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# Journal of Arts, Science and Teaching

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## Modern Strategies of Integrated Pest Management: A Review

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**Abstract:** *In this modern era with increasing human population there is a need to increase agricultural production per unit of land through economically and environmentally sustainable strategies. There is a worldwide growing awareness for promoting environmentally benign and ecosystem service (ESS) based sustainable agricultural practices through integrated pest management (IPM) strategies. They promote climate smart pest management (CSPM) as a part of IPM by using economic thresholds (ETs) for eco-friendly and sustainable climate smart agriculture (CSA) towards more production of crops. These approaches would bring down the pest load below economic threshold level (ETL) by judicious use of any control measures including broad-spectrum pesticides for sustainable agriculture. The ecological engineering (EE) approaches combine knowledge of ecology with the essence of a new IPM approach for the 21st century. Even it will enhance triple-E (ecological, environmental and economic) sustainable management of pest and also promote E<sup>3</sup> strategy (Ecosystem service based Ecological engineering for Ecological pest management [ESS-EE-EPM]) of pest management for better cultivation of crops by using CSPM strategy under the arena of CSA in near future.*

**Keywords:** ESS, IPM, CSPM, CAS, ETL, EE, sustainable management, E<sup>3</sup> strategy.

**1. INTRODUCTION:** There are near one billion hungry in today's world and the explosion of human population in developing countries is creating an unprecedented demand for greater production of agricultural products [1-2]. In this modern era with increasing human population, there is a need to increase agricultural production per unit of land through economically and environmentally sustainable strategies [2-4]. Pest control is the regulation or management of a species defined as a pest and among them insects are major constraints in the production of crops throughout the world [5-6]. In fact, plants and insects have been living together for more than 350 million years and about 45% of known insects feed on plants [7-9]. Approximately two third known herbivorous insect species are Coleopteran beetles or Lepidopteran caterpillars [10-11]. Plants respond to



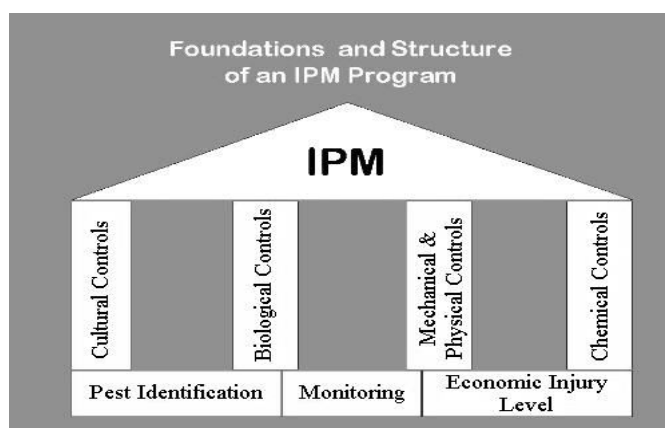
herbivore attack through dynamic defense (direct and indirect) mechanisms (constitutive or induced) by structural barriers, toxic chemicals and attractant for natural enemies to counter against the herbivores [9-11]. Pest control measures may be performed as part of an integrated pest management strategy by physical, mechanical, cultural, chemical and biological means [1-5]. It has been developed as a way to control pests without relying solely on pesticides [5]. IPM is a systematic plan which brings together different pest control tactics into one program. Most management practices are long-term activities that aim at preventing pests and diseases from affecting a crop [6-8]. Management focuses on keeping existing pest populations and diseases low. Control, on the other hand, is a short-term activity and focuses on killing pest and disease. Therefore, management is of a much higher priority than control [5-6].

The IPM has been evolving over the decades to address the deleterious impacts of synthetic chemical pesticides on environment. Recent advancement in IPM programmes have employed molecular techniques including better breeding programmes, genetically modified crops (GMOs) expressing resistant traits and use of synthetic and natural semiochemicals around the world for pest control [12-16]. Sighting a single pest does not always mean control is needed which is actually the first step to remove the possibility of injudicious use of pesticides [17-19]. But in the modern industrial agricultural system long persistent broad-spectrum pesticides (e.g., insecticides and fungicides) are still being used indiscriminately in nature to increase agricultural productivity and ensure food security [20-23]. This injudicious application of pesticides obviously leads to the destruction of ecological biodiversity including beneficial natural enemies, essential pollinators and foragers [1, 6, 16]. This actually hampers the sustainability and normal functioning of the food chains by toxic effect and biomagnifications through trophic interactions in our ecosystem [24-16]. These also result in secondary pest outbreak and development of pesticide resistance in insect pests and emergence of pest biotypes. At this point, population dynamics based eco-friendly approaches would obviously be helpful in the conservation of natural enemies which would bring down the pest load below economic threshold (ET) and eventually lower broad-spectrum pesticides use which generally brings pest resurgence and pest resistant problems [2, 19-20, 27]. Different IPM management strategies include different eco-friendly control strategies for sustainable management of pest.

## **2. DIFFERENT INTEGRATED PEST MANAGEMENT (IPM) STRATEGIES:**

IPM is a broad-based approach that integrates practices for economic control of pest. It aims at suppressing pest populations below the economic injury level (EIL) [2, 18, 25]. IPM emphasizes the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control

mechanisms. The IPM has been adopted since the 1970s, shortly after World War II, when synthetic pesticides became widely available [1, 5]. It extended the concept of integrated control to all classes of pests and was expanded to include all tactics. The IPM process starts with monitoring, which includes inspection and identification, followed by the establishment of EILs [17-19]. IPM includes different methods of pest control such as resistant varieties, cultural methods, physical methods, behavioural methods, mechanical methods, natural enemies and pesticides are integrated to suppress pest population without hampering other components of the environment (Figure 1).



**Figure 1.** Foundations and structure of IPM strategies.

**2.1. ETs Based Pest Management:** Two basic components of decision making in pest management are the EIL and ETs [28-29]. The EIL is the lowest population density that will cause economic damage and ET is defined as the pest population density at which control should be initiated to prevent an increasing pest population from exceeding the economic injury level [17-19]. The ET is always below the EIL [17]. The development of a different model—a dynamic plant-based EIL—facilitates to judge the success of an ET [18-19]. To estimate the exact ET, it is necessary to calculate life table data for both the predator and prey species (crop pest) and relate this to temperature, time and spatial dynamics [28-30]. The limitation of the ET is that it is based on parameters that are changing all the time, and many are often not known [17-18]. The damage or losses caused by a certain density of insects cannot be predicted or precisely implied. Farmers cannot base their decisions on just a simple count of pests [19]. They will have to consider many other aspects of the crop (crop ecology, growth stage, natural enemies, weather condition, etc.) and their own experience and economic and social situation before they can make the right crop management decisions.

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**2.2. Green Pest Management (GPM):** GPM is a part of IPM where control based on natural organic materials. The Beginning Green pest control has its roots in IPM, which came into vogue during the 1980s [24]. It was borrowed from agricultural pest management as a way to manage pests using non-chemical methods that include mechanical, physical, and cultural protocols [31-33]. Chemical pesticides were also used, but in greatly reduced amounts and frequency, and new chemical pesticides were developed that were effective at much lower concentrations. These newly developed materials had very short environmental life spans, which forced the pest management industry to look at alternate chemical protocols and to strengthen and refine their non-chemical ones. Bio-pesticides are usually less toxic than conventional pesticides and generally affect only the target pest and closely related organisms, in contrast to conventional broad-spectrum pesticides that may affect organisms as varied as birds, insects and mammals [21, 34]. Bio-pesticides often are effective in very small quantities and decompose quickly, resulting in lower exposures and lack the pollution problems caused by conventional pesticides [34-35]. Certain essential oils found in plants contain natural chemicals that, when properly formulated and applied, kill pests by attacking its nervous system [23-24]. GPM program must consider the entire structure and the immediate exterior environment as part of the pest management strategy.

