, toxic organics, nitrate, or radioactivity as the significant chemical parameters. Doran and Zeiss (2000) advocated the use of a number of quantitative aspects of soil organisms, like their abundance, diversity, food web structure, and community stability as the biological indicators of soil health. Prashar and Shah (2016) suggested texture and water holding capacity as the physical parameters; pH, salinity, and soil organic matter content as the chemical parameters; and microbial activity, mineralization of nitrogen and soil respiration as biological parameters.

In this section, the adverse effects of industrial agriculture have been discussed on some of the above parameters of soil health.

2.1. Effects of industrial agriculture on the physical parameters of soil health

The insecticides, fungicides, herbicides etc. have adverse impacts on the soil fauna, some of which (e.g. annelids) are highly beneficial for the soil physical parameters. The chemical fertilizers, on the

other hand, have more direct impacts on the porosity, permeability, water holding capacity, moisture, bulk density and compaction of the soil, as revealed by the field and experimental investigations conducted across the world (Mari et al. 2008, Batey 2009, Azadegan and Amiri 2010, Beylich et al. 2010, Chakraborty et al. 2010, Bandyopadhyay et al. 2011, Vengadaramana and Jashothan 2012, Tadesse et al. 2013, Malik et al. 2014, Massah and Azadegan 2016). Some of the recent studies are described below.

Malik et al. (2014) carried out experiments on the yield of rice crops in silty clay loam with various combinations of organic manures and chemical fertilizers; and compared the physical properties of the soil before and after harvesting. Their studies revealed that there is no significant difference in grain yield in the chemical and organic farming systems, the soil treated with organic manures (vermicompost and crop residues) have a notably higher water holding capacity and soil moisture content than those treated with inorganic fertilizers. They attributed this to the enhancement of soil faunal activity by the organic manure, which improves the soil aggregation and porosity, leading to increased infiltration rates.

Massah and Azadegan (2016) have shown that application of inorganic fertilizers leads to the formation and accumulation of inorganic salts in the soil, which in turn bring about soil compaction, and decrease porosity. 81.4% decrease in soil permeability and a 34% decrease of water content have been recorded. Moreover, it increases the bulk density of the soil and makes the soil more resistant against penetration of plant roots, thus hindering root development and plant growth, which ultimately results in a 40% decrease in the yield of wheat crop.

The field experiments conducted by Tadesse et al. (2013) reveal the following positive impacts of the farm yard manures over chemical fertilizers on the physical parameters of soil health:

- (i) Increase in water holding capacity
- (ii) Increase in soil organic matter, which improves the physical, chemical and biological environment of the soil.
- (iii) Decrease in soil bulk density, which favours root development and plant growth.

These authors, however, suggest integrated application of farm yard manure along with nitrogen and phosphorous fertilizers to sustain productivity and preserve soil health. Vengadaramana and Jashothan (2012) also suggested the application of organic manure to increase the water holding capacity of the soil.

The experiments performed by Chakraborty et al. (2010) in a maize-wheat system on s and y loam soils indicate that soil moisture content and plant-available water content are significantly lower in the plots with prolonged treatment of inorganic fertilizers than those treated with organic manures.

2.2. Effects of industrial agriculture on the chemical parameters of soil health

Changes in soil organic carbon, nitrogen content, pH, moisture and thus the variation in nutrient availability to soil microbes have been observed due to long-term application of inorganic fertilizers (Bunemann and McNeill 2004; Bohme et al. 2005; Wu et al. 2012). These inorganic fertilizers, in comparison to the organic fertilizers like cattle manure, unfavourably affect the soil organic carbon

and pH (Sradnick et al. 2013), and do not have any positive impacts on soil enzymes like dehydrogenase, β -glucosidases, alkaline phosphatases, proteases etc. (Casida et al. 1964, Nannipieri et al. 1990, Bohme et al. 2005, Lazcano et al. 2013).

Erin Flynn, in a series of experiments carried out in 2003, proved that the chemical fertilizers rich in ammonium salts may decrease the pH of the soil to a great extent. The soil microorganisms (mainly bacteria) convert the ammonium to nitrate, and release H^+ ions. If there is no buffering agent in the soil to bind that free H^+ , it results in a decrease of the soil pH. He has further shown that if ammonium fertilizer is applied to a soil which was already acidic, its pH will continue to decrease, causing the soil nutrients to be increasingly insoluble and therefore useless to the plants. Ogbodo (2013) obtained similar results after studying different types of soil samples (clay, s and y clay, s and y loam and clay loam) from fifteen different farm locations and inferred that long term application of chemical fertilizers leads to a substantial decrease of the soil pH (4.0 to 5.6), multiple nutrient deficiency problems and inadequacy of phosphorous.

In addition to the above impacts of fertilizers on soil chemistry, the detrimental effects of copper on the soil are much more prominent in presence of the nitrogen-phosphorus-potassium based inorganic fertilizers (Xie et al., 2009b). While the bio-manures tend to form complexes with heavy metals and pesticides, thus decreasing their bioavailability in soil (Perez-de-Mora and Madrid 2007), the chemical fertilizers have no such positive impact.

2.3. Effects of industrial agriculture on the biological parameters of soil health

The microbial populations and activities of organisms are significantly less in soils treated with inorganic fertilizers than those treated with organic manure (Kumar et al. 2000, Kang et al. 2005, Islam et al. 2009, Yang et al. 2011, Chauhan et al. 2011, Tan et al. 2012, Sradnick et al. 2013). Furthermore, long term application of the chemical fertilizers may be extremely harmful to the plant-friendly bacteria groups like *Pseudomonas* (Islam et al. 2009; Wu et al. 2012).

The toxicity effect of heavy metals and pesticides like copper, cadmium and cypermethrin on soil microflora is higher in soils treated with inorganic fertilizers as compared to organic-manure treated soils (Xie et al. 2009b).

The chemical fertilizers may also lead to the generation of nitrogen channels or patches in the land, thus giving rise to nitrogen gradients in the soil that affects the soil microbial biomass as well as microbial functional diversity (Li et al. 2013).

III. THE INTERNAL STRUCTURES OF CLAY MINERALS AND THEIR ADSORPTION PROPERTY

3.1. The structural types of clay minerals

In the mineral kingdom, the clay minerals belong to the phyllosilicate subclass (Greek *Phyllon*: leaf) of silicate class. Some general aspects of the internal structures of these minerals are briefly described

here. For an elaborate account of the internal structures of different clay mineral groups, Mukhopadhyay (2013) may be referred.

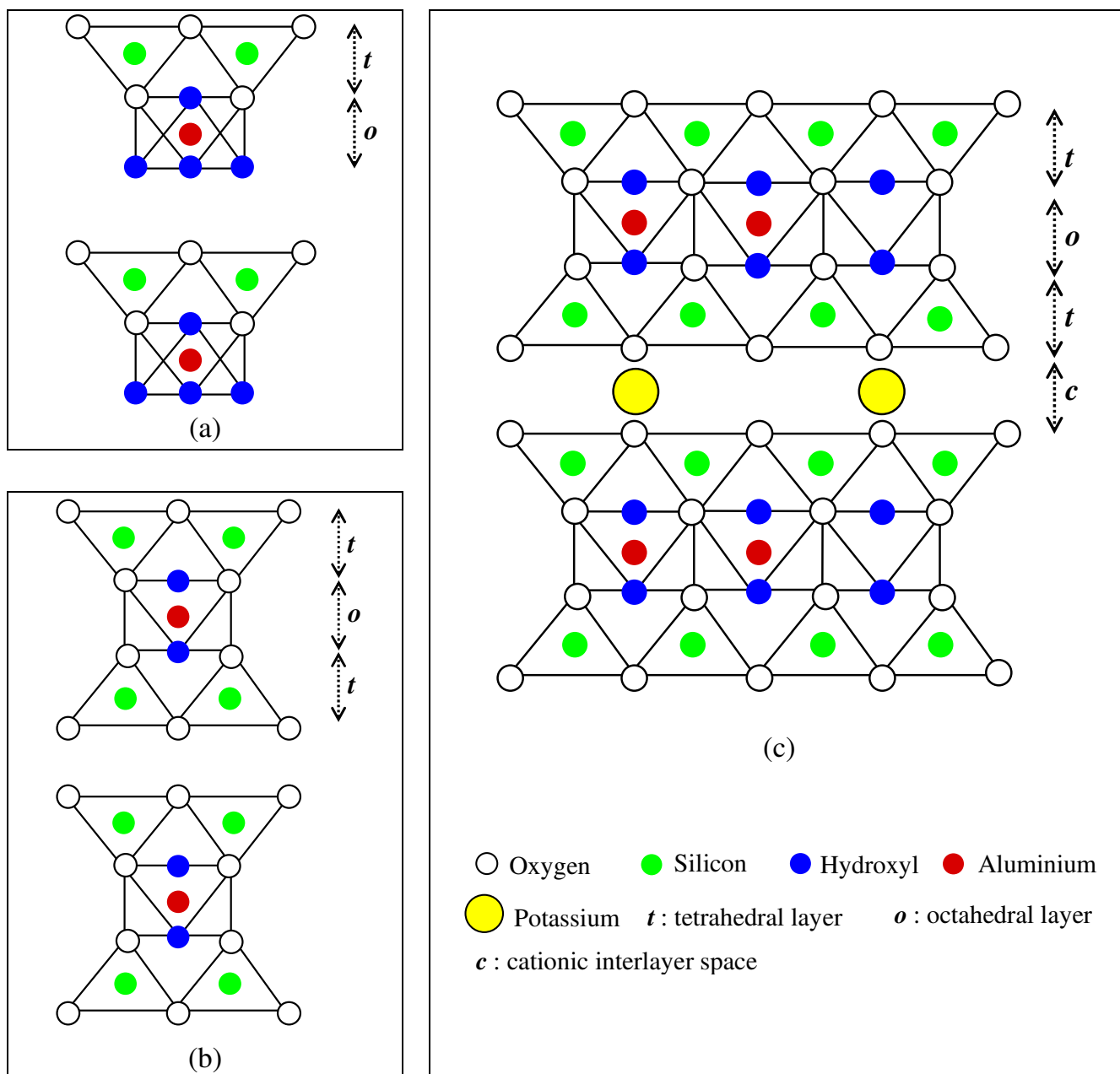


Figure 1

(a) The *t-o* structure in kaolinite.

(b) The *t-o-t* structure in pyrophyllite.

(c) The *t-o-t-c* structure in muscovite and other di-octahedral phyllosilicates. The clay minerals of illite, smectite and vermiculite groups have di-octahedral or tri-octahedral *t-o-t-c* structure.

(i) *The tetrahedral sheets:* Like the other minerals belonging to the silicate subclass, the SiO_4^{-4} tetrahedron is the fundamental structural unit of the clay minerals. Each tetrahedron is linked to three neighbouring tetrahedra by sharing three (out of four) apical oxygens, every tetrahedron, therefore, has three bridging and one non-bridging oxygen. Thus a layer or sheet of SiO_4^{-4} tetrahedra is formed, known as the tetrahedral sheet or *t-sheet*.

- (ii) *The octahedral sheets*: Each tetrahedron in the *t*-sheet has a negative charge of -4 . In many phyllosilicates, OH^- group provides an additional negative charge to the structure. This excess negative charge is neutralised by the bivalent cations (Mg^{+2} , Fe^{+2} etc.) or trivalent cations (mainly Al^{+3}) in *octahedral cationic sites*. These octahedra are linked to the *t*-sheets by sharing their non-bridging oxygens. An infinitely extended layer of cation-centred octahedra, known as the octahedral sheet or *o*-sheet, is thus formed parallel to the *t*-sheet.
- (iii) *Trioctahedral and Dioctahedral structures*: If the octahedral cations are bivalent, then each apical anion of the octahedron is surrounded by three cations. In that case, all the octahedra attached to the *t*-sheet have bivalent cations in their centres.

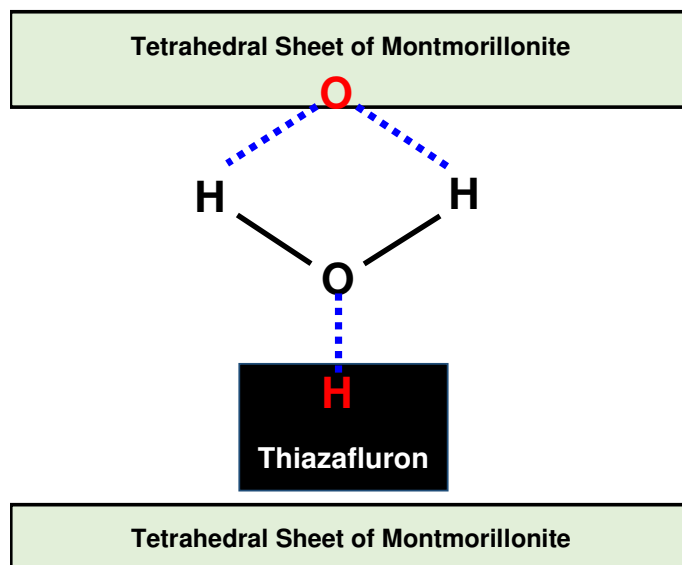


Figure 2

Schematic diagram showing the bonding of the non-ionic contaminant thiazafluron in the interlayer space of montmorillonite by water molecule. For detailed molecular structure, Fig. 5 of Cox *et al.* (1995) may be referred.

O (in red font): oxygen atom in the tetrahedral sheet of montmorillonite.

H (in red font): hydrogen atom in the thiazafluron molecule.

■ ■ ■ ■ (Blue dotted line): hydrogen bond.

On the other hand, if the octahedral cations are trivalent, then each apical anion of octahedron is surrounded by two cations. In that case, two-third octahedra attached to the *t*-sheet have trivalent cations in their centres, and the remaining one-third octahedra are vacant.

- (iv) *The structural types of clay minerals*: The phyllosilicate subclass is divided into a number of structural types based on the arrangement of *t*-sheets and *o*-sheets, as described below.
- t-o structures (1:1 structure)*: One *t*-sheet is connected to one *o*-sheet, to form a *t-o* layer (Figure 1a). These *t-o* layers are electrically neutral. They are bonded to one another by weak Van der Waals bonds. Examples: the minerals belonging to the kaolinite group.
- b) t-o-t structures (2:1 structure)*: One *o*-sheet is situated in between two *t*-sheets, to form a *t-o-t* layer (Figure 1b). The non-bridging oxygens of the two *t*-sheets face each other, and the

apical oxygens of both of them are shared by the octahedra of the intervening *o*-sheet. These *t-o-t* layers are electrically neutral. They are bonded to one another by weak Van der Waals bonds. Examples: many phyllosilicates like talc (trioctahedral), pyrophyllite (dioctahedral) etc. have this type of structure, but the clay minerals having one *o*-sheet in between two *t*-sheets generally have *t-o-t-c* structures described below.

- c) *t-o-t-c structures (2:1:1 structure)*: If Si^{+4} is substituted by Al^{+3} in some of the tetrahedra, then the net positive charge of a *t-o-t* layer decreases. The excess negative charge is balanced by the inclusion of *interlayer cations* in between two *t-o-t* layers (Figure 1c). These cations are known as interlayer cations. An interlayer cation is surrounded by 12 oxygens: 6 bridging oxygens from each *t-o-t* layer in its opposite sides. So its position is known as the 12-fold coordination site. Examples: the clay minerals belonging to illite, smectite, and vermiculite groups.

3.2. The adsorption and ion exchange properties of clay minerals

In the clay mineral groups having *t-o-t-c* structures, the most common interlayer cations are K^+ in illite, Ca^{+2} and Na^+ in smectite, and Mg^{+2} in vermiculite. These interlayer cations may be readily replaced by other cations when the mineral surface is in contact with a liquid containing different types of cations like Cu^{2+} , Pb^{2+} , Zn^{2+} , Cd^{2+} , Mn^{2+} etc. This is known as *cation exchange* property of clay minerals. The cation exchange capacity is different in different types of clay minerals, as shown in Table-1.

These clay minerals have a stronger affinity for heavy metal cations than for the alkali and alkaline earth cations they have in interlayers spaces (Tiller 1996), which facilitate their application as adsorbents of heavy metal contaminants from water-soil solutions.

In addition to the heavy metal cations, the interlayer spaces of smectite and vermiculite may also accommodate various organic molecules (Ravich and ran and Sivasankar, 1997).

In the minerals of palygorskite-sepiolite group, the cationic octahedra linked to the *t*-sheets form chains or ribbons instead of the octahedral sheets. The vacant spaces between these octahedral chains can accommodate cations and organic molecules.

Clay Mineral Group	Cation Exchange Capacity (meq/100gm)	References
Kaolinite	0 – 5	Silva et al. (2018)
Illite	10 – 40	Silva et al. (2018)
Smectite	40 – 150	Silva et al. (2018)
Vermiculite	33 – 174	Ghabru et al. (1989)
Palygorskite-sepiolite	4 – 40	Galan (1996)

Table-1. Cation exchange capacities of different types of clay minerals.

IV. CLAY MINERALS AS THE POTENTIAL ADSORBENTS OF PESTICIDES

Natural clays, especially those having $t-o-t-c$ structures, are effective adsorbents for cationic and highly-polar pesticides owing to their internal structures and also for the following physico-chemical properties that are unique to them.

- (a) Due to their very fine grain size, the clay minerals can mix well with the pesticide particles or the aqueous solution containing pesticides.
- (b) Because of the hydrophilic, negative character of their surfaces, clays are very good adsorbents for cationic and highly-polar pesticides.
- (c) The clay minerals, like the other phyllosilicates, have very thin, flaky grain shape which maximizes the surface area of the grains and consequently enhance the surface reactions.

Some salient features of removal of different types of agriculturally generated contaminants (mainly pesticides, also herbicides and fungicides) by the clay minerals are described below.

4.1. The cationic contaminants

These compounds are readily adsorbed by clay minerals with $t-o-t-c$ structures through ion-exchange processes. For instance, the adsorption of cationic pesticides like chlordimeform, diquat, paraquat and difenzoquat takes place by charge-pattern interactions between these cations and the surface charges of the clay mineral (Weber and Weed, 1968; Hermosín and Rodríguez, 1981; Lagaly, 1986; Rytwo et al., 2004).

The binding coefficients of organic cations to clay minerals are much greater than those of inorganic cations. The clay minerals can almost completely adsorb organic contaminants of cationic nature from a liquid substrate, up to its cation exchange capacity (Rytwo et al., 1995, 2004).

4.2. The anionic contaminants

These types of contaminants are generally repelled by the negatively charged t -sheets of clay minerals. Their adsorption by clay is therefore very limited. Some of these contaminants, however, may be attached to the positively charged polyhedral edges of the clay minerals. In some cases, certain polyvalent metal ions may form cation bridges to attach them to the clay minerals (Cornejo et al. 2008). A clay derivative produced with montmorillonite and large organic cations can adsorb the anionic herbicide sulphometuron (Mishael et al. 2002a, b). There is, however, ample scope for future scientific researches to synthesize new clay derivatives that are more effective to neutralize a wider range of anionic contaminants.