**2.3. Agro-Ecosystem Analysis (AESA) based IPM:** In modern IPM emphasis is given to AESA where farmers take decisions based on larger range of field observations [35-37]. The IPM has been evolving over the decades to address the deleterious impacts of synthetic chemical pesticides on environment ultimately affecting the interests of the farmers [1-2]. The ETL was the basis for several decades but in modern IPM emphasis is given to AESA where farmers take decisions based on larger range of field observations. In AESA based IPM emphasis is given to natural enemies, plant compensation ability, abiotic factors and P: D ratio [36-37]. Understanding the intricate interactions in an ecosystem can play a critical role in pest management thorough analysis of the agroecosystem. The health of a plant is determined by its environment which includes physical factors (i.e., soil, rain, sunshine hours, wind etc.) and biological factors (i.e., pests, diseases and weeds). All these factors can play a role in the balance which exists between herbivore insects and their natural enemies [37-39]. Understanding the intricate interactions in an ecosystem can play a critical role in pest management [2]. Decision making in pest management requires a thorough analysis of the agroecosystem [4-5]. Farmer has to learn how to observe the crop, how to analyze the field situation and how to make proper decisions for their crop management. It is an approach, which can be gainfully employed by extension functionaries and farmers to analyze the field situations with regards to pests, defenders, soil conditions, plant health and the influence of climatic factors and their relationship for growing a healthy crop.

**2.4. Ecological Pest Management (EPM):** EPM is an approach to increase the strengths of natural systems to reinforce the natural processes of pest regulation and improve agricultural production [37, 40-41]. EPM is thus ecologically-based pest management that makes full use of natural and cultural processes and methods, including host resistance and biological control [42-44]. It emphasises the growth of a healthy crop with the least possible disruption of agro-ecosystems, thereby encouraging natural pest control mechanisms. Worldwide public attention has been focused on the importance of EPM since the United Nations Conference on Environment and Development held in Rio de Janeiro in June 1992 [45-47]. Agenda 21, the blueprint for action prepared by the conference, recognised pesticide pollution as a major threat to human health and the environment worldwide and identified IPM as a key element in sustainable agricultural development [48-49]. EPM is belonging to the denominated ‘clean’ technologies which combine the life cycle of crops, insects and implicated fungi, with natural external inputs (i.e., bio-pesticides) that allow a better guarantee of good harvesting even in difficult conditions of pests and diseases that emerge with the temperature and water level changes typical of climate change [36, 50]. By promoting a diversified farming system, the practice of EPM builds farmers’ resilience to potential risks posed by climate change [3]. With the EPM approach, farmers can avoid the costs of pesticides as well as the fuel, equipment and labour used to apply them [50-51]. Although this can cause a slight drop in productive performance but the risk of losing an entire crop is reduced dramatically. EPM is not easy to implement and requires substantial knowledge and monitoring for the combined components of the system to produce success. In addition, no single biological controller works in every situation. In the long run, more than one type of biological controller may have to be used to achieve uniform control across a variety of different situations and land types [45-46]. In agricultural production systems where the environment is relatively free of polluting elements (such as pesticides), and pests are becoming progressively more aggressive, conditions for EPM development are better [51-52]. When EPM is used, farmers can benefit from the opportunity to sell their goods as healthy organic products that can fetch a higher market price.

**2.5. Ecological Engineering (EE) for Pest Management:** It has recently emerged as a paradigm for considering ecologically sustainable pest management approaches [46, 53]. The term “ecological engineering” was first used by Odum (1962) to refer to the environmental manipulation by man using small amounts of supplementary energy to control systems in which the main energy drives are still coming from natural sources [54]. EE for pest management is based on informed ecological knowledge rather than high technology approaches such as synthetic pesticides and genetically engineered crops [53]. The EE involves manipulating farm habitats, making them less favorable for pests and more attractive to beneficial insects. Pest suppression via ecological engineering is placed in the broader context

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of ecosystem services (ESS) provided by farmland biodiversity including nitrogen fixation and the conservation of pollinator species and wildlife [52]. Although they have received far less research attention and funding, ecological approaches may be safer and more sustainable than genetic engineering of crops [53-54]. The utility of EE for pest management is much more than so-called ‘chocolate-box ecology’, where the practices are aesthetically pleasing but lacking in rigour and efficacy.

**2.6. Agro-Ecology Based Pest Management:** One way of further advancing the ecosystem management approach in IPM is through the understanding that crop health and sustainable yields derive from the proper balance of crops, soils, nutrients, sunlight, moisture and coexisting organisms [26, 34, 41]. The agroecosystem is productive and healthy when this balance of rich growing conditions prevails, and when crop plants remain resilient to tolerate stress and adversity. If the cause of disease, pest, soil degradation etc. is imbalance, then the goal of EE is to recover the balance [46, 53]. This is known in ecology as resilience and requires a thorough understanding of the nature of the agro ecosystems [47-55]. Agro-ecology provides basic ecological principles on how to study, design and manage agroecosystems that are productive, enduring and natural resource-conserving [56-58]. It goes beyond a one-dimensional view of agroecosystems to embrace an understanding of ecological and social levels of coevolution, structure and function [37]. Instead, it emphasises the interrelatedness of all agroecosystem components and the complex dynamics of ecological processes such as nutrient cycling and pest regulation. From a management perspective, the agroecological objective is to provide a balanced environment, sustainable yields, biologically mediated soil fertility and natural pest regulation through the design of diversified agroecosystems and the use of low-input technologies [40]. The main goal is to enhance the immunity of the agro ecosystem and regulatory processes through management practices and agro-ecological designs that enhance plant species and genetic diversity, and organic matter accumulation and biological activity of the soil [40]. Agroecosystems can be manipulated to improve production and produce more sustainably, with fewer negative environmental and social impacts and fewer external inputs [40, 58]. The ultimate goal of agro-ecological design is to integrate components so that overall biological efficiency is improved, biodiversity is preserved and agroecosystem productivity and its self-sustaining capacity are maintained.

### 3. DISCUSSION:

Modern agriculture includes climate smart pest management (CSPM) as a part of IPM by using ETs for eco-friendly and sustainable climate smart agriculture (CSA) towards more production of crops [3, 17-19, 36, 50]. The basic information on the

biology of an insect pest is necessary before deciding any strategy to combat with the pest [59-65]. But still, spraying different broad spectrum synthetic chemical insecticides or few botanicals are the general practices for the control of any pests in the field without considering their injury level or action threshold [2, 25, 27-28]. Even majority of the currently using synthetic chemical pesticides and their non-judicious uses over the decades have biomagnifications potential with catastrophic effects on food chain as well as deleterious impacts on environment which also affecting the interests of the farmers [1, 17, 19, 29]. The assessment of crop loss due to insect pest becomes essential for any planned crop protection against a particular pest in a particular crop as key component of IPM [5, 24]. Pest population dynamics and yield loss assessment data with ETs are the primary tool to design a module for insect pest management [2, 29-30]. The ET is a complex value that depends on estimating and predicting several difficult population parameters, EIL variables, pest and host phenology, etc. [17-20]. Though most ETs are relatively crude because of their dynamic variables particularly pest population parameters and EIL variables [18-19]. But still the ET is more effective than using no ET at all in IPM for minimizing hazards to humans and the environment by judicious pesticide applications [5, 17]. In ecological research, life table study is a central theme to calculate the vital statistics of pest population dynamics and their management [7, 10, 25, 27, 49, 57]. Whereas, the role of host-plant with respect to their food quality is an important factor in feeding dynamics or nutritional ecology for regulating herbivorous insect population growth and survival [9, 12, 61-65]. Thus, both population parameters and feeding dynamics of any insect pest is widely useful technique in their management [38, 56, 59, 65]. But till date there is a gap between long term population study and determination of descriptive ET for a particular pest on a specific crop towards ecologically sustainable agriculture (ESA) [3, 25, 27, 36]. Today we need to determine the economic threshold (ET) through the yield loss calculation along with their population dynamics and nutritional ecology for their ecologically sustainable management (ESM) [25, 27, 36, 53]. It will ultimately help to develop an alternative method for ecologically sustainable agricultural (ESA) practices by judicious use of any or more suitable control measures other than chemical pesticides under the strategy of GPM for better production of crops in our agro ecosystem. Even, ETs based time series for judicious application of any sustainable control measures against the pests and carbon sequestration efficiency (CSE) of crops will obviously reduce ecological imbalance to promote CSA. Consequently, a comprehensive integrated pest management (IPM) program is needed for sustainable agriculture to reduce the reliance on the chemical pesticides and to promote green pest management. The sustainability must be in terms of ecological, environmental and economical point of view for better agricultural practices. Even, it will be an alternative smart management strategy for judicious use of any control measures including pesticides with minimum management cost as well as minimum agro-ecological imbalance

through CSPM with maximum net profit and better production of any crop. For the triple-E (ecological, environmental and economic) sustainable management of pest, the integration of ecosystem service by habitat manipulation through ecological engineering is essential. Thus, ecological principle-based pest management (EPM) along with the IPM approaches or E<sup>3</sup> strategy (Ecosystem service based Ecological engineering for Ecological pest management [ESS-EE-EPM]) of pest management obviously promote better cultivation of crops by using CSPM strategy under the arena of CSA in near future.