4.3. The basic contaminants

The basic pesticides like atrazine, simazine etc. are adsorbed by the clay minerals of smectite group (e.g. bentonite, montmorillonite) through hydrogen bonding and protonation (Davies and Jabeen, 2003). These workers applied FT-infrared spectroscopy, thermogravimetric analysis, high pressure liquid chromatography and X-ray diffraction to study the adsorption of basic pesticides and two model compounds, 2-chloropyrimidine and 3-chloropyridine, on clay minerals with $t-o$ and $t-o-t-c$ structures (kaolinite and montmorillonite respectively), and found that the model compounds were

absorbed by the *t-o-t-c* clays by ion exchange mechanism. Their studies further revealed that these compounds could not be adsorbed by kaolinite.

4.4. The neutral and acidic contaminants – the application of clay-derivatives

The natural clay minerals are not very effective adsorbents of acidic and neutral contaminants, but their adsorption capacity can be greatly enhanced by the incorporation of large alkylammonium cations in the interlayer spaces (Aguer et al. 2000, Akcay and Yurdakoc 2000, Boyd et al. 1988, Carrizosa et al. 2000, 2001, Celis et al. 1999, 2000a, Hermosín and Cornejo 1993, Sánchez-Martín et al. 2006, Zhao et al. 1996). Some commonly used alkylammonium cations are:

- Dodecyl-ammonium (DDA)
- Octadecyl-ammonium (ODA)
- Octadecyltrimethyl-ammonium (ODTMA)
- Diocadecyldimethyl-ammonium (DODDMA)
- Hexadecyltrimethyl-ammonium (HDTMA)

The clay-derivative *organoclays* thus synthesized can be effectively used in the following cases.

- (a) Adsorption of the uncharged fungicide triadimefon by Arizona montmorillonite (SAz-1) increased from 0 to >90% after modification with HDTMA cations.
- (b) The adsorption of triadimefon by HDTMA-exchanged Wyoming (SWy-2) montmorillonites were 6 – 16 times greater than that of untreated clay sample.
- (c) The acidic pesticides can be adsorbed effectively after modification of montmorillonite with large alkylammonium cations, especially at low pH levels. For example, the adsorption of 2,4-D (Hermosín and Cornejo, 1992, 1993), imazamox (Celis et al., 1999), bentazone (Carrizosa et al., 2000), dicamba (Zhao et al., 1996; Carrizosa et al., 2001) and picloram (Celis et al., 2002b) have been reported.

4.5. The non-ionic contaminants

The adsorption of these pesticides and herbicides are largely controlled by the nature of the inorganic cations in the interlayer spaces of clay minerals. The cations of low ionic potential are directly coordinated with the contaminant atoms. But those with higher ionic potential are bound with the latter atoms by water molecules, known as ‘water bridges’ (Cox et al. 1995, Cornejo et al. 2008). Hydrogen bonding plays a part in this adsorption process. In pyrifenoxy, for example, the pyridinium nitrogen atom is directly linked to the Cu^{2+} ion, but bound by a water molecule to the interlayer Mg^{2+} cation in montmorillonite (Farmer and Mortland 1966, Lagaly 2001). Bonding by water molecule is also observed during the adsorption of the herbicide thiazafuron in the interlayers of montmorillonite (Cox et al. 1995).

IV. CONCLUSION

The scientific investigations carried out over the last few decades on the impacts of the implements of modern agriculture on soil and the application of clay minerals for the recovery of soil health lead us to the following conclusions.

- (i) The chemical fertilizers, pesticides, herbicides, fungicides etc. adversely affect the physical parameters (texture, water holding capacity), chemical parameters (pH, salinity, soil organic matter content), and biological parameters (population of soil organisms, microbial activity, soil respiration etc.) of soil health. Prolonged use of these chemicals may render the soil incompatible for future agricultural activities.
- (ii) Since it is not possible to turn away from these harmful chemicals right now, their use must be restricted, and some appropriate remedial measures must be adapted to free the soil from the contaminants introduced by them.
- (iii) Clay minerals, owing to their characteristic physical and chemical properties and ready availability, may serve as effective but inexpensive substance to remove a wide range of contaminants from the soil.
- (iv) While the clay minerals per se can very efficiently adsorb the cationic and basic contaminants from the soil, their applicability to remove anionic, acidic and neutral contaminants is very limited. The latter types of contaminants can be effectively adsorbed by some clay derivatives, synthesized by incorporation of different types of organic and inorganic groups in the interlayer spaces of clay structure.

To explore the further potentialities of clay minerals in the preservation or restoration of soil health, and to synthesize new clay derivatives to clear the environment from a wider range of contaminants, a comprehensive interdisciplinary scientific investigation is the need of the day that may sustain the soil for the future agricultural activities.

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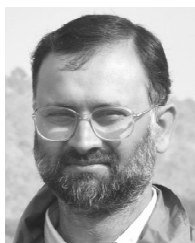
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বাংলা পাঠ্যপুস্তক ও ছাপাখানার প্রথম পাঁচ দশক

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সারাংশঃ বিদ্যার্জনের মাধ্যম হিসেবে বাংলা ভাষার ব্যবহার খুব বেশিদিনের নয়। তাই বাংলা ভাষায় পাঠ্যপুস্তক রচনার কাজও শুরু হয়েছে অতি আধুনিক যুগে। সাহিত্য রচনার মাধ্যম হিসেবে বাংলা ভাষা প্রায় পঞ্চদশ শতক থেকে নিয়মিতভাবে ব্যবহৃত হলেও ভাষার নিয়মবদ্ধ রূপ বা ব্যাকরণ এবং শিক্ষার্থীর জন্য বর্ণশিক্ষার পাঠ্যপুস্তকের পরিচয় পাওয়া যায়নি ছাপাখানা পূর্ব যুগে। ইংরেজ সিভিলিয়ানদের বাংলা ভাষাশিক্ষার হাত ধরে সেই পাঠ্যপুস্তক এর জন্ম হয় ১৮০০ খ্রিস্টাব্দে। সেই প্রয়াসকে দ্রুততর করতে সাহায্য করে মুদ্রণযন্ত্রের প্রতিষ্ঠা। হাতে লেখা পুথির পরিবর্তে মুদ্রিত পাঠ্যপুস্তক শিক্ষার্থীর জ্ঞানার্জনের হয়ে উঠেছে ততদিনে। দেশীয় ছাত্রদের জন্য স্কুল বুক সোসাইটির উদ্যোগে সেই প্রয়াসকে আরো মসৃণ এবং উন্নততর করার লক্ষ্যে অগ্রসর হয়েছিল। তার কিছু কাল পরে হিন্দু কলেজ পাঠশালা এবং তত্ত্বাবোধিনী পাঠশালার মতো ব্যক্তিগত ও গোষ্ঠীগত উদ্যোগও উন্নতির পক্ষে সহায়ক হয়েছিল। এভাবে ১৮০০ খ্রিস্টাব্দ থেকে ১৮৫০ খ্রিস্টাব্দ পর্যন্ত সুদীর্ঘ সময় বাংলা পাঠ্য পুস্তকের যুগান্তর ঘটে গিয়েছে, যার অন্যতম হাতিয়ার মুদ্রণযন্ত্র। প্রথমে প্রশাসক গোষ্ঠীর প্রয়োজনে যার জন্ম, পরেও ধনাঢ্য ব্যক্তিবর্গ ও গোষ্ঠীর সাহায্যে তার পরিপোষণ এবং পরবর্তী সময়ে সরকারি হস্তক্ষেপের দ্বারা প্রথাবদ্ধ ভাবে পাঠ্যপুস্তক এর ব্যবহার এক নতুন সম্ভাবনার জন্ম দিয়েছিলো। সেই সম্ভাবনার নাম মাতৃভাষায় শিক্ষার বিস্তার।

বীজ শব্দঃ পাঠ্যপুস্তক মুদ্রণযন্ত্র শিক্ষার্থী

বাংলা পাঠ্যপুস্তক ও ছাপাখানার প্রথম পাঁচ দশক

বাংলা ভাষায় লেখাপড়ার চর্চা ও বিদ্যার্জনের ইতিহাস সুপ্রাচীন নয়। কারণ বঙ্গদেশে বিদ্যা শিক্ষার মাধ্যম হিসেবে সংস্কৃত, আরবি-ফারসি এবং পরবর্তীকালে ইংরেজির প্রাধান্য বহুকাল ধরেই চর্চিত। শিক্ষালাভের সঙ্গে অর্থ উপার্জনের গণমানসিকতা শিক্ষালাভের প্রক্রিয়াকে চিরকাল অর্থকরী উপায় হিসেবেই দেখে এসেছে। তাই প্রশাসনের ভাষাতেই বিদ্যার্থীর পাঠ্যপুস্তক রচিত হয়েছে বারবার, যাতে করে বহু অর্থ ব্যয়ে শেখা বিদ্যা পরবর্তীকালে অর্থ উপার্জনের সহায়ক হয়। অনন্যদাম্পলের কবি ভারতচন্দ্র সংস্কৃত ভাষায় বুৎপত্তি অর্জন করা সত্ত্বেও আরবি ও ফারসি ভাষা শিখেছিলেন অর্থ উপার্জনের আশায়। দুই প্রখ্যাত বৈষ্ণব তত্ত্বজ্ঞ রূপ ও সনাতন গোস্বামী সংস্কৃত ভাষায় পণ্ডিত হওয়া সত্ত্বেও হুসেন শাহের রাজদরবারে পদপ্রাপ্তির জন্য আরবি-ফারসি শিখেছিলেন। ফলে পাঠ্যপুস্তকের ভাষা নির্ণয় করে সময়, সমাজ ও অর্থনীতির উন্নতি বা পরিবর্তনের গতিকে। এমনই প্রয়োজনের তাগিদে প্রশাসকের তদারকিতে হঠাৎ করেই বাংলা ভাষার ভাগ্য

উন্নতির পথ প্রশস্ত হয়েছিল। ইংরেজ সিভিলিয়ানদের বঙ্গদেশে প্রশাসক হিসেবে দায়িত্বভার অর্পণের আগে বাংলা ভাষায় অভিজ্ঞ করে তোলার জন্য লেখা হয়েছিল বাংলা পাঠ্যপুস্তক। যে পাঠ্যপুস্তকগুলি মুদ্রণযন্ত্রের সহায়তা লাভ করে বাংলা গদ্যের জন্মকেও ত্বরান্বিত করেছিলো।

বাংলা ভাষার অক্ষরগুলি প্রথমবার মুদ্রণযন্ত্রের স্পর্শ পায় পর্তুগীজদের সহায়তায়। পর্তুগীজ পাদ্রী মনোএল-দ্য-অ্যাসুস্পসাও 'কৃপার শাস্ত্রের অর্থভেদ' রচনা করেন। সেটি ১৭৪৩ খ্রিস্টাব্দে রোমান অক্ষরে লিসবন শহর থেকে মুদ্রিত হয়, যার মধ্যে ঢাকার ভাওয়াল পরগনার উপভাষা ও আরবি-ফারসি মিশ্রিত বাংলা অক্ষরের নিদর্শন রয়েছে।^(১) কিন্তু 'বাংলাভাষাকে মুদ্রণযন্ত্রের বৈপ্লবিক সহায়তা-দান পর্তুগীজদের কৃতিত্ব নয়, সে কৃতিত্ব ইংরেজের।..... বিদ্যাজগতে মুদ্রযন্ত্র বিপ্লব ঘটায়'।^(২) সেই কৃতিত্বের অন্যতম অংশীদার উইলিয়াম কেরী। প্রথমদিকে তিনি খ্রিস্টান মিশনারিদের সঙ্গে সংযুক্ত থেকে ধর্মপ্রচারকের মতই কাজ করেছিলেন। পরবর্তী সময়ে তাঁর ভূমিকার বদল হয়। ১৭৯৯ খ্রিস্টাব্দে খিদিরপুর অঞ্চলে একটি নীলকুঠি কিনে তিনি একটি কার্ঠের মুদ্রাযন্ত্র স্থাপন করেন।^(৩) সেখানে মিশনারীদের ধর্মীয় প্রচার সংক্রান্ত কাজকর্ম করা হতো। কিন্তু তৎকালীন প্রশাসক জর্জ উডিনি মিশনারিদের কাজকর্মের সমর্থক না হওয়ায় দিনেমার বা ডাচ অধিকৃত শ্রীরামপুরে মিশনপ্রেসের কাজ শুরু হয়।^(৪) শ্রীরামপুর ব্যাপটিস্ট মিশন শুরু হয় ১৮০০ খ্রিস্টাব্দের ১০ই জানুয়ারি ও শ্রীরামপুর মিশন প্রেসের কাজ শুরু হয় মার্চ মাসে।^(৫) এই দুটি প্রেসের মুখ্য কর্মকর্তা ছিলেন উইলিয়াম কেরী। যার প্রয়াসে পরবর্তীকালে বহু পাঠ্যপুস্তক মুদ্রিত হয়েছে উল্লিখিত প্রেস দুটি থেকে।

বাংলা ছাপাখানার বিকাশে উইলিয়াম কেরীর সঙ্গে যে বাঙালি কর্মকার অত্যন্ত দক্ষতার সঙ্গে কাজ করেছিলেন তিনি হলেন পঞ্চনন কর্মকার। ইনি ছিলেন অত্যন্ত দক্ষ কারিগর, যিনি প্রথম উইলকিন্স কোলব্রকের অধীনে কাজ করতেন। পরে তাঁর দক্ষতা দেখে শ্রীরামপুর প্রেসের কাজকর্মের সঙ্গে যুক্ত করা হয়। এই পঞ্চনন এবং তার জামাতা মনোহর, শ্রীরামপুর মিশন প্রেসের দক্ষ কারিগর ছিলেন যাঁদের নিরলস প্রয়াসে শ্রীরামপুরের ছাপাখানা সমৃদ্ধ হয়েছিল। হুগলির এই ছাপাখানা প্রতিষ্ঠার কিছুদিনের মধ্যেই কলকাতার বিভিন্ন জায়গায় প্রেস প্রতিষ্ঠিত হয়। কলুটোলায় চন্দ্রিকা যন্ত্রালয়, বউবাজারে শ্রীলোভেন্দ্র সাহেবের ছাপাখানা, মীরজাপুরে মুন্সি হেদাতুল্লাহর ছাপাখানা, সম্বাদ তিমির নাশক যন্ত্রালয়, আরপুলিতে শ্রীহরচন্দ্র রায়ের প্রেস, শাঁখারীটোলায় বদন পালিতের প্রেস, শোভাবাজারে বিশ্বনাথ দেবের প্রেস - এই সমস্ত প্রেস উনিশ শতকের প্রথম দশকের মধ্যে প্রতিষ্ঠিত হয়েছিল। ফোর্ট উইলিয়াম কলেজের পাঠ্যপুস্তকের চাহিদার যোগান দেওয়ার জন্য কলকাতায় আরও তিনটি ছাপাখানা প্রতিষ্ঠিত হয়। ১৮০২ খ্রিষ্টাব্দে গিলখ্রিস্ট শুরু করেন হিন্দুস্থানী প্রেস।^(৬) এই ছাপাখানা থেকে কলেজের বিদেশি পড়ুয়াদের জন্য উর্দু ভাষা ও সাহিত্যের বই ছাপানো হত। ১৯০৫ সালে কলেজের পৃষ্ঠপোষক মাথু সাহেব প্রতিষ্ঠা করেন পার্শিয়ান প্রেস। সেখানে ছাপা হতো ফার্সি বই। তারপর ১৮০৭ খ্রিস্টাব্দে খিদিরপুরে বাবুরাম প্রতিষ্ঠা করেন সংস্কৃত প্রেস। এই সংস্কৃত প্রেসই প্রথম পুরোপুরি স্বদেশি প্রেস। এখানে ছাপা হয়েছিল 'হেমচন্দ্র কোষ' (১৮০৭), 'অমর কোষ' (১৮০৭), 'অভিধান চিন্তামণি' (১৮০৮), 'গীতগোবিন্দ' (১৮০৮), 'ভাগবদগীতা' (১৮০৯) ইত্যাদি গ্রন্থ। তবে এই সমস্ত গ্রন্থই ছিল সাধারণ পাঠকের জন্য। সাধারণ পাঠকের কথা মনে রেখেই ১৮১৮-২০ সালের মধ্যে প্রতিষ্ঠিত হয়েছিল বটতলার ছাপার যন্ত্র, যা সাধারণ জনগণের পাঠ চাহিদাকে পূরণ করেছিল। কিন্তু পাঠ্যপুস্তক এর জন্য প্রয়োজন হয়েছিল বিদেশিদের সহায়তায় তৈরি কলেজ কর্তৃপক্ষ এবং স্বদেশী ব্যক্তিবর্গের দ্বারা তৈরি করা একাধিক সংস্কার সুনির্দিষ্ট প্রয়াস। যাদের কথা আমরা পরবর্তী পর্যায়ে আলোচনা করেছি। তার আগে দেখে নেওয়া যাক ঠিক কোন ধরনের পাঠ্যপুস্তকের ব্যবহার করা হতো ছাপাখানার প্রথম যুগের শিক্ষার্থীদের জন্য।

প্রথম যুগের বাংলা পাঠ্যপুস্তকগুলি ক্ষেত্রে প্রধানত তিনটি ভাগ লক্ষ করা যায়। এক. বর্ণশিক্ষা, দুই. ব্যাকরণ শিক্ষা এবং তিন. বাংলা দ্রুতপঠনের উপযোগী গ্রন্থ। পরিভাষাগত ভাবে এই বই গুলি কে চিহ্নিত করা যায় এভাবে – প্রাইমার, গ্রামার, রিডার। তবে অনেক ক্ষেত্রে একই বইতে প্রাইমার ও রিডারের প্রয়োজন সম্পন্ন করা হয়েছে, অনেকসময় প্রাইমার গ্রামার-এর প্রয়োজনও একটি গ্রন্থে মেটানোর চেষ্টা হয়েছে। উইলিয়াম কেরী ফোর্ট উইলিয়াম কলেজের দায়িত্বভার লাভ করে নিজেই ছাত্রদের প্রয়োজনের কথা মাথায় রেখে একটি ব্যাকরণ গ্রন্থ লেখেন। এটি প্রকাশিত হয় শ্রীরামপুর মিশন প্রেস থেকে ১৮১১ খ্রিস্টাব্দে। রেভেরেন্ড জেমস লঙের দ্বারা প্রকাশিত ফোর্ট উইলিয়াম কলেজের ব্যবহারের জন্য সরকার-ক্রীত যে পুস্তকের তালিকা প্রকাশিত হয়, তাতে দেখা যায় কেরীর ব্যাকরণটির (১ম সংস্করণ) দাম ছিল চার টাকা এবং সরকার কলেজের জন্য ১৮০২ খ্রিস্টাব্দে ১০০ কপি ক্রয় করেছিলেন।^(৭) এছাড়া দীর্ঘদিনের পরিশ্রমে তেরটি ভারতীয় ভাষার একটি বৃহৎ শব্দকোষ রচনা করেছিলেন, যেটি ১৮১২ সালের ১১ই মার্চে শ্রীরামপুর মিশনের ছাপাখানার অগ্নিকাণ্ডে অনেকটাই পুড়ে যায়।^(৮) এই উদ্যোগগুলি ছাড়াও অন্যান্য একাধিক লেখক নিয়োগ করে বাংলা রিডার গ্রন্থের চাহিদা মেটাতে একাধিক পাঠ্যপুস্তক প্রকাশ করাটাও তাঁর কৃতিত্ব। ১৮০১ খ্রিস্টাব্দ থেকে ১৮১৫ খ্রিস্টাব্দ পর্যন্ত মোট ১৩টি বাংলা গদ্য পাঠ্যপুস্তক প্রকাশিত হয়েছিল ফোর্ট উইলিয়াম কলেজের সিভিলিয়ান ছাত্রদের জন্য। গ্রন্থগুলির সবকটিই প্রকাশিত হয়েছিল শ্রীরামপুর মিশন প্রেস থেকে। বইগুলি হলো - উইলিয়াম কেরীর ‘কথোপকথন’ (১৮০১), ‘ইতিহাসমালা’ (১৮১২), রামরাম বসু রচিত ‘রাজা প্রতাপাদিত্য চরিত্র’ (১৮০১), ‘লিপিমাল্য’ (১৮০২), গোলকনাথ শর্মা রচিত ‘হিতোপদেশ’ (১৮০২), মৃত্যুঞ্জয় বিদ্যালঙ্কার রচিত ‘বত্রিশ সিংহাসন’ (১৮০২), হিতোপদেশ (১৮০৮), ‘রাজাবলি’ (১৮০৮), ‘প্রবোধচন্দ্রিকা’ (১৮৩৩), তারিণীচরণ মিত্র রচিত ‘ওরিয়েন্টাল ফেবুলিস্ট (১৮০৩), রাজীবলোচন মুখোপাধ্যায় রচিত ‘মহারাজ কৃষ্ণচন্দ্র রায়স্য চরিত্রং’ (১৮০৫) চণ্ডীচরণ মুনশী রচিত ‘তোতা ইতিহাস’ (১৮০৫), হরপ্রসাদ রায় রচিত ‘পুরুষ-পরীক্ষা’ (১৮১৫)।^(৯)

উপরে উদ্ধৃত এই সুদীর্ঘ গ্রন্থতালিকায় যে গ্রন্থ গুলির কথা উল্লেখ করা হয়েছে সেগুলির কোনটাই দেশীও ছাত্রদের জন্য লেখা হয়নি। এই অভাব পূরণ করার জন্য ১৮১৭ খ্রিস্টাব্দে ‘কলিকাতা স্কুল বুক সোসাইটি’ স্থাপিত হয়।^(১০) কিন্তু স্কুল বুক সোসাইটির আগে মিশনারিদের উদ্যোগে শিক্ষার উন্নতির জন্য একাধিক বিদ্যালয় প্রতিষ্ঠিত হয়। যেমন ১৮০০ সালে শ্রীরামপুরে প্রতিষ্ঠিত মিশনারি বঙ্গবিদ্যালয়, ১৮১৪ খ্রিস্টাব্দে চুঁচুড়ায় প্রতিষ্ঠিত মে সাহেবের পাঠশালা, ১৮১৭-১৮ সালে বর্ধমান অঞ্চলে প্রতিষ্ঠিত স্টুয়ার্ট সাহেবের পাঠশালা এবং ১৮১৯ সালে কলকাতার লন্ডন মিশনারি সোসাইটির উদ্যোগে প্রতিষ্ঠিত কলকাতার বিদ্যালয় ইত্যাদি।^(১১) কিন্তু এই বিদ্যালয়গুলিতে বর্ণপরিচয় ও বানান শিক্ষার কোন ছাপা বই না থাকায় এই ঘাটতি পূরণে শ্রীরামপুর মিশন প্রেস নিজস্ব উদ্যোগে ‘লিপিদারা’, ‘বানান’, ‘গুরুশিষ্য’ ইত্যাদি বিভিন্ন গ্রন্থ প্রকাশ করে।^(১২) যে বইগুলির উল্লেখ পাওয়া যাচ্ছে ১৮১৮ খ্রিস্টাব্দে ২৩শে সেপ্টেম্বর তারিখে অনুষ্ঠিত স্কুল বুক সোসাইটির প্রথম বার্ষিক সভার প্রতিবেদনে।^(১৩) স্কুল বুক সোসাইটি প্রতিষ্ঠিত হওয়ার পর তাদের নিজস্ব উদ্যোগে প্রকাশিত হয় একাধিক গ্রন্থ, যেগুলি একাধারে বাংলা প্রাইমার ও রিডারের চাহিদা পূরণ করেছিল। এর মধ্যে উল্লেখযোগ্য হল জেমস স্টুয়ার্টের এর লেখা ‘বর্ণপরিচয়’ (১৮১৮)। গ্রন্থটি ছাপানো হয়েছে শ্রীরামপুর ব্যাপ্টিস্ট মিশন থেকে। প্রথম প্রকাশনায় তিনশ কপি ছাপানো হয়েছিল। ছাপতে ব্যয় হয়েছিল এক শত চল্লিশ টাকা। পরবর্তীকালের বিভিন্ন রিপোর্টে এই গ্রন্থের প্রকাশনা ও সমাদরের প্রসঙ্গ উল্লেখিত হয়েছে। গ্রন্থটি প্রথম পাঠে স্বরবর্ণ ও সংখ্যার সঙ্গে পরিচিতি ঘটিয়ে বানান, বানানের পরে নীতি কথা, ৭-১০ নম্বর পাঠ্যে এক অক্ষর এবং দুই অক্ষরের শব্দ, ১৪-১৯ নম্বর পাঠ্যে তিন বর্ণের শব্দ শেখানো হয়েছে। ১৮১৭ থেকে ২৫ বছর পর্যন্ত বাংলা গ্রন্থের চাহিদা পূরণ করেছে এই বইটি।^(১৫)

বাংলা পাঠ্য পুস্তকের জগতে স্কুল বুক সোসাইটি কর্তৃক প্রকাশিত রাধাকান্ত দেবের ‘বাংলা শিক্ষাগ্রন্থ’ (১৮২০) বিশেষ গুরুত্বপূর্ণ। একই সঙ্গে প্রাইমার এবং রিডার। এখানে প্রথমে বর্ণমালা, স্বরবর্ণ ও ব্যঞ্জনবর্ণের সঙ্গে পরিচয় ঘটানো হয়েছে, দ্বিতীয় পৃষ্ঠায় যুক্তাক্ষর, ষষ্ঠ পৃষ্ঠায় ত্র্যক্ষর। ত্রিশ পাতার পর থেকে গ্রন্থটিতে শব্দাবলী সঙ্গে পরিচয় ঘটানো হয়েছে। যেমন ৩৭ পৃষ্ঠায় –

‘ঘরে যাও খেলা করো বহি পড়ো’^(১৬)

দুই শব্দের এই গতিময় বাক্য রাধাকান্ত দেবই প্রথম পাঠ্যপুস্তকে সংযুক্ত করলেন। পরবর্তীকালে ১৯৩০ খ্রিস্টাব্দে প্রকাশিত রবীন্দ্রনাথের ‘সহজপাঠে’ও এই রীতি অনুসরণ করা হয়েছে।^(১৭) তবে শুধু বর্ণশিক্ষাই নয়, দ্রুত পঠনযোগ্য বিষয় হিসেবে সময়জ্ঞান, কালনির্ণয়, বার, তিথি, নক্ষত্র, মাস ইত্যাদি সাধারণ জ্ঞানের বিষয়গুলি যুক্ত করেছেন। রাধাকান্ত দেবের পরে স্কুল বুক সোসাইটির পুস্তক প্রকাশনা যুগে বাঙালি কর্তৃক রচিত পাঠ্যপুস্তক হিসাবে নীলরত্ন হালদার রচিত ‘কবিতা রত্নাকর’ গ্রন্থটি ১৮২৫ খ্রিস্টাব্দে প্রকাশিত হয়। গ্রন্থটির পৃষ্ঠা সংখ্যা ছিল ৯৬। এছাড়া তারিনীচরণ মিত্র, রাধাকান্ত দেব এবং রামকমল সেনের সহযোগিতায় ১৮১৮ খ্রিস্টাব্দে ইংরেজি ও আরবি থেকে একত্রিশটি কাহিনী বাংলায় অনুবাদ করিয়ে ‘নীতিকথা’ নামে একটি পুস্তক প্রকাশ করে স্কুল বুক সোসাইটি। এটি একটি বাংলা রিডার গ্রন্থ। এই নীতি কথা সিরিজে আরও দুটি বই প্রকাশিত হয় – নীতিকথা দ্বিতীয়ভাগ (১৮১৯ সেপ্টেম্বর) এবং তৃতীয় ভাগ (১৮১৯)। এই দুটি গ্রন্থ মে সাহেব ও পিয়ারসন এর উদ্যোগে লেখা।^(১৮) নীতিকথার তৃতীয়ভাগ গ্রন্থটি স্কুল বুক সোসাইটির প্রেসে মুদ্রিত হওয়ার খবর পাওয়া যায়। কিন্তু অন্যান্য গ্রন্থগুলি, যেমন – রাধাকান্ত দেবের ‘বাঙ্গালা শিক্ষাগ্রন্থ’ (১৮২০), নীলরত্ন হালদারের ‘কবিতা রত্নাকর’ বা ‘নীতিকথা’ গ্রন্থের প্রথম ভাগ গ্রন্থগুলি শ্রীরামপুর ব্যাপ্টিস্ট মিশন প্রেস ও শ্রীরামপুর মিশনের সহযোগিতায় মুদ্রিত হয়। শ্রীরামপুরের এই দুটি প্রেসের সঙ্গে ‘স্কুল বুক সোসাইটি’র নিবিড় সম্পর্কের কথা জানা যায় শ্রীপাত্তের বক্তব্য থেকে –

‘কলকাতা স্কুল বুক সোসাইটি প্রতিষ্ঠিত হয় ১৮১৭ সালের জুলাই মাসে। মিশন প্রেসের সূচনা থেকেই সোসাইটির নিবিড় সম্পর্ক। বাংলা হরফ এবং ছাপার কাজ উন্নত করা ছিল সোসাইটির আর এক লক্ষ্য। এ ব্যাপারে তাঁদের প্রধান সহায়ক ছিলেন মিশন প্রেস। বাংলায় ‘ইটালিকস’ নেই, ছাত্ররা যাতে সহজে বিশেষ বিশেষ, উদ্ধৃতি এবং বিশেষ কোন শব্দ বা বাক্য ধরতে পারে তার জন্য উইলিয়াম হপকিন্স পীয়ার্স তৈরি করেছিলেন ‘ইটালিকস’-এর বিকল্প এক বিশেষ ছাঁদের বাংলা হরফ। সোসাইটির তৃতীয় বার্ষিক বিবরণে (১৮১৯-২০)। এই হরফ তৈরির ইতিহাস ও নমুনা রয়েছে’।^(১৯)

কলকাতা স্কুল বুক সোসাইটি কেবলমাত্র বাংলা প্রাইমার ও রিডার গ্রন্থ প্রকাশ এই থেমে যায়নি, তাদের উদ্দেশ্য ছিল বঙ্গীয় বালক ও যুব সমাজের সর্বাঙ্গীন ভাষাশিক্ষা। স্কুল বুক সোসাইটির সপ্তম রিপোর্টে দেখা যায়–

‘The conviction that a Bengalee Grammar, better adopted to the instruction of native youths than one on their list, has led your committee to solicit the services of Baboo Rammohan Roy in preparing one; they are happy to report that this gentleman has cheerfully engaged to give his immediate attention to the executive execution of his work.’^(২০)

রামমোহন রায়কে একটি স্কুল পাঠ্য ব্যাকরণ গ্রন্থ রচনা লেখার জন্য অনুরোধ করা এবং তাতে তাঁর রাজি হওয়ার খবর এখানে পাওয়া যাচ্ছে। প্রসঙ্গত উল্লেখযোগ্য যে রামমোহন রায় তাঁর প্রথম বাংলা ব্যাকরণ গ্রন্থটি লেখেন ইংরেজিতে, গ্রন্থ

নাম ‘Bengalee Grammar in the English Language’, যেটি প্রকাশিত হয় ইউনিটেরিয়ান প্রেস থেকে ১৮২৬ খ্রিস্টাব্দে।^(২১) পরবর্তী সময়ে ১৮৩৩ খ্রিস্টাব্দে ‘গৌড়ীয় ব্যাকরণ’ নামে স্কুল বুক সোসাইটি প্রেস থেকে গ্রন্থটি মুদ্রিত হয়। গ্রন্থটির একটি সংক্ষিপ্ত সংস্করণ প্রকাশিত হয়। ১৮৪০ খ্রিস্টাব্দে, যে সংস্করণটি তৎকালীন তত্ত্বাবোধিনী পাঠশালা এবং হিন্দু কলেজের পাঠশালায় বাংলা শ্রেণীতে ব্যাকরণ পাঠ্য হিসেবে গৃহীত হয়েছিল।^(২২) এই ধরনের একটি ব্যাকরণের জন্যই যেন তৎকালীন বাংলার শিক্ষাজগৎ প্রতীক্ষা করছিল। এছাড়া ১৮৩০ খ্রিস্টাব্দে ‘প্রাচীন ইতিহাস সমুচ্চয়’ নামে একটি ইতিহাস গ্রন্থ প্রকাশ করে কলকাতা স্কুল বুক সোসাইটি।^(২৩) ১৮৩৩ খ্রিস্টাব্দের পর থেকে অর্থনৈতিক সংকটের কারণে এবং সোসাইটির কোষাধ্যক্ষ ম্যাকিন্টোশ কোম্পানির পতনের ফলে এর কার্যক্রম সংকুচিত হয়ে পড়ে।^(২৪)

এখানে উল্লেখ করা প্রয়োজন যে বাংলা ছাপানোই শেষ কথা নয়। ছাপা বই বিক্রির জন্য দরকার একটি বিক্রয়কেন্দ্র, যেখান থেকে ক্রেতা নিজে এসে বই কিনতে পারে। আধুনিক পদ্ধতিতে বই বিক্রির ব্যবসা ইংরেজরা এদেশে এসে প্রথম শুরু করে। ফোর্ট উইলিয়াম কলেজের পৃষ্ঠপোষকতাই ছাপা বাংলা বই এবং শ্রীরামপুর মিশন প্রেসে ছাপা বই বিক্রির জন্য নিজস্ব কেন্দ্র ছিল। তবে তা বিক্রয়কেন্দ্র বা বুক ডিপোজিটরি নয়। স্কুল বুক সোসাইটি এই বুক ডিপোজিটরি ব্যবস্থার পতন করে ১৮২৬-এ। তবে স্কুল বুক সোসাইটি ব্যবসা করার জন্য বই বিক্রি করতেন না। তাঁদের উদ্দেশ্য ছিল শিক্ষার গণপ্রসার ঘটানো। তাই বইয়ের আখ্যাপত্র বা বিজ্ঞাপনে বই কোথায় পাওয়া যাবে, তার স্পষ্ট নির্দেশ থাকতো। বই পাওয়া যেত সেই বইয়ের মুদ্রকের বাড়িতে বা ছাপাখানায়, লেখকের বাড়িতে, কখনও বা অন্য কারোর বাড়িতে বা অফিসে। ১৮২৬-এ শুরু হয় স্কুল বুক সোসাইটির ডিপোজিটরি। তার কুড়ি বছর পর ১৮৪৭ খ্রিস্টাব্দে ইশ্বরচন্দ্র বিদ্যাসাগর খোলেন সংস্কৃত প্রেস ডিপোজিটরি।^(২৫) তবে সে অনেক পরের কথা।

স্কুল বুক সোসাইটির কার্যকাল পর্যন্ত ব্যক্তিগত ও গোষ্ঠীগত বা কখনও কখনও প্রশাসনিক উদ্যোগে পাঠ্যপুস্তক রচনার কাজ চলেছে। এরমধ্যে মুদ্রণযন্ত্রকে নিয়ন্ত্রনের জন্য প্রশাসনিক উদ্যোগের রদবদল হয়েছে। যেমন ১৭৯৯ খ্রিস্টাব্দে প্রথম সেন্সর ব্যবস্থা চালু হয়, পরে ১৮১৮ সালে ওয়ারেন হেস্টিংস সেন্সর ব্যবস্থা তুলে দেন।^(২৬) ফলে পাঠ্যপুস্তক নির্মাণ, বিদ্যাশিক্ষার নীতি ও পদ্ধতি নির্ণয় ইত্যাদি ক্ষেত্রে প্রশাসনের সাময়িক হস্তক্ষেপ ছিল কিন্তু ১৮৩৩-এ এসে তা আরো বিস্তৃত হলো।

এ প্রসঙ্গে মেকলের প্রতিবেদন উল্লেখযোগ্য। ১৮৩৫-এ ভারতবর্ষীয় শিক্ষা সম্বন্ধীয় প্রতিবেদনে জানিয়েছিলেন ভারতীয়দের ইংরেজি শিক্ষার প্রয়োজনীয়তা ও উদ্দেশ্য। সেখানে স্পষ্ট বলা হয়েছে ‘to create a new class of Indians who may be interpreters between us and the millions whom we govern; a class of persons, Indian in blood and colour, but English in taste, in opinions, in morals and in intellect’^(২৭)। মেকলে সাহেবের এই প্রতিবেদনে এটা স্পষ্ট হয়ে ওঠে যে ইংরেজি শিক্ষা ও চর্চার মাধ্যমে এমন একটি শ্রেণীর জন্ম দেওয়া প্রয়োজন যারা বৃহত্তর জনগোষ্ঠীর সঙ্গে ইংরেজ প্রশাসকের ভাব বিনিময়ের মাধ্যম হিসেবে কাজ করবে। এমনকি মাতৃভাষায় শিক্ষাদানের বিষয়টিও তারাই পরিচালনা করবে। শিশির কুমার দাশ এর বিশ্লেষণ অনুযায়ী ইংরেজ প্রশাসক একেবারে নিজস্ব স্বার্থে ভারতবর্ষীয়দেরকে ইংরেজি এবং তাদের মাতৃভাষা উভয় ভাষাতেই শিক্ষিত করে তুলতে চাইছিল, যেখানে ইংরেজি শিক্ষিত নব্য সম্প্রদায় মাতৃভাষা শিক্ষার প্রসারে এগিয়ে এল, ‘where the English education has was spread along with the vernacular education, and the English education class took interest in the mother tongue’।^(২৮) কিন্তু মতদ্বৈত তৈরি হয়েছিল এঁদের মধ্যেই এই বিষয়টা নিয়ে যে কেবলমাত্র ইংরেজি শিক্ষার প্রসারে ভবিষ্যত উন্নতির পথ প্রশস্ত করবে, না নিজস্ব ভাষা ও সংস্কৃতির পুনরুদ্ধারের মাধ্যমে নিজেদের সমৃদ্ধ করে তুলতে হবে।