#### **4. CONCLUSION:**

There is a worldwide growing awareness for promoting environmentally benign and ESS based sustainable agricultural practices through AESA based IPM. Even, EE work by tailoring ESS manipulation, such as push-pull strategy, intercropping, trap cropping, cover cropping, bank cropping, etc. according to needs for better production of crops. These approaches would bring down the pest load below ET and eventually lower broad-spectrum pesticides use to avoid pest resurgence as well as pest resistant problems. Ecological thinking applied to agriculture and environment has undergone an impressive development nowadays, in the context of the problems arising from the sustainable development and biodiversity conservation which happens at present. The changes in climate, the often-divided agricultural working systems and the frequent deficient and incorrect crop technologies cause significant agro-ecological changes. The EE involves manipulating farm habitats, making them less favourable for pests and more attractive to beneficial insects. Although they have received far less research attention and funding, ecological approaches may be safer and more sustainable than genetic engineering of crops for pest management and it is much more than so-called chocolate-box ecology. This review will also raise awareness of the value and potential of international efforts to develop ecologically sound pest management approaches that confer ESS benefits including conservation of wildlife. The EE approaches described here combine in a dynamic way, knowledge of ecology, behaviour, agronomy, molecular biology and communication in arthropods to reduce pest numbers in low-input farming with the essence of a new IPM approach for the 21st century. Even it will enhance triple-E (ecological, environmental and economic) sustainable management of pest and also promote E<sup>3</sup> strategy (Ecosystem service based Ecological engineering for Ecological pest management [ESS-EE-EPM]) of pest management for better cultivation of crops by using CSPM strategy under the arena of CSA in near future.

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## Geology and Lithological Characteristics of the Eastcentral Rajmahal Highlands, Jharkhand, India

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**Abstract:** *The Eastcentral Rajmahal Highlands has an average elevation of 240 metres, but it ranges from less than 40 metres in the rolling low level plain surface to more than 400 metres at Agwanduari Paruni Pahar (440 m., 87°14'28" E & 24°05'24"N) in the Ranishwar Block. The study area represents a variety of landforms such as residual hills and hillocks, rolling uplands, dissected uplands, tors, erosional platform and rocky surfaces. These isolated or residual hills of various origins are locally known as 'Pahar' or 'Dungri'. Morphological zones of an area are directly the reflection of surface elevation and forms which are the resultant of geological make-up and the processes acting in the area. Seven major geological formations and the associated rocks types are found in the study area. Granite is the most common type of rock found almost all over the area. The Chhotonagpur Granite Gneissic complex cover the greater portion of the study area. The purpose of this paper is to highlight the geological and lithological details which ultimately determine the physical as well as the socio-economic structure of the area.*

**Keywords:** *Chhotonagpur, elevation, geological formation, granite, landform*

### 1. Introduction

The present discussion on geology and lithology of the Eastcentral Rajmahal Highlands has been necessitated owing to the fact that these are among some of the most significant determinants which exert control upon terrain classification and evaluation as well as upon the formation of the most fundamental trend-setting inputs of agriculture depth and properties of soils, quality and quantity of surface and underground drainage, mineral composition and many other components [1] [2]. A host of scholars have attempted to present detailed geological and lithological formations of this part of the Rajmahal Highlands. Among them the important scholars are Dana (1872), Medlicott (1972), Pascoe (1973), Wadia (1919), Fox (1931), Jones (1933), Krishnan (1968), Chatterjee (1940), Singh (1969) and Mahadevan (2002). On the basis of all these details and field study, the author has presented a detailed account of these two components.

## **2. Main Objectives**

The specific objectives are –

- To identify the major geological formations.
- To find out every litho-stratigraphic unit and their nature, characteristics and composition of rocks and minerals in detailed
- To identify which geological formations cover the greater and minor portion of the study area.
- to make an analysis of all these.

## **3. Study Area**

Extending from 23° 55'15"N to 24° 10'15" N latitudes and 86°56'00" E to 87° 30'00" E longitudes, the Eastcentral Rajmahal Highlands covering three blocks of Dumka district *viz*; Dumka, Raniswar and Shikaripara in the State of Jharkhand, India is a portion of the Chotanagpur Highlands (Fig.1). Occupying an area of 1164.6 sq. kilometres, the study area comprises the entire portion of Dumka, Ranishwar and Shikaripara administrative blocks of Dumka district of Jharkhand and lies in the Eastcentral Rajmahal highlands. It includes 753 villages as well as one municipal area of Dumka Town. The study area is mainly characterised by undulating and rugged terrains dotted with residual hills and hillocks. Therefore, the area is one of the backward regions of the State of Jharkhand.

## **4. Sources and Methods**

Georeferencing and mosaicking all the three C.D. block maps (Dumka, Ranishwar and Shikaripara) have been done. Maps of geology and lithology have been prepared from the District Resource Map published by the Geological Survey of India (GSI). These maps have been georeferenced, digitised and calculated the area of each litho units through 21<sup>st</sup> Century GIS Professional 2012 software (Figs. 1, 2 & 4).