যে কারণে ব্যক্তিগত উদ্যোগে প্রতিষ্ঠিত এবং গোষ্ঠীগত প্রয়াসে স্থাপিত প্রতিষ্ঠানে ইংরেজি পাঠ্যগ্রন্থের পাশাপাশি বাংলা পাঠ্যগ্রন্থের ব্যবস্থাও করা হয়েছে। যেমনটি পাওয়া যায় দেবেন্দ্রনাথ ঠাকুর প্রতিষ্ঠিত তত্ত্ববোধিনী পাঠশালার পাঠ্যসূচিতে।

এই একই সময়ে লর্ড বেন্টিন্গ দেশের বেসরকারি শিক্ষাপ্রণালীর বিবরণ জ্ঞাপন ও শিক্ষা সংস্কার সম্পর্কে সরকারি কর্তব্য নির্ধারণের জন্য উইলিয়াম অ্যাডামকে কমিশনার নিযুক্ত করেন (১৮৩৫)। অ্যাডামের রিপোর্টে দেশীয় শিক্ষাপ্রণালীর শোচনীয় অবস্থার কথা উল্লেখ করে প্রচলিত জনশিক্ষার উপর ভিত্তি করে জাতীয় শিক্ষার ভিত্তি নির্ধারণের প্রস্তাব এবং গ্রাম্য পাঠশালাগুলির সংস্কারের প্রয়োজনীয়তার কথা উল্লেখ করে মাতৃভাষাকেই শিক্ষার মাধ্যম বলে উল্লেখ করা হল। কিন্তু সেই সিদ্ধান্ত কাজে পরিণত হল না, কারণ পার্লামেন্ট ইংরেজি শিক্ষার পক্ষপাতী ছিল এবং দেশীয় ইংরেজি সমর্থকরাও অত্যন্ত শক্তিশালী; তাই বাংলা শিক্ষা বা বাংলা ভাষা শিক্ষা সরকারি আনুকূল্য পেল না।^(২৯) তখন হিন্দু কলেজের অধ্যক্ষ সভার সদস্যরা বাংলায় শিক্ষাদানের জন্য হিন্দু কলেজের অধীনে একটি বাংলা পাঠশালা স্থাপনে উদ্যোগী হলেন (১৮৩৯)। এর উদ্দেশ্য ছিল ‘to provide a system of national education and to instruct Hindoo Youths in literature and in the Bengali Language’।^(৩০) ১৮৪০ সালের ১৮ই জানুয়ারী পাঠশালার কাজ শুরু হয়।

হিন্দু কলেজ পাঠশালায় প্রস্তুত উল্লেখযোগ্য পাঠ্যপুস্তকটি হল অধ্যক্ষ রামচন্দ্র বিদ্যাবাগীশের ‘শিশুসেবধি বর্ণমালা’ গ্রন্থটি। এই ‘শিশুসেবধি’ একটি সিরিজ বা গ্রন্থমালা। মোট ৭টি ‘শিশুসেবধি’ গ্রন্থের উল্লেখ পাওয়া যায়। এর মধ্যে প্রথম ও দ্বিতীয় সংখ্যা রামচন্দ্র বিদ্যাবাগীশের রচনা। এই দুটি গ্রন্থ মুদ্রিত হয়েছিল ব্রজমোহন চক্রবর্তীর ‘প্রজ্ঞাযন্ত্র’ নামক প্রেস থেকে।^(৩১) বর্ণমালার তৃতীয় ভাগ পঞ্চম সংস্করণ প্রকাশিত হয়েছে সমাচারচন্দ্রিকা প্রেস থেকে। ‘শিশুসেবধি’ গ্রন্থের কয়েক পৃষ্ঠার ব্যাকরণ চর্চায় সাধারণ ছাত্রদের ব্যাকরণ শিক্ষা সম্পন্ন হয়নি। তাই ক্ষেত্রমোহন দত্ত ‘গৌড়ীয় ব্যাকরণ’ (১৮৪১) নামে একটি বই প্রকাশ করেন, যেটি মুদ্রিত হয় কলকাতার ইম্পিরিয়াল প্রেস থেকে। এই প্রেসের মালিক ছিলেন পঞ্চগনন দে।

হিন্দু কলেজ পাঠশালার আদর্শে দেবেন্দ্রনাথ ঠাকুর তত্ত্ববোধিনী সভার অধীনে ১৩ই জুন ১৮৪০ তারিখে তত্ত্ববোধিনী পাঠশালার পাঠ্যসূচির পর্যালোচনা করলেই দেখা যাবে উভয়ক্ষেত্রে শিক্ষণীয় বিষয়ের অভিনবত্ব ও বৈচিত্র্য থাকলেও বাংলা ও ইংরেজি উভয় ভাষায় উপর বিশেষ গুরুত্ব দেওয়া হত যা সেই যুগের ভাষা শিক্ষা বিষয়ক ও প্রশাসনের রাজনৈতিক স্বার্থ সুরক্ষার প্রকাশ।^(৩৪)

প্রথম শ্রেণীঃ অক্ষর, বানান, হিতোপদেশক ইতিহাস, ব্যাকরণ ও গণিতের প্রাথমিক সূত্র, গোলাপের মূল প্রকরণ এবং ভারতবর্ষের সংক্ষিপ্ত বিবরণ।

দ্বিতীয় শ্রেণীঃ ব্যাকরণ, অঙ্ক, ক্ষেত্রপরিমাপ বিদ্যা, জ্যোতির্বিদ্যা, ইংল্যান্ড ও ভারত বর্ষের ইতিহাস এবং পত্র লিখন পদ্ধতি

তৃতীয় শ্রেণীঃ শুদ্ধরূপে ভাষা গঠনের নিয়ম, জমিদারি ও বাণিজ্যবিষয়ক ব্যবহার, প্রাচীন ও আধুনিক ইতিহাস, জ্যোতির্বিদ্যা, রাজনীতি, নীতিবিদ্যা, গভর্নমেন্ট এর ব্যবস্থা।

তত্ত্ববোধিনী পাঠশালার পাঠ্যসূচিঃ

১ম শ্রেণীঃ বাংলা পাঠ্যঃ কঠোপনিষৎ, রাজা রামমোহন রায়ের গ্রন্থের চুম্বক, তত্ত্ববোধিনী সভার বক্তৃতা, পদার্থবিদ্যা অঙ্ক। ইংরেজি পাঠ্যঃ Reader No. 4, Poetical Reader No. 2, Grammar, History of Bengal

২য় শ্রেণীঃ	বাংলা বইঃ ব্যাকরণ, ভূগোল, অঙ্ক। ইংরেজি পাঠ্যঃ Reader No.3, Poetical Reader No.1, Grammar, History of Bengal
৩য় শ্রেণীঃ	বাংলা বর্ণমালা ২য় ভাগ, মনোরঞ্জন ইতিহাস, ভূগোল, অঙ্ক। ইংরেজী পাঠ্যঃ Reader No.1, Spelling No.2
৪র্থ শ্রেণীঃ	বাংলা পাঠ্যঃ নীতিকথা ২য় ভাগ, বর্ণমালা ২য় ভাগ, অঙ্ক। ইংরেজী পাঠ্যঃ Reader No.1, Spelling No.2
৫ম শ্রেণীঃ	বাংলাঃ নীতিকথা ১ম ভাগ, বর্ণমালা ১ম ভাগ, অঙ্ক। ইংরাজিঃ Easy Primer.
৬য় শ্রেণীঃ	বাংলাঃ নীতিকথা ১ম ভাগ, অঙ্ক। ইংরাজিঃ Easy Primer.

এই পাঠশালাগুলির পাঠ্য পুস্তকগুলির দিকে তাকালে বোঝা যায় ইংরেজির পাশাপাশি বাংলা ভাষায় জ্ঞান-বিজ্ঞান চর্চা ও ভাষাশিক্ষার দিকে যথেষ্ট যত্ন নেওয়া হয়েছে। এই গুরুত্বপূর্ণ পদক্ষেপগুলির কারণে পরবর্তীকালে বাংলা ভাষা জ্ঞানচর্চার এবং সাহিত্য নির্মাণের মাধ্যম হিসেবে নিজের স্থান করে নেওয়ার সুযোগ পেয়েছে। এই প্রসঙ্গে উল্লেখযোগ্য যে তত্ত্ববোধিনী পত্রিকা ও সভার জন্য দুজন ধনাঢ্য ব্যক্তি মুদ্রায়ত্ন কিনে সাহায্য করেন। প্রথম জন রামপ্রসাদ রায়; দ্বিতীয় জন কালীপ্রসন্ন সিংহ, যিনি ১৮৫৭ সালে দেখাশোনা করার জন্য ওই প্রেসের যন্ত্রাধ্যক্ষ হয়েছিলেন।^(৩৭) এভাবে তত্ত্ববোধিনী পাঠশালার পাঠ্যপুস্তকগুলি তত্ত্ববোধিনী সভার নিজস্ব প্রেসে মুদ্রিত হয়েছিল।

তত্ত্ববোধিনী পাঠশালার উজ্জ্বলতম পাঠ্যপুস্তক রচয়িতা অক্ষয় কুমার দত্ত। তাঁর লেখা উল্লেখযোগ্য গ্রন্থ গুলি হল ‘ভূগোল’ (১৮৪১), ‘চারুপাঠ’ (১ম ভাগ ১৮৫৩, ২য় ভাগ ১৮৫৪, ৩য় ভাগ ১৮৫৯) এবং ‘পদার্থবিদ্যা’ (১৮৫৫)। ‘চারুপাঠ’ বর্ণশিক্ষার প্রাইমার গ্রন্থ না হলেও ছাত্রপাঠ্য (Reader) হিসাবে খুবই উপযোগী ছিলো। ১৮৯৮ খ্রিস্টাব্দ পর্যন্ত এই গ্রন্থটির তেইশটি সংস্করণ প্রকাশিত হয়।^(৩৮) জনশ্রুতি আছে যে এই বই বিক্রির টাকায় তিনি কলকাতায় তিন মহলা বাড়ি তৈরি করিয়েছিলেন।

হিন্দু কলেজ পাঠশালা এবং তত্ত্ববোধিনী পাঠশালা বেশিদিন স্ব-অবস্থায় থাকেনি। হিন্দু কলেজ পাঠশালার উপর সরকারি হস্তক্ষেপ ঘটল (১৮৪১), ফলে পাঠশালার অবনতি ঘটল এবং সেটি সংস্কৃত কলেজ এর অন্তর্ভুক্ত হল। অন্যদিকে দেবেন্দ্রনাথের আর্থিক বিপর্যয়ের ফলে তত্ত্ববোধিনী পাঠশালা উঠে গেল এবং সেই জায়গায় আলেকজান্ডার ডাফ মিশনারি স্কুল স্থাপন করলেন।^(৩৯)

বাংলা পাঠ্যপুস্তকের এবং ছাপাখানার প্রথম পাঁচ দশকের পর্যায়ক্রমিক উন্নতির ইতিহাস অসম্পূর্ণ থেকে যাবে আর একজনের উল্লেখ না করলে। তিনি ইশ্বরচন্দ্র বিদ্যাসাগর। ১৮৪৮ খ্রিস্টাব্দে ‘ইতিহাসমালা’ ও ১৮৪৯ খ্রিস্টাব্দে ‘জীবনচরিত’ রচনা করে তিনি পাঠ্যপুস্তকের জগতে প্রবেশ করেন। শিক্ষা প্রশাসক হিসেবে বাংলা পাঠ্যপুস্তকের যে অভাব বোধ করেছিলেন তা পূরণের জন্য ‘বোধদয়’ রচনা করেন। সংস্কৃত কলেজের অধ্যক্ষ থাকাকালীন তৎকালীন ছোটলাট হালিডে সাহেবকে শিক্ষা বিষয়ক মতামত জানাতে শুরু করেন। যার মধ্যে পাঠ্যপুস্তকপ্রণয়নের জন্য গুরুত্ব দেওয়ার কথা বলা হয়েছিল। ১৮৫৫ খ্রিস্টাব্দে দক্ষিণবঙ্গের বিদ্যালয়ের সহকারি পরিদর্শক পদে নিযুক্ত হওয়ার সময় বর্ণপরিচয় প্রথম ভাগ ও দ্বিতীয় ভাগ রচনা করেন।^(৪০) যে গ্রন্থ দুটি তার প্রকাশনার দেড়শত বছর পরেও প্রাসঙ্গিকতা হারায়নি। এখানে উল্লেখযোগ্য যে এই গ্রন্থগুলির মুদ্রণের পেছনেও তার নিজস্ব উদ্যোগ রয়েছে। সংস্কৃত কলেজের দায়িত্বভার থাকাকালীন বন্ধু

মনমোহনের সঙ্গে যৌথ উদ্যোগে স্থাপন করেন একটি মুদ্রণযন্ত্র, যার নাম ‘সংস্কৃত যন্ত্র’। ১৮৪৭ খ্রিস্টাব্দে সরকারি নথি অনুযায়ী ফোর্ট উইলিয়াম কলেজের সেক্রেটারি জি.টি. মার্শালকে মদন মোহন ৭.৬.১৮৪৭ তারিখে একটি চিঠি লেখেন, যে চিঠিতে প্রেস স্থাপনের উল্লেখ রয়েছে।^(৪১) উনিশ শতকের দ্বিতীয়ার্ধে এই ‘সংস্কৃত যন্ত্র’ ছিল মুদ্রণযন্ত্রের আদর্শস্বরূপ। শুধু প্রেস প্রতিষ্ঠা করায় নয়, বই বিক্রির জন্য তিনি স্থাপন করেন ‘সংস্কৃত প্রেস ডিপোজিটরি’। এই সিদ্ধান্তগুলির কারণে বাংলা ভাষা এবং বাংলা ভাষায় শিক্ষা লাভের পথ সম্ভাবনাময় হয়ে উঠেছিল, যার অন্তরালে ছিল মুদ্রণ যন্ত্রের বৈপ্লবিক অবদান।

ছাপাখানা প্রতিষ্ঠিত প্রথম যুগের প্রতিষ্ঠানের উদ্যোগে মুদ্রণ যন্ত্রের প্রতিষ্ঠা হলেও ব্যক্তিগত উদ্যোগেও প্রচুর প্রেস স্থাপন করা হয়েছে। প্রতিষ্ঠানগত ভাবে যে যে উদ্যোগগুলি হয়েছে সেগুলি প্রধানত প্রশাসক গোষ্ঠীর তরফে তাদের নিজস্ব রাজনৈতিক স্বার্থ সুরক্ষিত করার জন্য। কিন্তু তাদের সেই উদ্যোগ ব্যক্তিগত প্রয়াসকেও ত্বরান্বিত করেছিল। প্রথমদিকে ধনাঢ্য ব্যক্তিদের সহযোগিতায় জনকল্যানের জন্যই এবং খানিকটা ব্যবসায়িক সুবিধার সুযোগ লাভের আশায় মুদ্রণযন্ত্রের প্রতিষ্ঠা শুরু হয়েছিল। কিন্তু পরবর্তীকালে ব্যক্তিগত ও প্রাতিষ্ঠানিক সমস্ত রকমের ছাপার উদ্যোগকে প্রশাসনিক নিয়ম তন্ত্রের মধ্যে কাজ করতে হয়েছে। তবে ব্যক্তিগত উদ্যোগ অনেক ক্ষেত্রেই গণশিক্ষার উন্নতিতে সহায়ক হয়েছে। যা উনিশ শতকের সংস্কৃতি নির্মাণের অন্যতম হাতিয়ার হয়ে উঠেছে।

ছাপাখানার প্রতিষ্ঠা বঙ্গদেশে এক বৈপ্লবিক পরিবর্তন এনে দিয়েছিল। মাতৃভাষায় বিদ্যাশিক্ষা লাভের সুযোগ সমাজের সর্বস্তরে শিক্ষার আলোক পৌঁছে দিয়েছিল, যেটি সম্ভব হতো না মুদ্রণযন্ত্রের সহায়তা না পেলে। কারণ হাতে লেখা পুঁথি সংরক্ষিত হত সীমাবদ্ধ মুষ্টিমেয় বিদ্যাজনের কাছে, তাই শিক্ষা ও সীমাবদ্ধ হয়ে থেকে যেত একটি সুবিধাভোগী শ্রেণীর হাতে। মুদ্রণযন্ত্রে ছাপান বই প্রথমে সহজলভ্য না হলেও পরে বটতলার সংস্করণে প্রচুর বই সাধারণ মানুষের কাছে পৌঁছে যেতে পারত। তাই তখন পুঁথি নয় ‘বই’ এনে দিয়েছে নতুন যুগের সূচনা সম্ভাবনা। শুধু তাই নয় ‘পুঁথিগত বিদ্যাকে স্মৃতিতে ধরে রাখতে ‘পদ্য’-এর সীমাবদ্ধতা থেকেও বেরিয়ে আসা সম্ভব হল।^(৪২) যে অনায়াসলব্ধ, সজীব গদ্যে দৈনন্দিন জীবনে বাঙালি কথা বলে, সেই গদ্যের জন্মের ইতিহাসটাও জুড়ে আছে ছাপাখানার প্রতিষ্ঠার সঙ্গে। বাঙালির প্রকাশ মাধ্যম হিসেবে বাংলা ভাষার এই যুগান্তর সম্ভব হয়েছে এই বৈজ্ঞানিক আবিষ্কারটির হাত ধরেই। প্রথমে পাঠ্যপুস্তক, তর্কবিতর্কের বই, স্বাধীন অনুবাদমূলক গ্রন্থ থেকে মৌলিক উপন্যাসের জন্ম হতে মাত্র অর্ধশতাব্দী সময় নিয়েছে। এর অন্যতম কৃতিত্ব মুদ্রণযন্ত্রের। পাঠ্যপুস্তকগুলির মাধ্যমে বাংলা ভাষা বাঙালি ছাত্রের শিক্ষা প্রণালী ও শিক্ষাব্যবস্থার মধ্যে গুরুত্বপূর্ণ জায়গা করে নিতে পেরেছিল। না হলে উপন্যাসের পাঠক এর জন্ম হতো না আর ভবিষ্যৎ প্রজন্মের সর্বাঙ্গীণ শিক্ষার পথ উন্মুক্ত হতো না এত সহজে।

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A Study of Vascular Plants on Concrete Houses in Kolkata

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Abstract: *The older historical buildings and heritage houses in Kolkata are the foundations of the community's most sustainable form of development. The unique character of each of these older neighbourhoods effectively embodies much of the essence of the economic, cultural, social as well as the environmental sustainability. This paper presents an insight to the interaction between human and concrete grown vascular fauna in this millennium old metropolitan city. A survey was carried out in randomly chosen six comparatively new (less than 50 years age) and old (more than 50 years age) houses scattered in the city in which the angiosperm plants growing on concrete were sampled. An interview of the residents was taken to ask about whether they eradicate the weeds (self or by hiring labour) and how much it costs for such cleaning. It was found that out of 11 plant species grown on the houses, 7 species were only in new houses while 8 species were only in the old one while, 4 species were common to both new and old houses. Five plant species are common to both. *Ficus religiosa* was the most abundant plant in both cases. The abundance of plants showed no significant differences in between these two groups of houses. In terms of cleaning the plants from the respective houses, in case of new houses, either it was done by hiring labour (66.67 % correspondents) or not cleaned at all (33.33 % correspondents). In case of old houses, cleaning was done either manually or by hiring labour or not cleaned at all. Each of the method groups was found to be equal (33.33% correspondents). The average cost of cleaning was Rs. 358.33 ± 130.65/- and Rs. 450 ± 298.60/- in new and old houses respectively. We hope this preliminary study will lay foundations for further research in detail to devise some control measures to eradicate this nuisance, thus providing a successful approach to ensure a more sustainable development in older buildings and houses.*

Keywords: Concrete-grown plants, *Ficus*, *Peperomia*, Weeding Methods, Weeding Expenses

I. INTRODUCTION

The development, which creates complete social and environmental harmony, is designated as sustainable⁽¹⁾. Negative impacts on environment through unplanned development may ruin sustainability as a whole. Therefore, assessment of environmental conditions is very much necessary for initiation of any sustainable development⁽²⁾. To achieve this goal, identification of the major positive aspects, its optimum utilization, and monitoring was necessary⁽³⁾. The symbiotic relationship between local ecology, social structure, and economic conditions of any habitat should be taken into account⁽¹⁾.



Citrus sp.



Ficus hispida



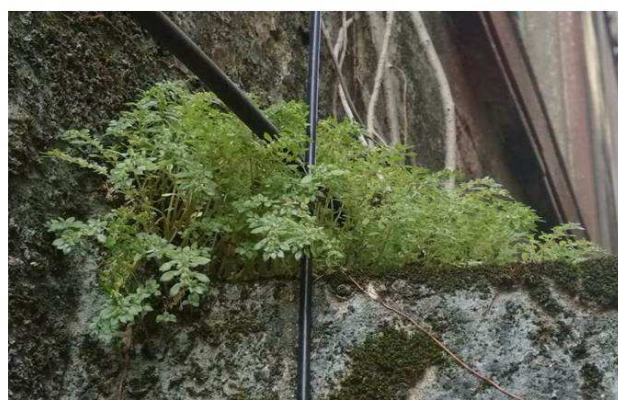
Ficus bengalensis



Ficus religiosa



Catharanthus



Pilea microphylla

Vegetation in cities includes a notable spontaneous component that grows voluntarily without human assistance on adventive or ruderal habitats⁽⁴⁾. They occur on a range of site conditions from remnant natural to semi-natural and artificial along a hemeroby scale⁽⁵⁾. Such vegetation often embodies natural elements with ecological value in built up areas in terms of plant species composition, accompanying wildlife and ecosystem processes⁽⁶⁾. They play a key urban ecological role of enriching the otherwise dominant formal green spaces in terms of ecological diversities, life forms, and landscape variations. In the course of urban development, such nature conducive enclaves are often left by default or created unintentionally, to be colonized gradually through natural seed dispersal by non-living or living agents⁽⁶⁾.

Concrete walls are familiar and conspicuous structures, yet they are usually given little attention from a biological perspective⁽⁷⁾. This is very unfortunate, as walls support a great diversity of flora and fauna. Walls are simply considered as man-made habitat representing a specific environment quite similar to rocks and rock fissures⁽⁸⁾. The walls provide demanding conditions for plants because of

natural calamities like exposure, drought, and anthropogenic activities⁽⁹⁾. Deposition of dusts, organic substances, suspended particles of air and atmospheric moisture are responsible for the formation of thin film of soil substratum on the walls and wall fissures leading to the development of a specialized flora^{(9),(10)}. This man-made habitat gradually influences a range of plant species to colonize on it⁽¹⁰⁾. Though the man-made walls represent extreme environments with edaphic factors such as the low availability of water and nutrients and exposure to wind and sun, still some plants show the capacity to grow over the walls⁽¹⁰⁾.

The presence of climbing or creeping plants, large plants or shrubs growing in the walls of the houses and buildings drives a bullet-headed root into crumbling masonry causing damage and disintegration of the material which if forcibly removed can pull off a weak surface of brickwork or plaster, thus causing movement of the foundations and subsequent cracking of walls⁽¹¹⁾. The data concerning the floral changes in Kolkata are scarce and fragmentary, yet there are only a few specific studies on the wall flora⁽¹²⁾. Keeping this in mind, a survey on wall flora was carried out to understand the urban environment and floral diversity of old heritage houses scattered in the city.

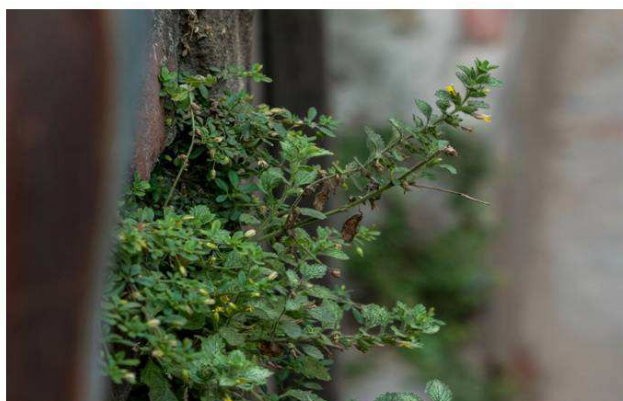
The present study focuses on identification of plants growing in the crevices and walls of old houses scattered in Kolkata metropolitan city and investigate the wall flora on sites undergoing reconstruction, restoration, and maintenance activities during this period of study. The results will help to establish the regularities and trends concerning the origin and the dynamics of the wall flora at the studied sites (Kolkata city, West Bengal, India) as well as to devise some techniques to remove this nuisance in terms of property damage thus maintaining the old walls of buildings and their neighbouring area.



Acalypha indica



Peperomia pellucida



Lindenbergia indica



Unidentified Species

II. METHODOLOGY

Surveys were carried out in Kolkata metropolitan city, India. The city is about 300 years old and located at 22°82'N; 88°20'E, spread along the eastern bank of Hoogly river in southern part of the state of West Bengal⁽¹³⁾. The climate of the city is hot and humid summer (average temperature ranging from 30–41°C) and slight cold winter (average temperature 23°C)⁽¹⁴⁾. The annual rainfall is about 1,600 mm⁽¹⁵⁾.

A total of 12 houses were surveyed throughout the city on July-August of 2018. Out of the total twelve, six houses were marked as “new” (less than 50 years of age) and the rest were marked as “old” (older than 50 years). Only angiosperm plants growing in the concrete were identified and their number was counted. For the unidentified species, specimens were collected. Later on they were identified with the help of plant taxonomists.

A randomly chosen resident of from all the houses were interviewed following a questionnaire, which included the age of the houses; whether plants grown on concrete are removed manually, or by hiring labour, or not removed at all and if labour is hired for cleaning then how much is the cost per cleaning etc.

Plant abundance was determined by calculating average of number of plants recorded. One way ANOVA was carried out to determine whether there is any significant difference of plant abundance in between all the sites and if there is any difference of plant abundance in “new” and “old” group of houses.

III. RESULTS

A total of 11 angiospermous plant species were found to grow on the concrete houses which belonged to eight identified and one unidentified genera (see table1). Seven plant species belonging to 5 genera and 8 species belonging to 6 genera were found to grow on new and old houses respectively. We did not find any significant variation of plant abundance along the sites (One Way ANOVA, $p > 0.05$) or in between new and old group of houses (Two way ANOVA with replication, $p > 0.05$).

From the survey of the resident, it was found that 66.67% correspondents in new houses clean by hiring labour and 33.33% of them do not clean at all. However, in case of old houses, we got three cases; they clean the plants either manually or by hiring labour or they do not clean them (33.33% in each case). The average cost of cleaning every time and the average annual cost of cleaning are also not significantly different in between this two groups of houses (One Way ANOVA, $p > 0.05$) (see Table 2).

Table 1: List of the vascular plants found on the concrete of the houses in Kolkata

Name of Plant	Family	Found in new/old
<i>Ficus religiosa</i>	Moraceae	Both
<i>Ficus benghalensis</i>	Moraceae	Both

<i>Ficus hispida</i>	Moraceae	Both
<i>Peperomia pellucida</i>	Piperaceae	Both
<i>Citrus</i> sp.	Rutaceae	New
<i>Catharanthus roseus</i>	Apocynaceae	Old
<i>Carpesium</i> sp.	Asteraceae	Old
<i>Lindenbergia indica</i>	Orobanchaceae	Old
<i>Pilea microphylla</i>	Urticaceae	New
<i>Acalypha indica</i>	Euphorbiaceae	Old
Unidentified #1	Unidentified	New

Table 2: Differential Maintenance of concrete grown plants in New and Old houses

	New (percent correspondent)	Old (percent correspondent)
Hiring Laborer	66.67 %	33.33 %
Manual	Nil	33.33 %
No Cleaning at all	33.33 %	33.33 %
Average cost of cleaning per time (in Rupees)	358.33±130.65	450±298.60
Annual Cost of cleaning (in Rupees)	608.33±255.73	616.67±391.93

IV. DISCUSSION

The negative interaction between concrete growing plants and human in an urban landscape is a least explored area in scientific literature. This study makes a foundation on this topic to throw some light on this issue. Our study shows that the concrete grown plant community is more or less similar in both new and old group of houses in the city. In addition, the residents employ different methods to get rid of the menace in a little different manner in old and new houses. The residents of newer houses never clean the concrete growing weeds of their own. However, the residents of older houses often do so. This cause may be due to the fact that the owners of the new houses want their house get more neatly cleaned which is often done by professional laborer rather than manual one. The cost of cleaning is also not significantly different between these two groups of houses, which mean that concrete grown plants affect the residents financially almost in the similar fashion regardless the house is new or old.

The vascular plants grown on historical buildings and monuments are more diverse comprising as many as species belonging to thirty or more plant families⁽¹⁰⁾. However, this study encompasses only few species (Table 1). Historical monuments are generally thousands years old⁽¹⁰⁾ than the houses studied in this article. Since, the chance of colonization by the plants on the walls increases over time⁽⁹⁾, the historical monuments generally have more diversified plants. There is no doubt about the historical importance of Kolkata city⁽¹⁶⁾ but since this study was carried on only human inhabited residential areas of the city, the residences are quite newer than the historical monuments. However, our results have synchrony to⁽¹⁷⁾ some extent.

Concrete grown plants often make the plaster of the houses weak and if not managed with proper care, they may cause severe damage to the houses⁽⁹⁾. Even the germination of their seeds cannot be totally controlled as many biotic or abiotic agents mediate that process⁽¹⁸⁾. Germination of transferred seeds is almost inevitable and human has to dwell with the fact tactfully. This study helps to identify the problem and also tries to give an insight how it can affect the city dwellers financially. However, a detailed and extensive investigation is due on this issue.

Lastly, we would like to conclude by saying that the interaction between plants and human engineered urban habitat is everlasting and it is not very easy to get rid of it completely. But, due to its ill effects, such 'encroachment' has to be managed. We believe this study done on a metropolitan city will only put a foundation on further research on this issue which may someday find a way to control the urban nuisance.

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Sustainable Development Strategy and Sustainable de-growth Strategies – How Far do They Differ in Reality?

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Abstract: The capital approach to sustainable development strategizes gradual substitution of non-renewable resources by manufactured capital through technological progress. Sustainable degrowth strategy with its varying interpretations, on the other hand, proposes downscaling of some growth components or changing their composition according to the environmental constraints created by them. Present paper intends to examine the practical worthiness of Sprangenberg's degrowth criteria for environmental sustainability over the sustainable development strategies. It is done in the context of mining (coal) led growth discourse of Jaintia Hills District (JHD), Meghalaya India. Growth trend of JHD during 1993-2007 had been principally dependent on extraction of mineral resources (artisanal coal mining in particular). The statistical path dependent analysis in JHD context shows that mining led economic growth with its negative impact on bio-geo-chemical environment had been debarring the substitution of non-renewable coal resource by manufactured capital. Thus development is unsustainable according to the capital approach. In JHD in her mining led growth discourse, although many degrowth features in terms of down scaling of some growth components appeared, that did not lead to down scaling the negative impact on biophysical and chemical environment i.e sustainable degrowth did not occur.

Keywords: DPSIR framework; Rat-hole coal mining; Path coefficient analysis; Sustainable Livelihood approach; Sprangenberg's De-growth criteria

I. INTRODUCTION

The capital approach to sustainable development strategizes gradual substitution of non-renewable resources by manufactured capital through technological progress. By exploring the prospect of switch over from one resource mix to another through technological progress, it adheres with the principle of 'weak sustainability'. In Dasgupta – Heal – Solow (1974) framework for an economy whose economic growth is dependent on extraction of natural resources, the natural resource is required to be 'weak' essential. To achieve sustainability in terms of non-decreasing consumption over time, the elasticity of substitution between manufactured capital and natural non-renewable capital is required to be greater than one. And in case, elasticity of substitution is equal to one, the share of manufactured capital must be greater than the share of the natural capital in the total output. Hartwick's rule states that to ensure constant sustainable consumption and intergenerational equity, investment in other forms of capital must exceed the monetary value of depletion of natural resources contributing to the production of marketed goods (Howarth, 2007).

For the last forty years, on the other hand, the failure of mainstream economic (GDP) growth models to ensure ecological sustainability and socio economic equity, a group of political economists are putting

forward the sustainable de-growth strategy, in a contestable importance in both theoretical and policy context. Sustainable degrowth decouples economic growth from sustainable development. Six varying interpretations of de-growth strategy with their varying prospects have been identified in the literature: (i) GDP degrowth, (ii) consumption degrowth, (iii) work time degrowth, (iv) radical degrowth, (v) physical degrowth and (vi) agrowth (van den Bergh 2010). Sprangenberg's sustainability inequations (2010) providing the minimum conditions for environmental sustainability reckon the GDP degrowth and work time degrowth together. To ensure sustainability, the Sprangenberg's conditions state that GDP and average work hours should decrease and growth of use of natural resources must be slower than GDP growth rate.

The most powerful critique to degrowth theory however boils down to the fact that most of the degrowth variants give importance to the scale of economy and consumption and thus suggests for downscaling them ignoring or underestimating the nature of composition of various growth factors (van den Bergh, *ibid*) in the growth discourse of a particular economy. For an underdeveloped economy where consumption level is already very low, consumption degrowth and GDP degrowth are practically not possible. Lowering GDP growth may lower the investment potential for substituting non-renewable resources which is required for the resource 'dematerialization'. Work time degrowth i.e. reduction in average working hours to hold back the 'pull factor' (production capacity) and 'push factor' (spending power) of consumption growth are also not applicable there. Thus the GDP, consumption, and work-time degrowth along with radical degrowth, bringing about radical changes in values, ethics, institutions by 'escaping from the capitalist economy'. The critic of degrowth theories conclude that (Fournier 2008) degrowth strategies, are appropriate for the rich, over consumed, developed economies not for the underdeveloped ones. The physical degrowth strategy brings forth the reduction in physical size of the economy (in terms of resource use and pollutant generation) through appropriate environmental policy regulations and 'a-growth' in analogy to atheism. It talks about a strategy with indifference or no faith in economic growth (van den Bergh, 2010; Ott, 2012). Working at the 'real-real' level (Alier, 2009), primary concern of degrowth strategy may be to delimit the material throughput according to the ecological constraints. This can be done by strong environmental protection policies, restoration and conservation of natural resources. They can include various macro-rebound strategies like 'land grabbing', seed control, solar radiation management, control of tendency towards privatization etc to reach 'strong sustainability'. After, strong sustainability is reached, inter and intra-generational equity in distribution of resources at the global scale can be the target of degrowth strategy (Ott, *ibid*).

Given this theoretical and strategic debate between sustainable development and sustainable degrowth theories at the backdrop, the present paper intends to examine the practical worthiness of sustainable degrowth strategies over the sustainable development strategies as envisaged by the capital centric approach to sustainability in the context of a particular underdeveloped economy. For degrowth strategies the Sprangenberg's degrowth criterion has been chosen as the benchmark for the analysis. The growth discourse led by mining activities (principally coal mining by 'rat-hole' method) in Jaintia Hills District (JHD), Meghalaya in north east India has been chosen as a practical field for this research agenda. Section 2 presents a narrative statement of rat-hole coal mining incidence in Jaintia Hills District with its negative impact on ecological sustainability and shifting from agro based to mine based livelihood. In an integrated analytical framework combining DPSIR (Driver- Pressure- Impact-

Response; EEA, 1995) and SL (Sustainable Livelihood; DFID, 2000) approaches by statistical path dependent model, Section 3 characterizes coal mine led growth discourse of Jaintia Hills District in environment-economy-society nexus. While characterizing the growth discourse it further intends to identify which factor(s) are playing the significant role (impacting) to make the existing development path (un)sustainable. And on the basis of that diagnosis Section 4 critically examine what variant of degrowth strategy is applicable here and to what extent it deviates from capital centric strategy of sustainable development.