# LOCATION AND SURROUNDINGS: EASTCENTRAL RAJMAHAL

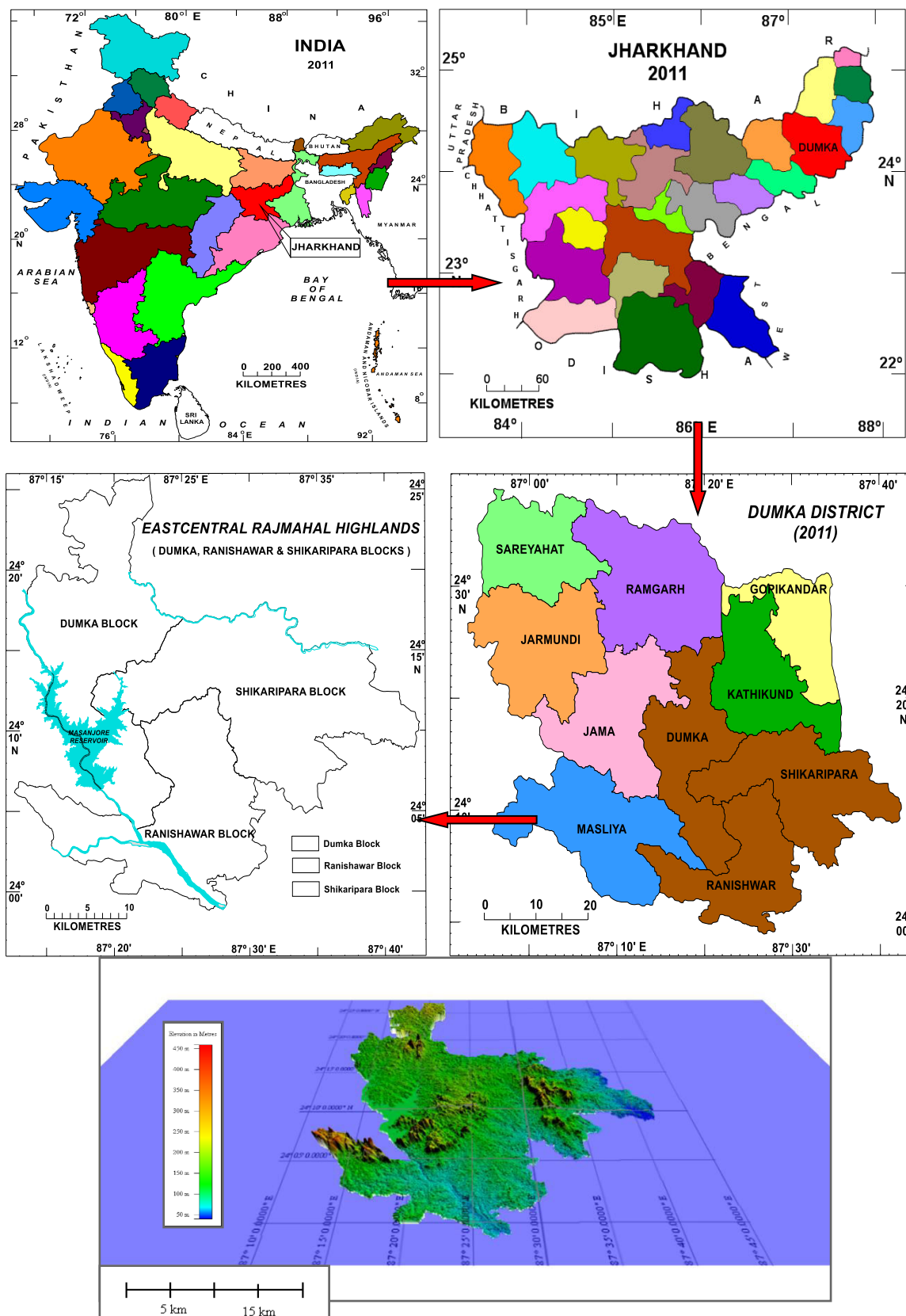


Fig.1

## 5. Geological Setup

The study area, the Eastcentral Rajmahal Highlands, possesses seven major geological formations (Table 1, Figs. 2 & 3).

### 5.1. Eastern Ghat Super Group

The geological formation of the Eastern Ghat Super Group belongs to Archean period. The Eastern Ghat Super Group in the study area consists of two lithological units, *e.g.*, a) Acid Charnockite (Ch1) and b) Basic Charnockite (Ch. 2). Some patches of Acid Charnockite (9.64%) are found in the western portion of Dumka and Ranishwar Blocks and central portion of the study area. Basic Charnockite is mainly found in very small patches (0.47%) in the southern parts of Dumka block. Charnockite is applied to any Orthopyroxene-bearing quartz-feldspar rock. It is composed of coesite, perthite or antiperthite and orthopyroxene (usually hypersthene). These non-foliated rocks were formed under relatively high temperature and pressure in the crust by tectonic forces [3]. So, it is a product regional, rather than contact metamorphism. It is created mostly from the granite clan of rocks or occasionally from thoroughly reconstructed clays and shales. These rocks are in generally bluish gray or darkish in colour. The composition of mineral shows an evenly presence of pleochroic rhombic pyroxene. Augite and hornblende are other femic minerals and Flagioclase feldspars, alkali feldspars and quartzs are the salic minerals present in this type of rocks.

### 5.2. Unclassified Metamorphic

Unclassified Metamorphic consists of Amphibolite, Hornblends Schist and Epidiorite (AHS) lithological unit. Amphibolite is a metamorphic rock composed primarily of amphibole. It is located in very small cut off patches (0.08%) in northern part of Dumka and Shikaripara Blocks and southern part of Shikaripara Block. These rocks are composed of Tremolite, Actinolite, Quartz, Epidote and Garnet. Nature and characteristics of these rocks are hard and foliated. 'It is the commonest mineral of the amphibole group. It has a variable composition, and may contain potassium and appreciable fluorine. Hornblende is commonly black, and it occurs in distinct monoclinic crystals or in columnar, fibrous, or granular forms. It is a primary constituent of many acid and intermediate igneous rocks and less commonly of basic igneous rocks, and is a common metamorphic mineral' [4]. Amphibolite 'a crystalloblastic rock is consisting mainly of amphibole and plagioclase with little or no quartz. As the content of quartz increases, the rock grades into hornblende-plagioclase gneiss' [4].

**Table 1: Major Geological Formations in the Eastcentral Rajmahal Highlands**

Geological Period	Geological Formations	Area Coverage (sq. km.)	% to Total Area	Geographical Distribution
Cenozoic	Laterite	44.65	3.83	Eastern parts of Shikaripara Block and extreme southern part of Ranishwar Block
Jurassic-Cretaceous	Rajmahal Trap	133.50	11.46	Eastern part of the study area
Triassic to Jurassic	Dubrajpur-Formation	2.87	0.25	Only northern part of Shikaripara Block
Permian	Barakar-Formation	64.05	5.50	Eastern part of Shikaripara Block
Archaean to Proterozoic	Chhotonagpur Granite Gneiss Complex	805.99	69.20	Northern (Dumka Block) parts of the study area; apart from the eastern, some small parts of the southern, western and middle portions, the whole of the study area.
	Unclassified Metamorphic	0.94	0.08	Northern part of Dumka and Shikaripara Blocks and southern part of Shikaripara Block
Archaean	Eastern Ghat Super Group	112.67	9.68	Southern, Western part of Dumka Block; Western of Ranishwar Block and central portion of the study area
<b>Total</b>		<b>1164.67</b>	<b>100</b>	

Source: Data obtained from Dumka District Resource Map (2009), prepared by the Geological Survey of India and compiled by the researcher

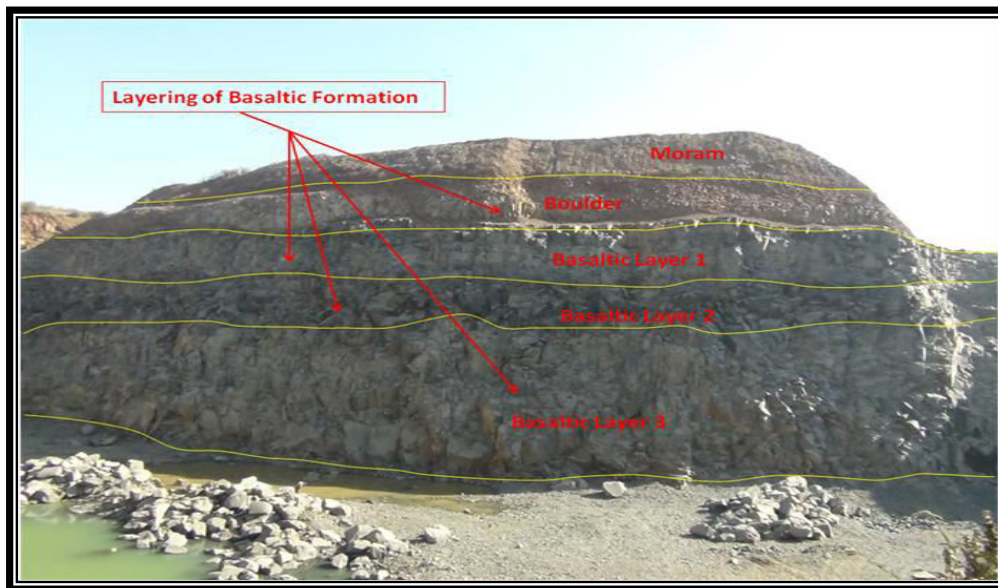


Photo 1: Layering of Basaltic Formation, (24° 13' 08" N, 87° 34' 36" E), Amtala, Shikaripara Block



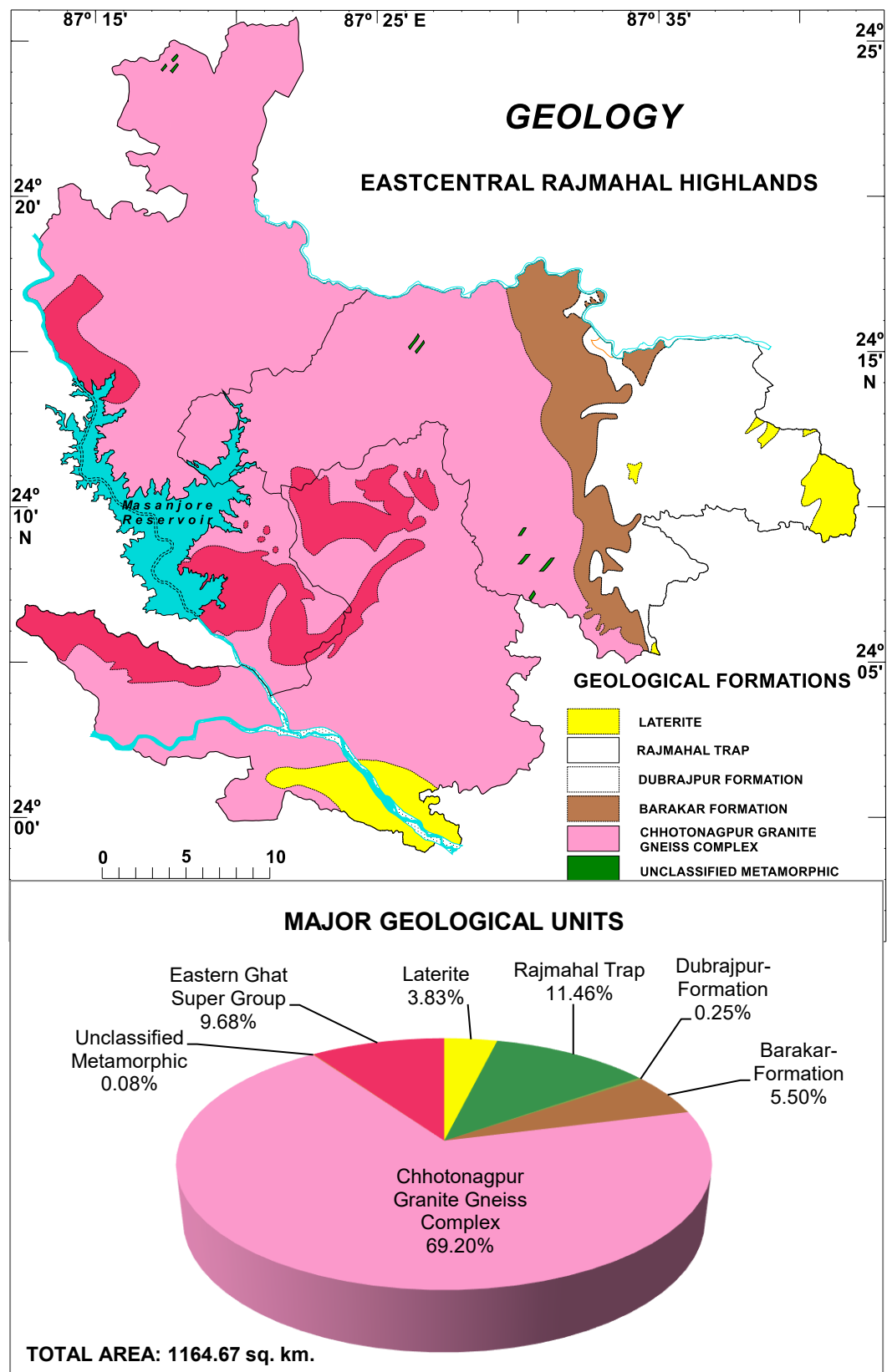


Figure 2 and 3

Source: Data obtained from Dumka District Resource Map (2009), prepared by the Geological Survey of India and compiled by the researcher

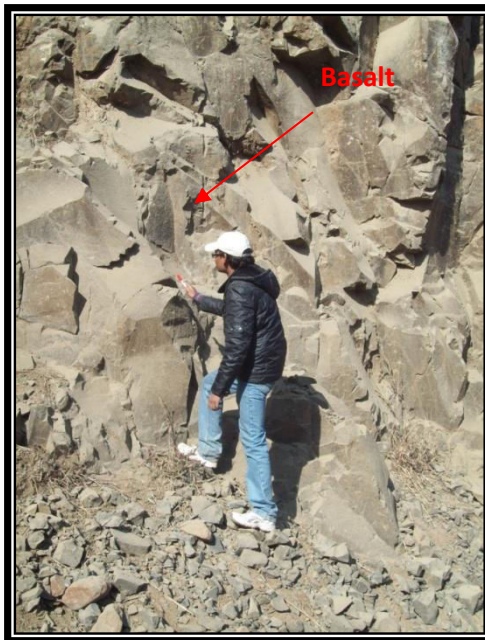


Photo 2: Basalt Wall of Makripahari  
*Khadan*, ( $24^{\circ} 13' 08''$  N,  $87^{\circ} 34' 36''$  E),

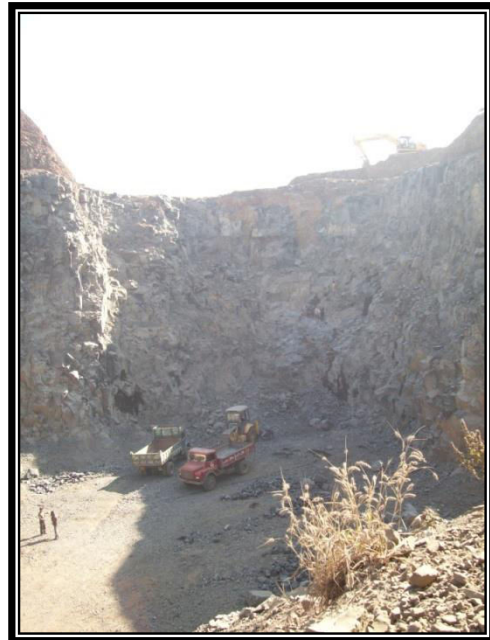


Photo 3: Makripahari *Khadan*, ( $24^{\circ} 13' 08''$  N,  $87^{\circ} 34' 36''$  E),



Photo 4: River Bed of Mayurakshi with rocky surface, Masanjore,  
Dumka Block

### 5.3. Chhotonagpur Granite Gneiss Complex

Chhotonagpur Granite Gneissic complex in the study area is represented by three lithological units, *e.g.*, i) Pegmatite/ Quartz Vein (PQ), ii) Unclassified Granite Gneiss with enclaves of metamorphic (GG) and iii) Garnet-Biotite Gneiss (GBn). Various dimensions of Pegmatite and Quartz Veins (0.11%) are passing through the northern (Dumka Block) parts of the study area. Quartz 'is the most abundant mineral in the rocks of the earth-crust. It builds massive formations, such as quartzites and quartz-reef, occurring as veins over long distances. River sands and sea-sands are composed of over 90 % quartz' [5]. Apart from the eastern, some small parts of the southern, western and middle portions, the whole of the study area consisting of unclassified Granite Gneiss with enclaves of metamorphic types (57.07%) of rock formation. Granite is the most common type of rock and it is found almost all over the area. 'It is coarsely banded and foliated texture. At places the banding is so coarse that the rock very much resembles with granite or some other plutonic rocks. The gneiss is composed of varying amounts of white or pink orthoclase, a little oligoclase, bluish quartz in small grains, biotite, muscovite, hornblende and the accessory minerals such as tourmaline, epidote, chlorite, garnet, spinel, graphite, magnetite, ilmenite *etc.*' [6]. Garnet-Biotite Gneiss is a hard foliated rock which is represented 12.02 % of the study area. Chhotonagpur Granite Gneissic includes enclaves of amphibolites and mica-schist. 'The rocks belonging to this system are the most ancient rocks forming the earth's crust. They are the gneisses, granites and schists along with extremely metamorphosed sedimentary rocks, which lie at the base of rock systems' [5].

### 5.4. Barakar Formation

The Barakar stage, named from the Barakar branch of the Damodar river, is widely distributed among the Gondwanas. In the Rajmahal field, it has large spread but thickness of a few hundred meters; rarely touching 550 m. Dolerite dykes are found to be intrusive into the Barakar rocks here. Barakar outliers are also observed on the valley of the Brahmani. The number of coal seams occurring in this area is also not known due to the difficulties of correlation [7]. Barakar Formation is an important formation in the Gondwana Super Group. These formations consist of Siltstone, Sandstone and Shale with Coal Seam (SDC) which occupies 5.50% of the total study area. Nature and characteristics of rocks are basically soft and medium hard layered sedimentary rock. Barakar Formation is only concentrated in the eastern part of Shikarapara Block. Coal is a sedimentary rock formed from organic matter and it is an important geological resource of the study area.