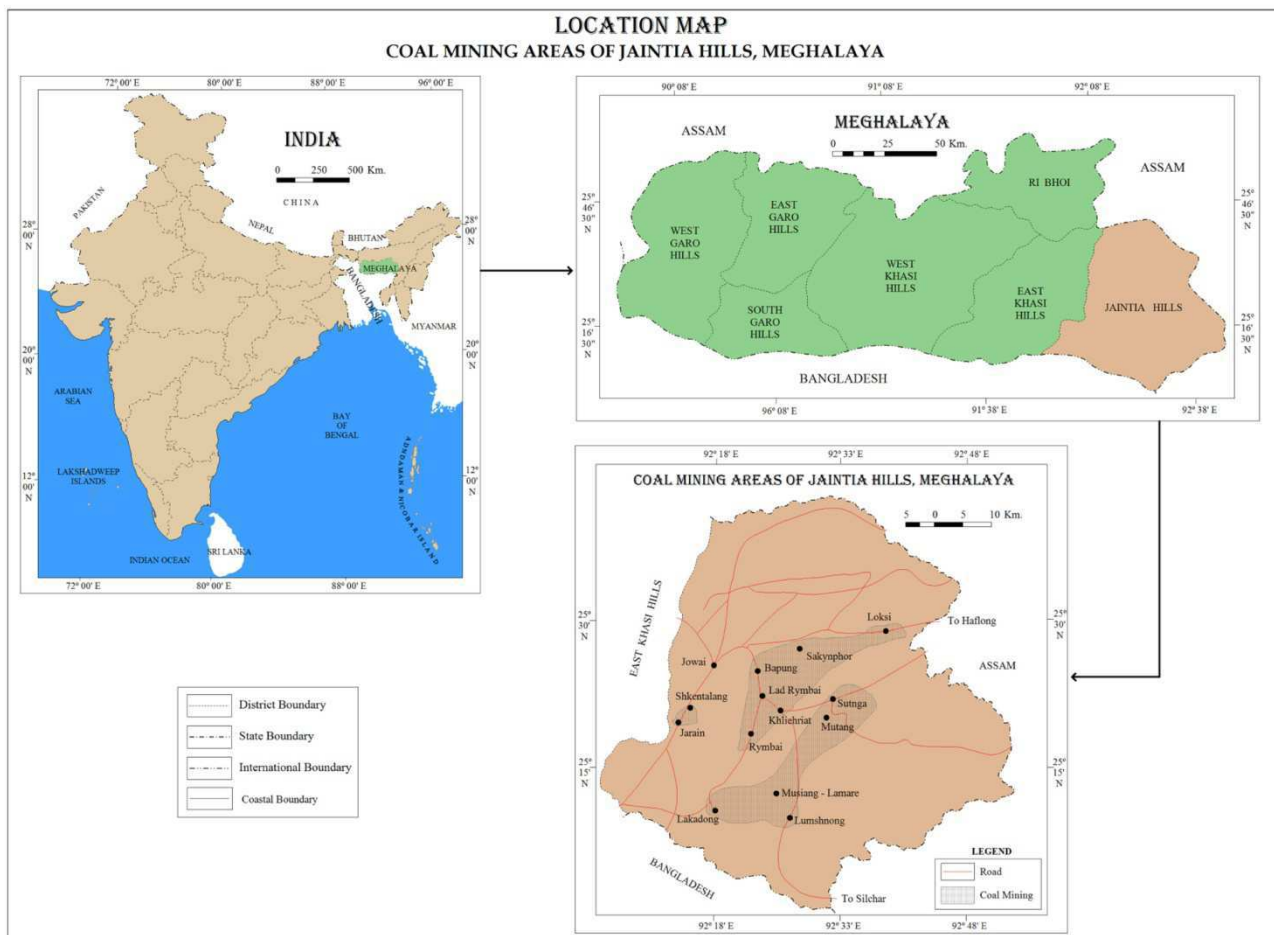


Figure 1: Coal mining area of Jaintia Hills District of Meghalaya, India

II. RAT-HOLE COAL MINING IN JAINTIA HILLS DISTRICT, MEGHALAYA, INDIA

Jaintia hills district lying between $25^{\circ}5'N$ – $25^{\circ}4'N$ in latitudes and $91^{\circ}51'E$ – $92^{\circ}45'E$ in longitudes, covering an area of 3819 km^2 is one of the seven districts of the state of Meghalaya. It has an international boundary in the south by Bangladesh (Figure 1). The population of the district is 392852 (2011 census) of which 96% is tribal. According to the Geological Survey of India in 1974, the total coal reserve in the district is 39 million tons. Sutnga, Lakadong, Musiang-Lamare, Khilehriat, loksi, Ladrymbai, Rymbai, Byrwai, Chyrmang, Bapung, Jarain, Shkentalang, Lumshnong, Sakynphor etc. are the main coal bearing areas of the district that altogether cover 57.9 km^2 (Sahu & Goel, 2004)) [9]. Jaintia Hills district although constitutes only 7.48% of the total coal reserve of the state, it contributes 75% of the total coal production (Sarma, 2005). After independence of Bangladesh in 1971 as Jaintia

got its district autonomy in 1972, coal extraction started rapidly rising (Figure 2). From 1975 till 2007 coal production increased by 161%. There are at least five possible reasons for this rapid unregulated depletion of coal resources. Firstly there is rising demand for coal export to Bangladesh and secondly the rising demand in Meghalaya and other states in India for coal as fuel in industrial production. Jaintia coal is sub-bituminous with high sulphur (principally organic) content (more than 5%; Behra, 2007). It is mostly used as fuel in the small and medium scale industries like cement, bricks, tea, fertilizer etc in Bangladesh and in India. It is not used by power plants and nor useful for manufacturing industries because of its high sulphur content. Demand for coal as input for cement and brick production i.e. in construction industry in Meghalaya may be an indicator of industrialization and infrastructural development in the state, while coal extraction in response to the rising export demand is purely a market driven phenomenon. Increasing demand for Meghalaya coal in Bangladesh is evident by the export trend over the time (Figure 3). Dawki–Tambil road that crosses the border of Bangladesh with land customs station at Dawki in Jaintia district plays a significant role in coal exporting activities. During 2005-06 for example, 70% of the total royalty from coal export to Bangladesh enjoyed by Meghalaya is contributed by Jaintia district itself (Rout, 2006). Third reason for rapid coal extraction in the district is an under-current apprehension of take-over of coal by public sector. Given the typical constitutional right of land ownership enjoyed by tribal community (Sixth Schedule of the Constitution of India), state government of Meghalaya cannot and does not intervene into artisanal private mining in tribal land. But there is every possibility that any day government can take over the ownership of the coal mines by revising the constitution. The State Government drafted a mining and mineral policy as per directives in 2004 by Supreme Court but kept in abeyance to enact the laws under pressure of powerful mining lobbies both at state and at the central level (Statesman, May13, 2012). Fourth driving force for rampant coal mining is poverty. Wherever the landowner needs some emergency cash and expects that there may be coal, forest cover is cleared and a shaft of diameter varying from 3m to 10m is sunk. Hole is dug into coal seam and goes deeper and deeper for several kilometres following the seam. These burrows or holes are big enough to accommodate just one person to crawl in with tools and basket or wheeled cart to carry out coal to the depots located near the main road. This is known as “rat-hole mining” as it is similar to the burrow making by the rats. There are approximately 5000 coal mines in this district. 99% of the workers in the mines are migrant from Bangladesh, Nepal and Assam Bihar and Jharkhand (the number of Nepalis workers estimated as 1,50,000 (Madhavan, 2005). According to an estimate from a NGO 70,000 (50,000 from a different source of information and there is a debate about the exact number!), children in the age between 7 to 17 are working in these private mines as the casual labour under private contractors without any security to their lives (Impulse 2011). Daily wage rate for mine workers (particularly for digging and cutting the coal with maximum life risk) is much higher than the agricultural wages (Lamin, 1995). The coal bed and seams in this particular area are horizontal to ground and few meters deep in the form of thin seam (30 to 212 cm in thickness (Guha Roy 1992) lying along the bedding planes of the host rock. Due to this peculiar geological characteristic of the coal beds in this area, the large scale mining is not economically profitable. Fourth important reason for rapid extraction is the undefined property rights to the coal underground. The tribal community land has been gradually privatized to reap the immediate benefit from mining (McDuié-Ra, 2007) without getting concerned with the long term environmental consequences and with the consequence when the coal resource will be totally exhausted. When the land owner starts digging burrow it is within his private land jurisdiction but as he enters underground the earth there is no private property demarcation; like ground water, coal becomes

a common pool resource under open access regime. As he cannot restrain his competitive neighbour to encroach upon coal resource in 'his' region, he wants to extract rapidly as much as he can. All these factors lead to rampant unscientific coal mining in this area. Although it is completely illegal and unscientific, government collects huge revenue in the form of royalty and transport tax from mine owners (Blahwar 2010).

The rampant unscientific archaic rat hole coal mining along with the absence of post mining treatment and management of mined areas are making the fragile ecosystems of the hilly area more vulnerable to environmental degradation. Mining induced deforestation leads to the increasing surface runoff and thus washing off the soil nutrients. Mine spoils or over burden create extremely rigid substrata for the plant growth. Continued soil acidification due to acid mine drainage and toxic elements of coal spoils like Al, Fe, Mn, Cu have caused enormous damage to the plant biodiversity in this area (Sarma, 2005). Due to mining induced changes in land use pattern and soil pollution the area of fallow land has steadily increased (Figure 4 and 5). Between 1975 and 2007, there has been decrease in forest area by 12.5%, while area under mining has increased three fold (Sarma et.al, 2010). The cultivable waste land in Jaintia district is found to be the highest (31%) in the state of Meghalaya.

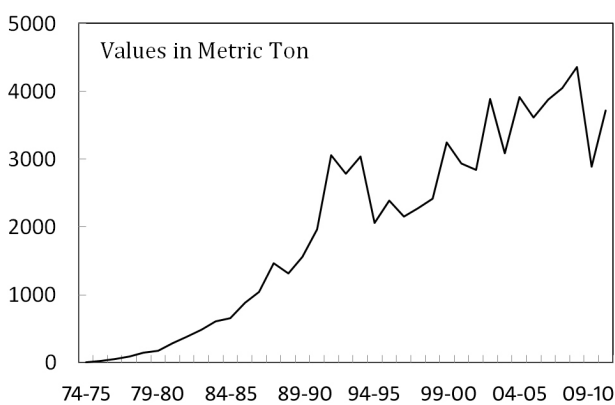


Figure 2: Coal extraction –Jaintia Hills District during 1974-75 - 2009-10

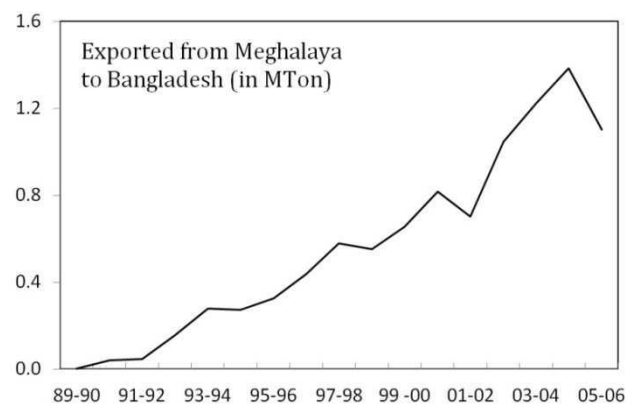


Figure 3: Coal Export to Bangladesh from Meghalaya: 2009-10

Acid mine drainage (AMD) in the surface water bodies, in the river streams from the active coal mines (while dewatering the mines in the post monsoon period to start mining in the dry winter period (Blahwar, 2010), coal dumps and abandoned mines is a very common phenomenon in Jaintia district. It is indicated by low pH (between 2-3), high conductivity, high concentration of sulphates, iron and toxic heavy metals, low dissolved oxygen (DO) and high BOD in the river stream water (Blahwar, Ibid; Swer & Singh, 2004), [20]in the coal belt area. Pyrite from surrounding coal gets quickly hydrolyzed in slightly acidic water, releases protons and sulphate further adding acidity and increasing sulphate concentration. pH values (annually on an average) in stream Kyrukhla in Khilehriat coalfield area since 1994-95 till 2007-08 is observed to be steadily declining (Figure 6). AMD has been injurious to aquatic biota, including fish, amphibians, aquatic plants and insects (Swer & Singh, ibid). AMD has also created a major constraint to the availability of potable water (Dkhar, 2010). Rice productivity on an average in the coalfield area is observed to be 860 kg/ha (where soil pH on an average is 3.54) compared to 1926 kg/ha in non-mined area (where soil pH is 4.35 on an average) and

1123 kg/ha in the abandoned mining sites. Rice crop shoot in the coal mined area is 2.75 gram per pot compared to 7.90 gram per pot in non-mined area (Choudhury et.al 2010).

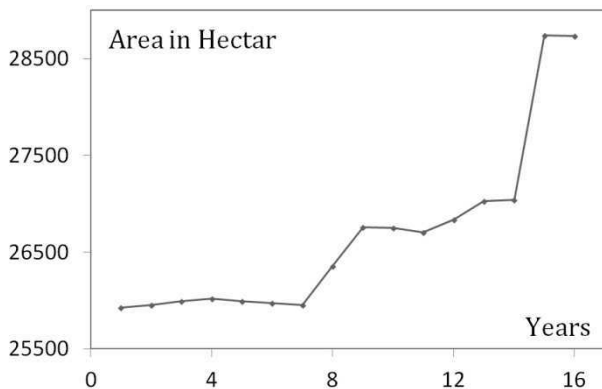


Figure 4: Area of fallow land (in hectare) in Jaintia Hills district: 1990-91 – 2007-08

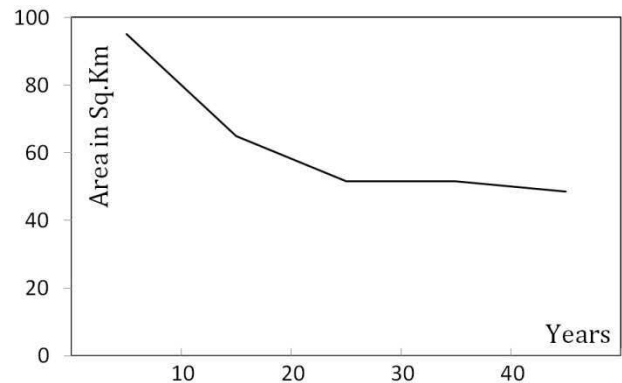


Figure 5: Dense forest area (Log Sq Km) during 1975-2007

Soil pH in the dumping site of the coal field area is around 2.42 and 2.56 in the paddy field nearby (Barua, Khare et.al 2010). Representative soil samples from different land uses (viz., non-mined, coal-mined and 4 years abandoned mining sites) of the three major coal belts viz., Bapung, Sutnga and Khliehriat in Jaintia Hills district show that coal mining has caused the decrease in the soil pH by about one unit compared to the soil free from mining activity where pH is 4.35).

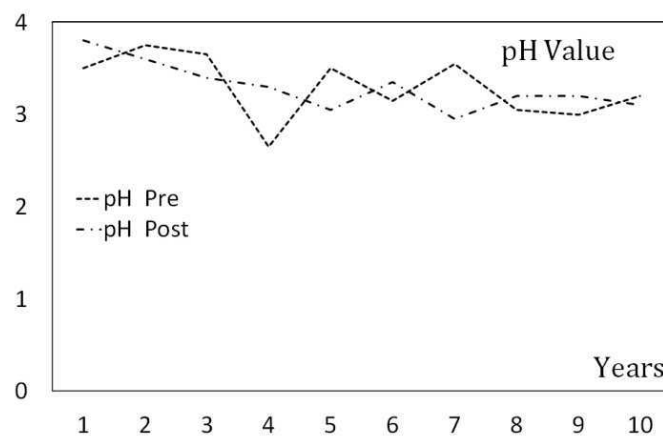


Figure 6: Average pH value of water in Kyrukhla stream in pre and post monsoon period during 1994 to 2003.

Along with rapid expansion of rat hole coal mining in Jaintia there has been increase in income and employment of a section of people associated with mining activities. The disparities in wage rates (daily wage rate in coal mining is higher than the agricultural wage rates; (Sahu et.al; ibid) also has increased. The local people usually don't sell their labour in the mines and most of the time they lease out their land to the coal traders and exporters. The major influx of labour comes from migration. The area under agricultural land has been steadily declining for diversification to coal mining. The overall socio economic impact is the undergoing shift from agro based livelihood to coal based livelihood. If

the present rate of coal extraction continues it is apprehended that coal reserve would be exhausted within next 15 years.

III. CHARACTERIZATION OF GROWTH DISCOURSE OF JAINTIA HILLS DISTRICT

3.1. Growth discourse of Jaintia District according to capital approach to sustainable development in an integrated economy-environment-society nexus framework

In present research work, to characterize the development process in Jaintia Hills district by capital centric theory of sustainability, high level scenario framework in economy-environment-society nexus, combining DPSIR (Driver-Pressure-State-Impact-Response; EEA, 1995) and SL (Sustainable livelihood) approaches as devised in Mukhopadhyay (2017) is re-considered. In terms of path coefficient analysis, statistically, it intends to establish that investment of manufactured capital to substitute the natural capital, i.e., coal (as capital centric theory to sustainable development recommends), has not occurred in Jaintia district. Hence the path of development in JHD is unsustainable. In Meghalaya cement industry in terms of investment ranks the second largest (more

than 3.6 million Rupees) position after the food processing industry. Coal is significantly used as input in cement production and cement is forward linked with infrastructural development. The production in cement industry is considered as a potential indicator of alternative form of industrialization and coal export as an indicator of outflow of capital from production sector to the export market sector to Bangladesh. These two are proposed as the *Driving* forces to rapid coal extraction that lead to the *Pressure* on environment indicated by increase in surface runoff (associated with mining induced deforestation)¹, fallow land and acid mine drainage indicated by pH and sulphate concentration in the stream flow in the coal belt area². These mining induced pressure and impact are changing the livelihood strategies from agro based to mine based. This change is reflected in per capita decline in rice production and fish production over time (Figure 7 and 8) – the two key indicators of agro based

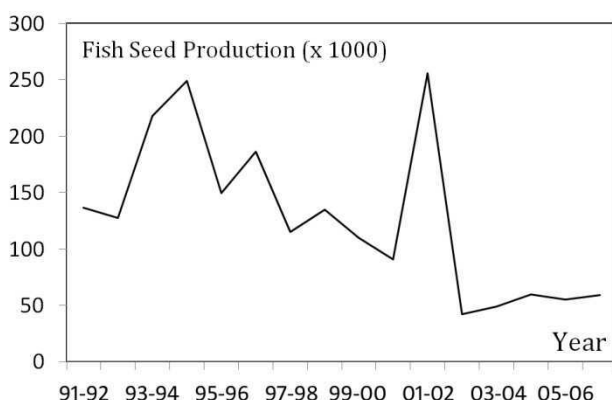


Figure 7: Fish seed production: 1991-92 to 2006-07

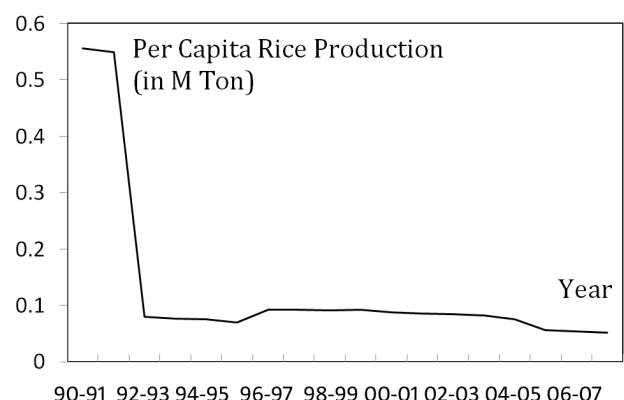


Figure 8: Per capita rice production : 1990-91 to 2006-07

livelihood. This integrated framework by a stylized chain of causality, not only explains the impact generating process at various levels in economy-environment-society nexus, but also characterizes the path of development of the society. Each causality path assess how directly and indirectly in an interactive way various economic components, like coal export demand (xprrt), cement production

(cmtpr), coal extraction (colex), hydrological components like increased surface run off (ISrof), hydro-geochemical components like those water quality indicator of acid mine drainage (here WQI, an index with pH value and sulphate concentration in a particular stream water) and land diversification (here Falnd, area of fallow land) over time are affecting rice and fish production – the key components of agro based livelihood in Jaintia Hills District (schematic representation in Figure 9). Five types of capital (natural, physical, social, human and financial) are involved in economic activities and environmental changes that shape up the livelihood strategies and outcomes.