### 5.5. Dubrajpur Formation

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‘Sandwiched between the underlying Barakar and the overlying Rajmahal trap is the Dubrajpur Formation, named after a village of the same name located in the Bansloi river valley on the plains, west of the Rajmahal Hills. It comprises conglomerate, ferruginous sandstone, coarse pink felspathic sandstone, red and brown siltstone and clay’ [8]. The greatest thickness of the Dubrajpur formation in the Rajmahal does not exceed to 106.88 meters [9]. This geological formation belongs to Triassic to Jurassic period. Dubrajpur formation represented Sandstone and Shale (SS) lithological unit and these soft, medium hard layered, usually white sedimentary rocks cover an area of 2.87 sq. km. (0.25%) of the total study area. Dubrajpur formation found only northern part of Shikaripara Block.

### 5.6. Rajmahal Trap

The Rajmahal Trap of the Gondwana super group takes its name from the Rajmahal hills. Rajmahal hills are made up of masses of volcanic rocks, *i.e.*, Rajmahal trap. Some 150 million years ago, the flow of Rajmahal lava took place and covers about 11.46% (133.50 sq.km.) of the total study area. Maximum portion of the Rajmahal hills is made up of Rajmahal trap with inter-trappen sedimentary beds. The thickness of the rocks is 600 m. Basaltic flows superimpose the Gondwanas in the form of continental sheet. But now due to erosion the rock is constrained to hill tracts only with a typical flat topped or terraced topography [10]. G.V. Hobson identified only ten distinct flows of trap averaging 22.86 metres each in thickness while other geologists have the opinion that the total number of the flows must be double [9]. Rajmahal Trap formation consists of Rajmahal Trap-Basalt/ Inter-Trappean Beds, Chart (RT) lithological unit. This hard rock is found in the eastern part of the study area belongs to Jurassic to Cretaceous period.

The dark coloured trap rocks are varying from dolerites to basalts, depending on their texture. Most of the rocks have a porphyritic texture but all different types of texture are institute in basaltic rocks, such as ophitic, granite-ophitic intersertal, hyal-ophitic which have been described from different localities. Phenocrysts or aggregates of feldspar, pigeonite are irregularly distributed in a ground mass of labradorite, pigeonite, augite, magnetite, glass and also palagonite and chlorophaeite. Some flows are vesicular, the cavities being filled with calcite, chalcedony and analcite [11].

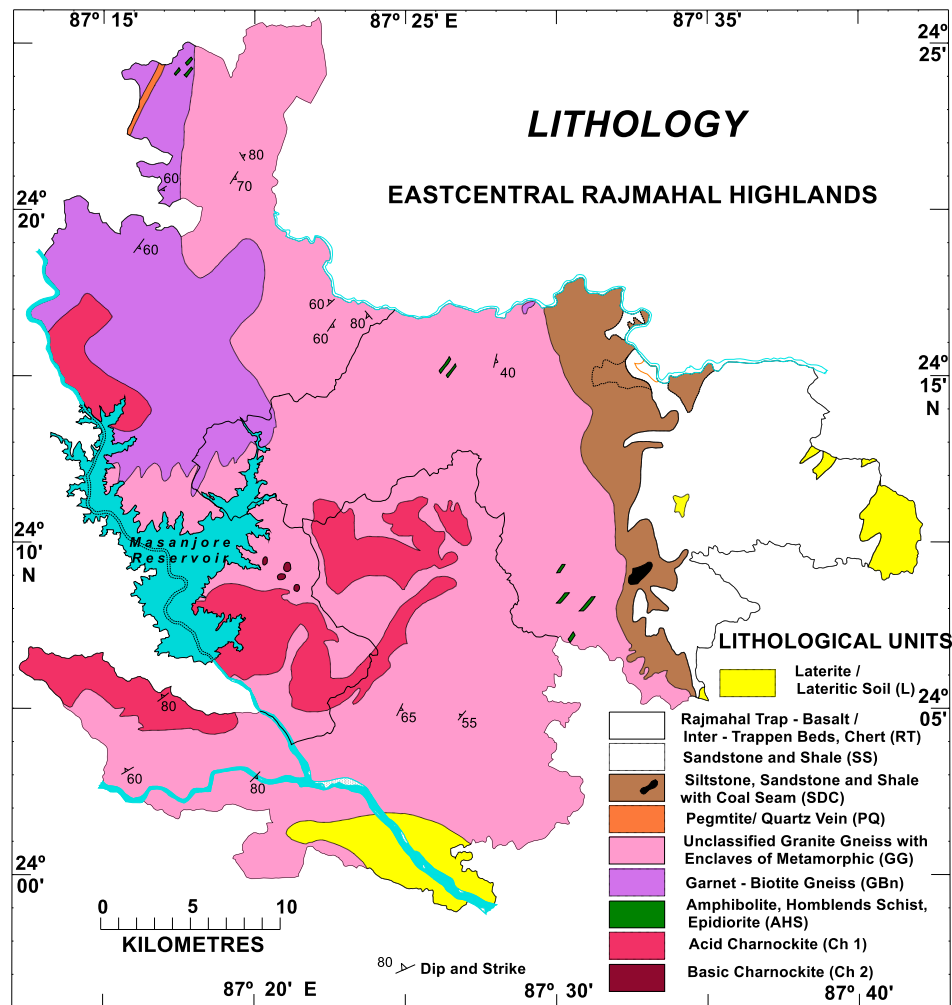
### 5.7. Laterite

Laterite is a product of weathering. Silica, alkalies and alkaline earths have been leached away and leaving behind alumina, iron, manganese and titanium. Laterite contains much water due to its vermicular and pisolitic structure [11]. Laterite formation belongs to the Quaternary to Tertiary period. These formations consist of Laterite/ Lateritic Soil (L) which is a soft and medium hard rock. It is distributed in some small patches in the eastern parts of Shikaripara Block and

extreme southern part of Ranishwar Block of the study area. Laterite covers an area of 44.65 sq. km. (3.83%) of the study area. Laterite is a product of tropical alteration suffered by some rocks. It is a peculiar ferruginous material, porous, pitted clay-like rock with red, yellow brown, grey and mottled colours, depending on the composition. Generally ferruginous laterite is red to red-brown, aluminous laterite one grey or cream and the manganiferous one dark brown to black in colour [11]. According to Fox, primary laterite is a residual weathering product of various types of igneous, sedimentary and metamorphic rocks [12].

## 6. Lithological Setup

Seven major geological formations of the Eastcentral Rajmahal Highlands are characterised by different lithological units. Every litho-stratigraphic unit is described by their nature, characteristics and composition of rocks and minerals in detailed (Figs. 4, 5 & Table 2, 3). Various important rocks and minerals *i.e.*, Basalt, Granite-Gneiss, Coal, China clay, Lead, Zinc, Silver, Laterite and *Moram* are the main components that make the surface (Table 3, 4).