3.1.1 Data sources and methodology

The empirical analysis in this research work is exclusively based on secondary data. The detailed description of the various data sources are given in Table 1 (Appendix A). The analytical methodology is the statistical Path Analysis with the time series data.

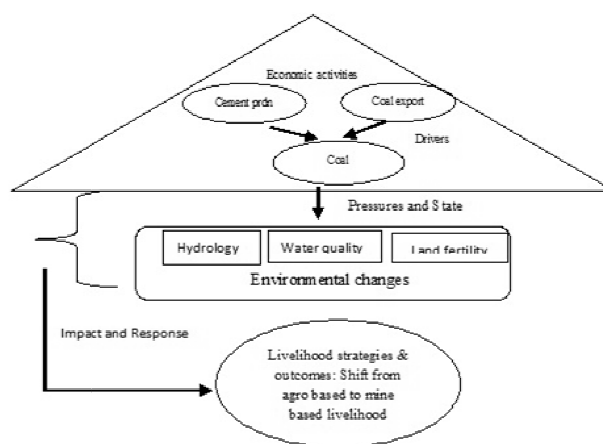
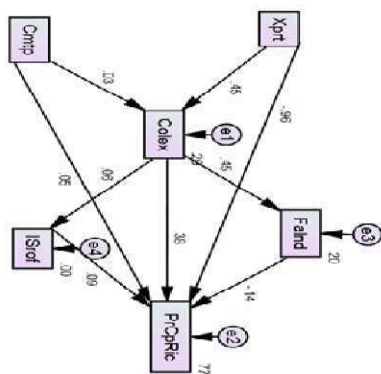


Figure 9: Integrated analytical framework proposed and used in the present work

We here propose a model (Structural Equation Model) that explains the relationship among the variables across time (as described in Figure 9: Integrated Analytical Framework) and then we apply the statistical path dependent analysis. The statistical path analysis with those available data purports to fit the proposed structural model against the null model which assumes that there is no relation between the variables proposed in structural model. The method of estimation is recursive regression method. Each variable enters stage by stage to explain the variable followed in the next stage to show the potential causal dependencies. In our particular context for example, at stage 1 coal export in Bangladesh (Exprt) and cement production (Cmtpr) enter to explain rapid coal extraction (Calex) and at stage 2, Calex enters to explain increase in surface run off (ISrof) and area of fallow land (Falnd) and finally, ISrof and Falnd enter to explain the per capita rice production (PrCpRic). Path coefficients estimated (here, Maximum Likelihood Estimates) from layered multiple regression analysis show the effect size of each of the observed component and they are displayed against their respective arrows in the path diagram (Figure 10A and Figure 10B). Effects are direct and indirect. Indirect are those effects or impacts mediated by others. Here path coefficients are standardized coefficients based on standardized data that show the relative importance of each of the proposed independent variables. Among the various Fit Indices criteria (Bentler, 1990; Kline 2011), we found that proposed Rice-Coal Path Model have satisfied the acceptable threshold levels of relative χ^2 and Root Mean Squared

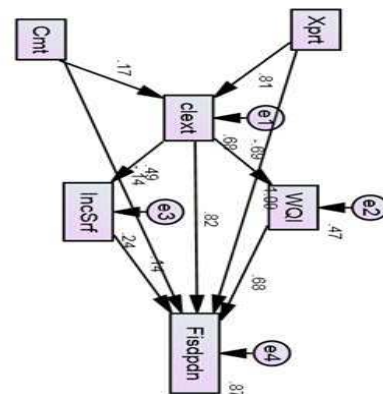
Residuals (RMR). The Fish-coal Path model on the other hand satisfies χ^2 fit and Relative χ^2 (Table 2).

We have used the statistical software AMOS; IBM SPSS 20. The software generates the path model diagrams. In the present context it explains the decline in per capita rice (PrCpRic) and fish seed (Fisdpdn) production (Figures 10A and 10B) by the chains of proposed DPS factors. The rice-coal extraction and fish-coal extraction paths are studied with 18 years' (1990-2007) and 10 (1994-95 -2003-04) years' time series data respectively. 18 years' and 10 years' data have been treated as 18 and 10 set of observations in the given time scale.



Observed endogenous variables (4): Colex, ISrof, Falnd, PrCpRic
Observed endogenous variables (2): Xprt, Cmt
Unobserved exogenous variables (4): e1, e2, e3, e4

Figure 10A Rice-coal path diagram



Observed endogenous variables (4): clext, IncSrf, WQI, Fisdpdn
Observed endogenous variables (2): Xprt, Cmt
Unobserved exogenous variables (4): e1, e2, e3, e4

Figure 10B Fish-coal path diagram

3.1.2. Results of the statistical path analysis

The results of the statistical path analysis (Table 3 to 10 in Appendix A) establish that export of coal in Bangladesh has the largest size effect (in terms of direct, indirect and overall effects with statistical significance) to explain the variability in per capita rice production. And in all the cases the effect is negative. Due to the direct (unmediated) effect of xprt on PrCpRic, when xprt goes up by 1 standard deviation, PrCpRic goes down by 0.958 standard deviations. This is in addition to the indirect (mediated) effect that xprt has on PrCpRic. And in terms of indirect (mediated) effect also export has the largest effect on per capita rice production. So far the fish seed production is concerned, the direct effect of export (negative) is the largest and the effect (positive) of water quality (acid mine drainage) index is the second largest. Pearson correlation coefficient between Water Quality Index (WQI) and fish seed production (Fisdpdn) is the largest among all others. Impact of export driven coal extraction on environmental components, particularly on fallow land (Falnd) and water quality index (acid mine drainage) are statistically quite significant. When coal extraction goes up by one unit standard deviation (SD) area of fallow land rises by 0.45 SD. Again when coal extraction goes up by one unit SD, WQI falls by 0.69 SD.

From the results of the statistical analysis we can reach some important conclusions on the coal based economic growth in Jaintia district. Rising coal export from Meghalaya to Bangladesh, acts as the major driving force to rapid coal extraction. This indicates that there is flight of capital from coal mining through the export market and thus no repatriation of profit from coal sector for industrialization is taking place. The shift of livelihood from agro based to coal based along the existing growth path is unsustainable as export is the major driver to the coal extraction. After coal reserve will be exhausted, this growth path will no more sustain. Thus the basic capital oriented sustainable development condition (in Heal-Solow-Dasgupta- Hartwick framework) i.e. substitution of natural capital by manufactured capital is not created in Jaintia District. Increasing area of fallow land and water quality deterioration has a long term negative impact on rice and fish production making them unsustainable. To redirect the growth path toward economy –environment –sustainability, the policies are required to intervene in the export market mechanism which is oligopolistic in nature and mostly controlled by the traders and contractors in Bangladesh border area. To build up the potential of sustainability in economic development of this hilly district in north east India export market regulation, gradual substitution of capital from coal mining to manufacturing industry, along with hydro geological, hydro geochemical and land diversification management can be included into the policy formulations.

3.2. Growth discourse of Jaintia District in terms of Sprangenberg's various degrowth criteria

Variant degrowth strategies recommend for downscaling of various economic growth factors or changing the composition of those growth factors according to the ecological constraints and socio-economic inequality created in the growth process. Table 11 exhibits the trend of various economic growth factors and the growth induced environmental state factors in Jaintia district over time (between 1993-94 and 2006-07). In the existing mining led development path, Jaintia Hills District has been going through many degrowth experiences without taking any degrowth strategies and without having any positive impact on environmental sustainability and equity in distribution of income. Sprangenberg's minimum conditions (Sprangenberg, 2010) for environmental sustainability via degrowth states that the growth in per capita productivity $d\left(\frac{Y}{L}\right)$ must be lower than economic growth $d(Y)$ which would generate more job or more employment (L) leading to more equality in distribution. This means:

$$d\left(\frac{Y}{L}\right) < d(Y) \Leftrightarrow d(L) > 0 \dots\dots (1)$$

It is also required that, resource (R) productivity $\left(\frac{Y}{R}\right)$ should grow faster than the economic growth (dY) so that intensity of use of resource and energy will decline via resource dematerialization; i.e.,

$$d(Y) < d\left(\frac{Y}{R}\right) \Leftrightarrow d(R) < 0 \dots\dots\dots (2)$$

Equations (1) and (2) together constitute Sprangenberg's sustainability inequation condition, which is as follows:

$$d\left(\frac{Y}{L}\right) < d(Y) < d\left(\frac{Y}{R}\right) \dots\dots (3)$$

3.2.1 Data source and methodology

In order to assess the coal mining led growth discourse of JHD in terms of Sprangenberg's propositions, we have chosen the following five study variables:

- (i) Y_t : Net District Domestic Product (NDDP) of Jaintia Hills District at time t
- (ii) L_t : Total working population in JHD³ at time t
- (iii) R_t : Total mineral resources extracted in JHD at time t (more than 80% of the extracted mineral resources in JHD is coal)
- (iv) $\frac{Y}{L}$: Net District Domestic Product (NDDP) i.e., Y_t per number of workers (L_t) at time t
- (v) $\frac{Y_t}{R_t}$: Share of mining and quarrying in NDDP the data on Net District Domestic product of JHD at time t

Considering the overall trend, data on the aforementioned study variables, are found to be mostly non-linear and sometimes irregular in nature. For this reason, to examine the growth discourse in JHD, total time period (1993-94 till 2005-07) i.e., 14 years have been segmented into three different time phases: Phase-I: Time period during 1993-94 –1998-99; Phase-II: Time period during 1999-00 –2004-05 and, Phase-III: Time period during 2004- 2005-07

For studying the change for each of the variables say, $d\left(\frac{Y}{L}\right)$ in the first time phase say, we have

considered $\frac{\left(\frac{Y}{L}\right)_{t:1998-99}}{\left(\frac{Y}{L}\right)_{t:1993-94}}$ i.e., NDDP per number of workers during 1998-99 compared to that during

1993-94. If $d\left(\frac{Y}{L}\right) > 1$, that indicates NDDP per number of workers has increased during that time period.

(The detailed description of the data sources for those study variables is given in Table 1 in Annexure A).

3.2.2 Analytical Results

Change in the growth trend of Jaintia Hills District in terms of (i) the NDDP ($d(Y)$), (ii) per capita NDDP $d\left(\frac{Y}{L}\right)$ and (iii) per capita resource productivity in terms of share of mining & quarrying in NDDP i.e., $d\left(\frac{Y}{R}\right)$, have been estimated by the method mentioned in 3.2.1 and the results are summarized in Table 11. In all those three time segments the first part of Sprangenberg's sustainability inequation i.e., $d\left(\frac{Y}{L}\right) < d(Y)$ has been satisfied, but that has not lead to more employment i.e., $d(L)$ in all the cases < 1 which indicates that absorption of labour force in the

economy has been decreasing. Never $d(Y) < d\left(\frac{Y}{R}\right)$ in any time phase, although the resource productivity $d\left(\frac{Y}{R}\right)$ (here the productivity of coal in NDDP) has been declining since 1999-2000. In all the cases $d(R) > 1$, which indicates resource extraction has been increasing but comparing those three different time phases it has increased at the decreasing rate. Summarizing the trend we find that in JHD in her 14 years growth discourse from 1993-94 till 2006-07:

$$d\left(\frac{Y}{R}\right) < d\left(\frac{Y}{L}\right) < d(Y)$$

along with the fact that employment has been decreasing at the constant rate and resource extraction (principally coal) increasing at the decreasing rate. Decreasing rate of increasing extraction of (coal) resource can be the reason of rapid depletion of the reserve of natural resource. Rise in resource productivity is lagging behind the economic growth and resource 'dematerialization' as per Sprangenberg's condition, has not occurred.

Col.1	Col.2	Col.3	Col.4	Col.5
Growth & environmental state Factors	Growth trend during 1993-94 --1998-99	Growth trend during 1999-00 -- 2004-05	Growth trend during 2004-05 -- 2006-07	Observations (growth / degrowth)
Change in Per capita NDDP $d\left(\frac{Y}{L}\right)$	1.42	1.20	1.10	Growth at decreasing rate
Change in NDDP at constant price $d(Y)$	1.64	1.30	1.29	Growth at decreasing rate
Change in share of Mining & quarrying in NDDP $d\left(\frac{Y}{R}\right)$ in %	1.08	0.59	0.96	Degrowth in value terms in NDDP
Change in % of total workers in population $d(L)$	0.91	0.94	0.92	Decrease of employment almost at the constant rate
Change in resource extraction $d(R)$	1.42	1.23	1.12	Growth at decreasing rate

Table 11: Trend of various economic growth factors and the growth induced resource extraction in Jaintia district over time

IV. CONCLUSION

Down scaling of some growth components do not necessarily lead to sustainable degrowth with respect to income equality and environmental sustainability. In Jaintia district in her mining led growth discourse, degrowth feature of downscaling of intensity of resource use in domestic product took

place, but that did not lead to higher employment i.e. greater income equality. Nor did it lead to down scaling the harmful impact on biophysical and chemical environment, ensuring environmental sustainability. In other words, in Jaintia Hills District, some degrowth features in terms of Sprangenberg's sustainability inequation appeared, but that did not lead to the sustainable degrowth.

Steady rising in coal export in proportion to the extracted amount of coal further corroborates the proposition which is already established in the statistical path dependent analysis. The statistical path dependent analysis shows that coal export and export market mechanism are the major driving forces in the development scenario of Jaintia district. Not the down scaling of GDP growth, nor lowering per capita productivity of workers (of total workers in Jaintia district marginal workers (having work of 3 to 6 months) constitutes 25 to 28% during 1991 to 2011) can reduce the negative impact on environment and promote equality. One is required to weaken the dominance of export market (of coal) on the economy leading to unregulated rapid depletion of coal and thereby generating negative impact on environment. The value of extracted coal resource is being leaked out from domestic sector into the international export market which is principally under the control of traders, mine contractors (who take lease of mine from land owners), not belonging to the Jaintia district. Repatriation of profit from mine sectors does not occur. Since coal is mined by traditional method there lays the scope of coal resource productivity to improve (which is one of the conditions of resource dematerialization) by changing the technique of extraction. But for that economy needs some investment and thus a switch over of capital from one sector to another. This can be done by strategically downscaling the growth of some sector (may be coal export sector) to up scale the growth of some other sectors required. In this way therefore in the context of a less developed Jaintia hills district economy, no contradiction between the capital approaches to sustainable development and sustainable degrowth approaches was evident. Degrowth theories cannot tell how degrowth can be achieved. In the given context, sustainable degrowth therefore can be treated as the goal or objective and investment by substitution of capital from one use to another as per capital centric approach to sustainable development can be chosen as a strategic instrument to achieve that goal.

End notes

¹Data for mining induced increase in surface runoff (IncSrf) is generated by using the formula: $IncSrf = (P - Et_{rf}) * Frstlost$; where P : rainfall precipitation, ET : evapotranspiration, $Frstlost$ - area of loss of forest estimated from percentage change of area from dense forest to coal mine area from satellite imagery data in Sarma Tripathi and Kushwaha, 2010. For ET we have taken the average of the values of evapotranspiration of the reference crop in Jaintia on the basis of the data from 1901-2001 from India Water Portal

²Acid mine drainage occurs while dewatering the mines in the post monsoon period to start mining in the dry winter period (Blahwar, 2010). Due to the non-availability of data following the basic premise of Gray Kuma on MAMDI (Modified Acid Mine Drainage Index; Gray, 1996 or Kuma, et.al 2011), we have re-normalized the scoring system for these two constituents - pH and sulphate and re-constructed MAMDI by the formula $(pH \text{ score} + \text{Sulphate score})/100$ (Constrained by data, our index could not capture some of the toxic elements of AMD, particularly metallic ones). Scores are taken from Kuma (2011)

³In the period when the number of working population is not available, it is estimated from the census data on 1991, 2001, 2011 by fitting the trend line equation.

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APPENDIX A

Table 1

DATA	DATA SOURCES
Rice production: area and yield in JHD Fish Production Fallow lands: area in hectare Net Domestic Product and Per Capita Income of Jaintia district Annual sectoral growth rate (agr, fishing, mining & quarrying, forestry and so on) of Jaintia and other districts of Meghalaya Total workers in Jaintia Hills District Gross District Domestic Product % of Jaintia district’s contribution to NSDP	District level Key Statistics of Meghalaya, Directorate of Economics and Statistics, Govt. of Meghalaya
Water quality parameters in Kyrhohkkla river stream	Meghalaya State Pollution Control Board
Coal prodn in Jaintia and other districts of Meghalaya Coal extraction in Meghalaya Coal export from Meghalaya to Bangladesh Contribution of coal mining to NSDP of Meghalaya	Directorate of Mineral resources and Directorate of Economics and Statistics, Govt. of Meghalaya;
Total number of workers in JHD	District Census, 1990, 2011, Govt of Meghalaya
Production and investment in Cement industry	Handbook of Statistics, Govt of

	Meghalaya State Development Report, Govt of Meghalaya
Mining area, Dense forest Grassland/Non-forest, Open forest, Settlement, Cropped area in Km ² and in % of total area	Sarma, K and S.P.S. Kushwaha (2005) "Coal mining impact on land use/ land cover in Jaintia hills district of Meghalaya, India using remote sensing and GIS technique"

†Data and data sources

STATISTICAL TABLES

Table 2: Rice-Coal and Fish-Coal Path Models and model fit indices

Fit Index	Acceptable Threshold Levels	Rice-Coal Path Model	Fish-Coal Path Model
Chi sq (Absolute Fit)	Low chi-sq to d.f with an insig p value $p \geq 0.05$	0.02	0.05
Relative chi-square (Chi-sq/df)	2.1 (Tabachnic & Fidel (2007); 3.1 (Kline, 2005))	3.46	2.12
RMR (Root mean square residual)	Good models have small (RMR<0.10)	0.05	0.16

Table 3: Pearson correlation matrix in case of Rice–Coal Path analysis

		cmt	xprt	Colex	isrf	Falnd	PrCpRic
cmt	Pearson Correlation	1					
	Sig. (2-tailed)						
	N	18					
xprt	Pearson Correlation	-0.001	1				
	Sig. (2-tailed)	0.996					
	N	18	18				
Colex	Pearson Correlation	0.033	0.446	1			
	Sig. (2-tailed)	0.895	0.063				
	N	18	18	18			
isrf	Pearson Correlation	0.595**	0.036	0.059	1		
	Sig. (2-tailed)	0.009	0.888	0.816			
	N	18	18	18	18		
Falnd	Pearson Correlation	-0.138	0.776**	0.449	-0.035	1	
	Sig. (2-tailed)	0.585	0.000	0.062	0.890		
	N	18	18	18	18	18	
PrCpRic	Pearson Correlation	0.126	-0.829**	-0.097	0.105	-0.670**	1
	Sig. (2-tailed)	0.619	0.000	0.701	0.678	0.002	
	N	18	18	18	18	18	18

**. Correlation is significant at the 0.01 level (2-tailed).

Table 4: Standardized direct effects in case of rice–coal path

Dep var	Indep var	Estimate
Colex	← xprt	0.446*
Colex	← cmt	0.034
isrf	← Colex	0.059

Falnd	←	Colex	0.449*
PrCpRic	←	Colex	0.377*
PrCpRic	←	xprt	-0.958**
PrCpRic	←	Falnd	-0.137
PrCpRic	←	isrf	0.092
PrCpRic	←	cmt	0.048

Note: ** significantly different from zero at the 0.001 level (two-tailed)

* significantly different from zero at the 0.05 level (two-tailed).