**Table 2: Lithological Units in the Eastcentral Rajmahal Highlands**

Era	Period	Super Group	Formations	Lithology	Nature & Characteristics	Area Coverage (sq. km.)	% to Total Area
Cenozoic	Tertiary to Quaternary		Laterite	Laterite/Lateritic Soil (L)	Soft and Medium Hard Rock	44.65	3.83
Mesozoic	Jurassic to Cretaceous	Gondwana Super Group	Rajmahal Trap	Rajmahal Trap-Basalt/Inter-Trappean Beds, Chert (RT)	Hard Rock	133.50	11.46
	Triassic to Jurassic		Dubrajpur-Formation	Sandstone and Shale (SS)	Soft and Medium Hard Layered Sedimentary Rock	2.87	0.25
Paleozoic	Permian		Barakar-Formation	Siltstone, Sandstone and Shale with Coal Seam (SDC)			64.05
Precambrian	Archaean to Proterozoic	Chhotonagpur Granite Gneiss Complex		Pegmatite/Quartz Vein (PQ)	Hard Rock	1.30	0.11
				Unclassified Granite Gneiss with enclaves of metamorphic (GG)	Hard Foliated Rocks	664.64	57.07
				Garnet-Biotite Gneiss (GBn)		140.05	12.02
	Unclassified Metamorphic		Amphibolite, Hornblends Schist, Epidiorite (AHS)	0.94		0.08	
		Archaean	Eastern Ghat Super Group	a) Acid Charnockite (Ch1)	112.20	9.64	
	b) Basic Charnockite (Ch2)			0.47	0.04		
	<b>TOTAL</b>						<b>1164.67</b>

Source: Data obtained from Dumka District Resource Map (2009), prepared by the Geological Survey of India and compiled by the researcher

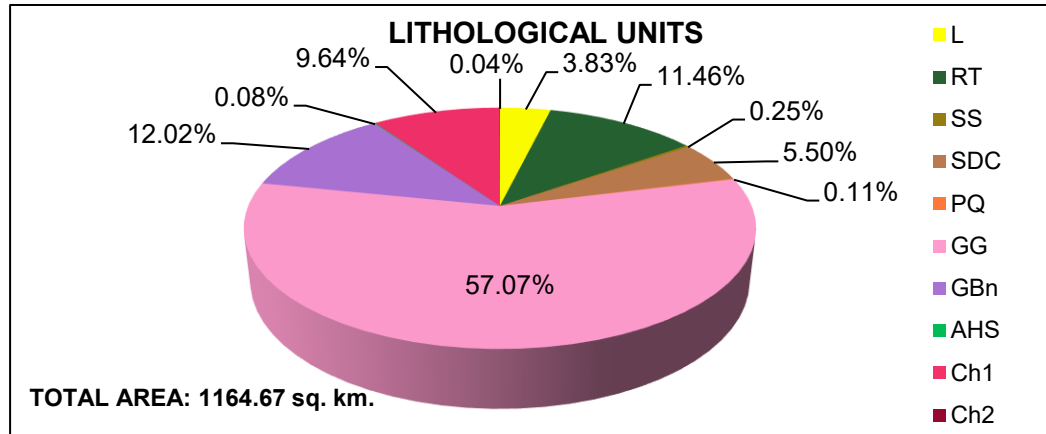


Figure 5

Source: Diagram prepared by the researcher on the basis of tabulated data

**Table 3: Composition of Rocks and Minerals in the Eastcentral Rajmahal Highlands**

Geological Formations	Rock Composition	Minerals Composition
Laterite	Laterite or Lateritic Soil	Iron, Aluminium, Kaolinite and Illite clay minerals, <u>Quartz</u> , <u>Zircon</u> , oxides of <u>Titanium</u> , <u>Tin</u> , <u>Manganese</u> ,
Rajmahal Trap	Basalt, Inter-Trappean Beds, Chert	Quartz, Pyroxene, Plagioclase, Olivine, Magnetite, Ilmenite, chalcedony-cryptocrystalline silica, very fine-grained quartz
Gondwana Super Group	Siltstone, Sand Stone, Shale, Coal, Feldspathic & Kaolin's rocks	Feldspar, Quartz, Dolomite, Mica, Kaolin, Iron, Fireclay
Chhotonagpur Granite Gneiss Complex	Granitic Rocks, Porphyritic, Pegmatite, Gneisses	Pyroxene, Garnet, Kyanite, Sillimanite, Quartz, Muscovite, Biotite, Garnet, Tourmaline, Beryl, Amphibole, Pyroxene, Garnet, Kyanite, Sillimanite,
Unclassified Metamorphic	Amphibolites, Hornblends Schist, Epidiorite	Tremolite, Actinolite, Quartz, Epidote, Garnet <i>etc.</i>
Eastern Ghat Super Group	Charnockite, Quartz-Feldspar rocks	Pyroxene, Augite, Flagioclase Feldspars, Alkali Feldspars, Quartz,

Source: Raw data obtained from Dumka District Resource Map (2009), prepared by the Geological Survey of India and compiled by the researcher

**Table 4: Geological Resources in the Eastcentral Rajmahal Highlands**

Geological Resources	Utility
<b>Basalt/ Stone Quarry</b>	Railroad ballast, aggregate in Highway construction, flooring, countertops, window sills and wall covering
<b>Granite-Gneiss</b>	Building material for counter tops and floors, roads, curbs, curling stones, grave stones, monuments, memorials
<b>Coal</b>	Fossil fuel, Plastics, Electricity, Industrial use etc.
<b>China clay</b>	Manufacturing of earthenware, tiles, pipes, bricks, glazed pottery and high-grade porcelain
<b>Lead</b>	Covering, plumbing, ammunition, manufacture of PbEt4 - an antiknock compound in petrol.
<b>Zinc</b>	Protective coating for Iron and Steel, Main alloy for Brass, Medical purposes
<b>Silver</b>	Photography (AgBr), Dental alloys, Solder and brazing alloys, Electrical contacts, High-capacity silver-zinc and silver-cadmium batteries, Silver paints are used for making printed circuits
<b>Laterite/Lateritic Soil</b>	Building stones; widely used as road metal; Architectural and Ornamental use etc.
<b>Moram/Kankar</b>	Lime and Cement making material, Road construction

Source: Raw data obtained from Dumka District Resource Map (2009), prepared by the Geological Survey of India and compiled by the researcher

## 7. Conclusion

Finally, it can be said that the geological formation provides the properties and characteristics of the surface forms. Most of the area has moderate fertile land in the study area, because of the presence of the basement rocks. Therefore, the area may be utilised through proper capability classification of terrain. The study reveals that the Eastcentral Rajmahal Highlands has a range of geological details which have relatively low to moderate potentialities for economic activities, particularly agricultural prosperity.

## Acknowledgments

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## **Financial Literacy and Financial Performance: A Study on SVSKP Beneficiaries in the District of Paschim Medinipur**

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&

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**Abstract:** *Financial literacy has been assumed as one of the key parameters required for establishing, managing and progressing of any business. The prime objective of our present study is to establish the impact of financial literacy on the financial performance of Swami Vivekananda Swanirbhar Karmasanasthan Prakalpa (SVSKP) beneficiaries in the district of Paschim Medinipur. We have considered the beneficiaries of Swami Vivekananda Swanirbhar Karmasanasthan Prakalpa (SVSKP) of the Paschim Medinipur district and who have undergone financial literacy training i.e., Rural Self Employment Training Institutes (RSETI) conducted by Allahabad bank. We have randomly selected 100 respondents who have taken 15 to 20 days training by the Institute. The collected primary data have been analyzed using SPSS Software and the significance of the results has been tested using inferential statistics. The results confirm the presence of significant strong positive relationship between financial literacy and financial performance of the trainees. From the findings, the study concludes that high scores on financial literacy among beneficiaries led to higher financial performance of their business.*

**Keywords:** *Financial literacy, financial performance, RSETI, SVSKP beneficiaries, Paschim Medinipur.*

### **Introduction**

“Without financial literacy, we cannot expect to make major headway in either financial inclusion or consumer protection” – Dr. K. C. Chakrabarty, Deputy Governor, Reserve Bank of India.

All over the world, it has been recognized that financial inclusion growth leads to overall development of the economies. Financial inclusion is trying to ensure that a range of appropriate financial services is available to every individual. In order to achieve the essence of financial inclusion, it is necessary for the financially

excluded people to have access to financial services to begin with followed by improving their financial literacy which help them in choosing most appropriate inventions that would meet their personal financial needs.

Financial literacy refers to the set of skills and knowledge that allows an individual to make effective decisions with their financial resources. Making the right decision with the financial resources is playing an important role in the business performance. Management of financial resources of a business is a very hard task to the financially illiterate individuals. Therefore, Government has taken an initiative to improve financial literacy among the small business entrepreneurs through different training program.

Financial literacy provides knowledge and understanding of financial concepts and the skills, motivation and confidence to apply such knowledge and understanding in order to make effective decisions across a range of financial contexts and to improve the financial well-being of SMEs (Hogarth, 2002). According to Miller et al (2009), facing educated, financial regulators are forced to improve the efficiency and quality of financial services.