Table 5: Standardized indirect effects in case of rice–coal path

Variable	cmt	xprt	Colex	Falnd	isrf
Colex	0	0	0	0	0
Falnd	0.015	0.2	0	0	0
Isrf	0.002	0.026	0	0	0
PrCpRic	0.011	0.143	-0.056	0	0

Table 6: Ranking of size effect on per capita rice production

	cmt	xprt	Colex	Falnd	isrf
Direct effect	5	1 (-)*	2 (+)*	3 (-)	4 (+)
Indirect effect	3	1	2	NIL	NIL

Table 7: Pearson correlation matrix in case of Fish –Coal Path

		Cmt	Xprt	clxrt	IncSrf	WQI	Fisdpgn
Cmt	Pearson Correlation	1					
	Sig. (2-tailed)						
	N	10					
Xprt	Pearson Correlation	-0.734*	1				
	Sig. (2-tailed)	0.016					
	N	10	10				
clxrt	Pearson Correlation	-0.470	0.762*	1			
	Sig. (2-tailed)	0.170	0.010				
	N	10	10	10			
IncSrf	Pearson Correlation	-0.211	0.500	0.451	1		
	Sig. (2-tailed)	0.558	0.141	0.191			
	N	10	10	10	10		
WQI	Pearson Correlation	0.620	-0.800**	-0.647*	-0.397	1	
	Sig. (2-tailed)	0.056	0.005	0.043	0.255		
	N	10	10	10	10	10	
Fisdpgn	Pearson Correlation	0.614	-0.784**	-0.345	-0.272	0.809**	1
	Sig. (2-tailed)	0.059	0.007	0.329	0.448	0.005	
	N	10	10	10	10	10	10

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

Table 8: .Standardized direct effects in case of fish–coal path

Dep Var	Indep var	Estimate
clext	← Xprt	0.807**
clext	← Cmt	0.173
WQI	← clext	-0.689*
IncSrf	← clext	0.493
Fisdpgn	← IncSrf	0.14
Fisdpgn	← WQI	0.68**
Fisdpgn	← clext	0.823**
Fisdpgn	← Xprt	-1.086**
Fisdpgn	← Cmt	-0.141

Note: ** significantly different from zero at the 0.001 level (two-tailed)

* significantly different from zero at the 0.05 level (two-tailed).

Table 9: Standardized indirect effects in case of fish–coal path

Standardized Indirect Effects					
	Cmt	Xprt	clext	IncSrf	WQI
clext	0	0	0	0	0
IncSrf	0.085	0.398	0	0	0
WQI	-0.119	-0.556	0	0	0
Fisdpgn	0.073	0.342	-0.399	0	0

Note: ** significantly different from zero at the 0.001 level (two-tailed)

* significantly different from zero at the 0.05 level (two-tailed).

Table 10: Ranking of size effect on per capita rice production

	cmt	xprt	Colex	Falnd	isrf
Direct effect	5	1 (-)*	2 (+)*	3 (-)	4 (+)
Indirect effect	3	1	2	NIL	NIL



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Shrinking Heritage Mangrove Ecosystem of Indian Sundarbans and Effect on Coastal Crabs: Conservation and Sustainable Management Issues

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Abstract: Indian Sundarbans being the UNESCO world heritage site and holding the largest coastal mangrove ecosystem in the world with 3.5% of the world's mangroves covering provides a wide range of ecosystem services with highly productive ecological communities. According to a report by scientists from the Zoological Society of London, Indian Sundarbans is losing its coastline of as much as 200 m in a single year, leading to rapid degradation of mangrove ecosystem. Further, remote sensing and GIS data revealed the loss of mangrove forest cover of about 5.5% from 1986 to 2012 in the Indian Sundarbans. This will inevitably lead to habitat destruction of shore crabs and thereby loss of species from ecological community. The intertidal brachyuran mud crabs, mangrove tree crabs and leaf litter feeding sesarmid crabs constitute the most dominant macro benthic faunal components along the shoreline of West Bengal that faces the daily tidal influences of Bay of Bengal. The semi-terrestrial shore crabs, Ocypode macrocera, and Ocypode ceratophthalmus, which serve as keystone species are typical inhabitants and predominant burrowing species along the coastal shoreline of West Bengal. Since, keystone species plays a crucial role in maintaining the structure and function of an ecological community, gradual decrease of such species will seriously upset the ecosystem causing major changes in community structure. In the present article an attempt has been made to highlight the role of shore crabs in maintenance of the Sundarbans mangrove. In order to sustain the environmental quality of the heritage ecosystem of Indian Sundarbans, adequate measures for conservation of the coastal crabs are essential. The sustainable ecosystem approach lies in the conservation of each and every component of valuable ecosystem for maintaining the biodiversity and equilibrium. Hence, the existence of heritage forest of Indian Sundarbans and sustainability of its valuable resources depend on effective future developmental measures and successful implementation of sustainable management plans, which could be achieved by sound management strategies involving local beneficiaries, stakeholders and governments.

Keywords: Sundarbans, mangrove ecosystem, coastal crabs, sustainable management.

I. INTRODUCTION

The Sundarbans, spread between India and Bangladesh and holding the heritage mangrove ecosystem, is recognized as a UNESCO World Heritage Site. They are part of World's largest delta formed from sediments deposited by three major rivers, the Ganga, Brahmaputra and Meghna, merging with the Bay of Bengal. Sundarbans supports the single largest contiguous block of mangrove forest in the world, of which India contributes to about 38 %. Mangrove forests are most productive and biodiverse wetlands supporting unique ecosystems, providing wide range of ecosystem services and are considered as one of the most threatened ecosystems of the world due to anthropogenic activities and global climatic changes^[1]. The biodiversity rich ecosystem provides food security to coastal

communities and is considered as one of the solutions of poverty reduction. The mangrove trees lining the eastern coast that faces Bay of Bengal, act as critical membrane between terrestrial and marine ecosystems. The valuable ecosystem being the natural wonders of our planet is losing its beauty and declining at faster rates (1 to 2% per year) than any other ecosystems on earth^[2]. During the last two centuries, major areas of mangroves have been converted into agricultural fields and recently into shrimp farms. Their destruction and degradation will eventually bring about tremendous ecological, social and economic losses in future. According to present report, loss of mangroves throughout the world may reach upto 60% by 2030^{[3],[4]}. Brachyuran crabs serving as keystone species and bioindicator species of tidal influenced shores and estuarine mudflats, are vital components of the marine food chain which plays important role in the maintenance of ecosystem^[5]. The intertidal brachyuran shore crabs constitute the most dominant macro benthic faunal components along the coast of West Bengal. They are serving at different trophic levels in the ecosystem both as the predator and the prey. Hence, conservation of each and every component of this valuable ecosystem is necessary for maintaining the biodiversity and equilibrium within ecosystem. Therefore, the objective of the present article is to highlight the present status and threats to mangrove ecosystem and coastal crab communities acting as keystone species by maintaining the structure and function of the ecosystem of Indian Sundarbans.

II. INDIAN SUNDARBANS AND MANGROVE ECOSYSTEM: THEIR IMPORTANCE AND CONSERVATION

The western part of Sundarbans constitutes the Indian Sundarbans, whose southern proximity meets the Bay of Bengal. The whole Sundarbans area was declared as Biosphere reserve in 1989, within which 1330.12 square km. is the core area representing the Sundarbans National Park, which holds world's largest estuarine mangrove forest. The buffer zone of 362.338 square km and surrounding the core zone includes Sajnekhali Wildlife Sanctuary. Out of the total area of 4263 square km of Indian Sundarbans, an area of about 2585 square km falls under Sundarbans tiger Reserve, which is further divided into four territorial ranges namely National Park East, National Park West, Sajnekhali Wild Life Sanctuary and Basirhat. Indian part of Sundarbans is dominated by mangrove swamps and out of the 50 species of mangroves recognized world over, only 35 species is known to thrive in Sundarbans. The largest unique mangrove ecosystem recognized as a site of national and international importance, provides a wide range of economic functions and helps in improving socio-economic conditions of the coastal communities. The mangroves of Indian Sundarbans are protecting our shoreline facing Bay of Bengal from major erosion damages due to waves, tropical storms and water runoff and acting as a barrier against natural calamities like cyclones, typhoon or tsunamis^{[6], [7]}. They exert a breakwater effect in absorbing most of the energy of wave action, thus protecting housing and service structures. They also have reserve capacity to absorb large quantities of storm waters, thus reducing flooding to adjacent areas. Anaerobic mangrove swamps have the capacity to trap heavy metals and pesticides, thereby improving water quality of coastal area^[8]. Mangroves also provide a natural filtering system for runoff water thereby helping water quality of coastal areas by extracting chemical pollutants from water. Above all, they are combating global warming and acting as 'carbon sinks' by absorbing most of the CO₂ to reduce green house gas emissions. Economically, mangroves are serving as source of timber charcoal, food, fodder and variety of products for coastal communities. The coastal mangrove

wetlands efficiently balance the energy requirements in the coast, supporting agriculture, coastal fisheries and shrimp farming.

III. REASONS FOR DEPLETION OF HERITAGE FOREST AND ITS BIODIVERSITY

Indian Sundarbans being the largest coastal mangrove ecosystem in the world is a home to almost 500 species of reptile, fish, bird and mammal's mangrove ecosystem is fairly resistant to environmental perturbations with high resilience ability, degradation through anthropogenic means are often irreversible. A number of species like Javan rhinoceros (*Rhinoceros sondaicus*), water buffalo (*Bubalus bubalis*), swamp deer (*Cervus duvauceli*), hog deer (*Axis porcinus*) and marsh crocodile (*Crocodilus palustris*) became extinct during the last 100 years from Sundarbans. The mangroves which form the important and dominant flora of Sundarbans, have been extensively exploited over centuries for the following major activities such as conservation of mangrove wetland for agriculture and aquaculture like shrimp farming, increasing demand for timber and fuel wood for consumption, anthropogenic impacts like human encroachment, reclamation etc. Other causes include salinity variations, coastal erosion, huge silt deposition and recurrent coastal flooding due to climate change and reduction in the periodicity and quantity of freshwater reaching the mangrove areas. Diversion of freshwater for irrigation and land reclamation has destroyed extensive mangrove forests. Habitat destruction through human encroachment has been the primary cause of mangrove loss. However, degradation of mangrove ecosystems on east coast of India is mainly due to continuous increase in anthropogenic activities such as conversion of mangrove wetlands for aquaculture and degradation of mangrove forest for timber^[9]. Sundarbans mangroves are habitats of endangered and vulnerable animals like spotted deer, jungle fowl, rhesus monkey, turtles etc. Further, the Tiger reserve provides characteristic type habitat suitable for animals inhabiting vast tidal swamp area. The world-famous Royal Bengal tiger (*Panthera tigris tigris*), which represents the flagship species is losing its unique habitat due to habitats shrinking "Quotation from newspaper" (Business Line, November 27, 2017).

IV. CRABS SERVING AS ECOSYSTEM ENGINEERS AND KEYSTONE SPECIES IN SUNDARBANS MANGROVE

Brachyuran crabs with large diversity and vital components of marine food chain and food web, play important role in controlling the ecological functions by feeding on detritus matter. They also have vital role in the maintenance, modification and regulation of the biotic environment by influencing both the abiotic and biotic components. Mangrove wetlands and tidal influenced sandy shores are home to various burrowing crabs like tree crabs (*Sesarma sp.*, *Metopograpsus sp.*), mud crabs (*Uca sp.*) and ghost crabs (*Ocypode sp.*). They depend directly upon mangrove influenced coastal ecosystem for survival, feeding, predation and reproduction by constructing biogenic structures. The mud crabs, like fiddler crabs are inhabitants of this typical estuarine ecosystem and serving as keystone species by frequently altering the substratum characteristics and generating bioturbation in the sediment (Fig 1.a-b). Their continuous burrow excavation and feeding activity expedite the oxygenation of the soil, increase regeneration of mangrove seedlings and bring about organic enrichment of the surface through nutrient and sediment turnover^[10]. Sesarmid crabs of Sundarbans mangroves are also

functioning as keystone species by influencing the structure and function of mangrove habitats through their burrowing activities and processing of leaf litter. Two semi-terrestrial shore crabs, *Ocypode macrocera* and *Ocypode ceratophthalmus*, commonly known as ghost crabs are inhabitants and predominant burrowing species along the coastal shoreline of West Bengal. Ghost crabs are excellent regenerators as well as excavators which dig and continuously maintain burrows in the sediment thereby transferring sediment from various depths to surface and playing an important role in biomixing. Their burrowing behaviour has been considered as one of the major bioturbations affecting the physical and chemical characteristics of the substratum, thereby promoting sediment turnover and biogeochemical cycling. Their frequent digging enhances oxygenation in sediment and promotes decomposition of organic materials (Fig 2. a-b). Through feeding activity they scrap the upper organic rich layer of the sediments regulating the organic content and the algal covering; on the other hand their byproduct from gut enriches the sediments with minerals like N and P^[11].

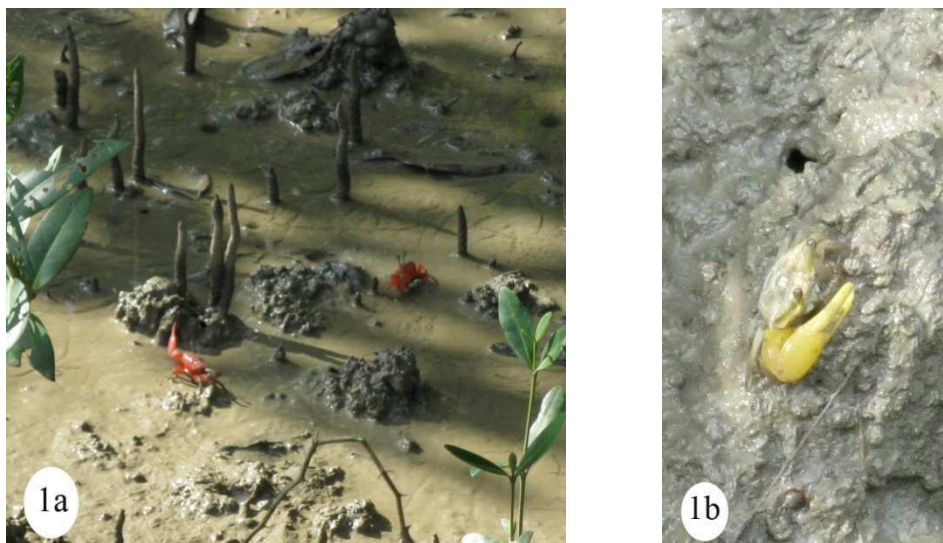


Figure 1.
Keystone species at mudflats of Sundarbans mangrove ecosystem;
(a) Red Fiddler crab (*Uca rosea*); (b) Yellow Fiddler crab (*Uca triangularis*)



Figure 2.
Shore crabs serving as ecosystem engineers and playing major role in bioturbation
(a) The Red Ghost crab, *Ocypode macrocera* in the process of burrow excavation;
(b) Horn-eyed Ghost crab, *Ocypode ceratophthalmus* (adult male).

V. SHRINKING HERITAGE ECOSYSTEM AND IMPACT ON COASTAL CRABS

The Sundarbans is losing its unique habitats and diverse flora and fauna due to continuous increase in anthropogenic stresses^[12]. According to present scenario, 50% of the remaining mangrove forests are in the process of gradual degradation and thereby struggling for existence. According to a publication by the School of Oceanographic Studies, Jadavpur University, by using remote Sensing and GIS, the mangrove forest cover of Indian Sundarbans has been depleted alarmingly of 124.418 sq. km. from 1986 to 2012, which is about 5.5 % “quotation from newspaper” (The Hindu, July 1, 2017). Significant losses have been noted in Islands like Dalhousie by 16 %, Jambudwip by 10%, Bhangaduni by 37%, Gosaba, Sajnekhali North, Matla, and Bulchery. Further, scientists from the Zoological Society of London reported the loss of Indian Sundarbans coastline of as much as 200 m in a single year leading to rapid deterioration in mangrove health. Hence, shrinkage of heritage forest and its valuable ecosystem is endangering the coastal crab diversity and thereby loss of keystone species from ecological community. Since, keystone species plays a crucial role in maintaining the structure and function of an ecological community, gradual decrease of such species will seriously affect the ecosystem causing major changes in community structure. If appropriate management and mitigation strategies are not taken, keystone species may represent the vulnerable category in coming future.

VI. CONCLUSION

The unique habitats and the diverse flora and fauna of the Sundarbans are dwindling due to pollution, urbanization, poaching, natural calamities and global climate change. Although conservation management is in effect with the recognition of the Sundarbans as a World Heritage Site by UNESCO, the requisite information on the species-specific functional roles in the sustenance of the ecosystem is still meager. In spite of the conservation efforts and the inherent tolerance to environmental perturbations and stress, the Sundarbans mangrove ecosystem is affected by the anthropogenic activities linked with aquaculture, agriculture and industries. Under such conditions, species specific information on the ecological roles may help enhance the conservation strategies. The crabs of the Sundarbans bear multifunctional roles in bioturbation, soil remodelling, nutrient cycling, sustenance of the food web, thereby qualifying as ecosystem engineers. Owing to the multiple links with the community members, the crabs are recognized as a keystone species, which justifies their significance in the context of the conservation of the Sundarbans mangrove. Different species of crabs of the Sundarbans are exploited as a resource for food security and livelihood, and thus sufficient care should be taken to ascertain the harvest following the principles of the maximum sustainable yield. The shrinkage of the Sundarbans mangrove and the anthropogenic factors may affect the coastal crab diversity. Thus appropriate steps for conservation of the crabs should be implemented, to ascertain the functional role of the crabs in the sustenance of the Sundarbans mangrove ecosystem.

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