Performance is commonly used as an indicator of a firm's financial health over a given period of time. The performance of a firm can be defined or measured in various ways. Each of these different measures captures a slightly different aspect of performance such as profitability, gauge return; others, like sales growth, market share growth, and gauge the growth of a firm.

### **Review of Literature**

**Huston (2010)** in his article titled 'Measuring Financial Literacy' pointed out that there was no universally accepted definition of financial literacy. Authors have proposed several definitions. He described financial literacy as measuring how well an individual can understand and use personal finance-related information. In addition, financial literacy includes the ability and confidence of an individual to use his/her financial knowledge to make financial decisions.

**Lusardi & Mitchell (2011)** well renowned financial literacy scholars and academicians in "Financial Literacy around the World: An Overview" highlighted the importance of financial literacy in an increasingly risky and globalized marketplace in which people must be able to make well-informed financial decisions. New international researches all around the world illustrate that financial illiteracy is widespread when financial markets are well developed and changing very fast. The study concluded that financial literacy should not be taken for granted even in those countries with well-developed financial markets. As the long-term shift continues towards individual responsibility for retirement saving, investment and dissimulation; it is significant to assess which programs best help people to make better and superior financial decisions. Lastly for financial

education programs to be effective having an impact have to target different population subgroups. To sum up, around the world financial literacy is crucial to retirement security.

**Joshi (2013)** in his research paper studied that the promotion of financial literacy in developing countries is timely and can be a win-win situation for poor people and financial service providers alike. It can help poor people to build assets and create wealth. Financial literacy skills can be applied in managing a wide range of individual, household, business, and community resources.

**Ramakrishna and Sudhakar (2015)**, in their research article titled ‘Financial Literacy Training: The Role of RUDSETIs’ tried to identify the major players or stakeholders in financial literacy education and their growing efforts in popularizing the financial services among the poor. Authors observed that the youth settled in respective areas post skill-development training at RUDSETIs/RSETIs had good knowledge of financial products compared to those making a living on self-employment in rural areas. Another observation was that the majority of the trainees established their self-employment ventures after the training at RUDSETIs/RSETIs, could record details of income and expenses due to their exposure to the same during their stay at the Institutes.

**Arora (2016)** conducted a study on ‘Assessment of Financial Literacy among Working Indian Women’ aimed to assess the financial literacy level among the Indian women. The study was based on 444 working women of urban areas of Rajasthan. Three parameters i.e., financial knowledge, financial behaviour and financial attitude were used to assess the level of financial literacy and found that the general awareness about financial planning tools and techniques among women remains poor. The study concluded that women are better in terms of financial attitude and behaviour as compared to financial knowledge.

**Dube and Asthana (2017)** in their article titled ‘A Comparative Study on Financial Literacy of Uttar Pradesh with Central Zone States in India’ tried to find out the financial literacy in Uttar Pradesh in pre financial inclusion scenario and to make a comparison of financial literacy level of Uttar Pradesh with other states in the Central Zone. Study provided the overview of the important constituents of financial literacy and the role of financial literacy in Indian context. In the study, they concluded with some findings those are the financial literacy level in Uttar Pradesh was half of the financial literacy level in India and less than the Central Zone financial literacy level. They also found that the financial literacy in terms of financial attitude, financial behaviour and financial knowledge of Uttar Pradesh stood third, fourth, and third respectively out of four states in the Central Zone.

**Research Gap**

In rural India, most of the people are financially illiterate and unable to take deliberate financial decision at the right time. Consequently, their financial performance is not sound. They require various types of training concerning to financial literacy. A very few research works have been conducted so far in order to investigate the relation between financial literacy and financial performance. On the basis of existing research gap, we have identified the following objectives in our present study.

**Objectives of the Study**

The focal objectives of the study are:

1. To highlight the role of Rural Self Employment Training Institutes (RSETI) on financial literacy of beneficiaries under different Prakalpa like SVSKP located in Paschim Medinipur district;
2. To analyze the impact of financial literacy on performance of small business owned by these different beneficiaries.

**Hypothesis of the Study**

**H<sub>0</sub>:** There is no impact of financial literacy on performance of small business owned by these different beneficiaries.

**H<sub>1</sub>:** There is impact of financial literacy on performance of small business owned by these different beneficiaries.

**Research Methodology**

**Data Collection:** The current study is based on the data collected from the primary sources. The data on financial literacy is collected from RSETI Institutes organized by Allahabad bank and data on business performance collected directly from respondents who have been trained from these institutes.

**Locale:** The study has been conducted in the sub-urban and rural areas of Paschim Medinipur district of West Bengal. We have taken respondents who have taken training from RSETI Institutes organized by Allahabad bank.

**Sample Size:** A total 100 sample units have been taken into consideration. Among them, 50 respondents were taken from the beneficiary of SVSKP and remaining respondents were taken from other different schemes.

**Analytical Tools and Techniques:** As per the nature of the data, descriptive analysis, correlation analysis and simple regression have been used through SPSS to measure the impact of financial literacy on business performance.

### Analysis and Interpretation

In the present study, we have taken the result score of an examination on financial literacy which is taken by the institution. With this result, we have measured the financial literacy among the beneficiaries. Performance is measured by scoring the answers to three questions that are aimed to determine the level of business's performance. The answer of the questions is scored by using likert five-point scale where 1 means strongly disagree, 2 means disagree, 3 means average, 4 means agree and 5 means strongly agree.

### Descriptive Analysis

In this analysis, we have described the basic features of the data by simple summaries about the sample and the measures.

**Table 1: Descriptive Statistics**

	N	Range	Minimum	Maximum	Sum	Mean	Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic
Financial Literacy	100	23.00	.00	23.00	1277.00	12.7700	.50229	25.229
Sales Growth	100	4.00	1.00	5.00	338.00	3.3800	.08851	.783
Revenue Growth	100	4.00	1.00	5.00	344.00	3.4400	.09025	.815
Profit Growth	100	4.00	1.00	5.00	340.00	3.4000	.08409	.707
Performance	100	12.00	3.00	15.00	1022.00	10.2200	.25008	6.254
Valid N (listwise)	100							

The total number of respondents was 100 with a minimum score for financial literacy and performance as 0 and 3 respectively while maximum score for financial literacy being 23 and performance 15. Average mean score was 12.77 for financial literacy and 10.22 for business's performance.

### Correlation Analysis

In this analysis, we ascertain the extent to which changes in business's performance is associated with changes in financial literacy. To compute the strength of the relations between the variables, the study used Karl Pearson's coefficient of correlation.

**Table 2: Correlations**

	Financial Literacy	Sales Growth	Revenue Growth	Profit Growth	Performance
Financial Literacy	1	.729** .000	.626** .000	.718** .000	.725** .000
Sales Growth	.729** .000	1	.876** .000	.907** .000	.975** .000
Revenue Growth	.626** .000	.876** .000	1	.791** .000	.937** .000
Profit Growth	.718** .000	.907** .000	.791** .000	1	.942** .000
Performance	.725** .000	.975** .000	.937** .000	.942** .000	1

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

Results from table 2 above reveals that there is a significant positive relation between financial literacy and business performance ( $r = 0.725$ , P-value  $< 0.01$ ). The correlation also shows that financial literacy is strongly correlated with the three variables i.e., sales growth, revenue growth and profit growth which measure the ultimate performance of a business. The maximum correlation is 0.729 between financial literacy and sales growth which implies that there is the highest positive association with sales growth and literacy. The minimum correlation is 0.626 between the financial literacy and revenue growth. This implies that there is the lowest but strongly positive association between the revenue and literacy.

### Regression Analysis

Regression analysis is the statistical technique that identifies the relations between two or more quantitative variables: a dependent variable, whose value is to be predicted, and an independent or explanatory variable (or variables), about which knowledge is available. The technique is used to find the equation that represents the relations among the variables.

The study adopted simple regression guided by the following model:

$$Y = \beta_0 + \beta_1 X_1 + E$$

Where,

Y= Business performance of the beneficiaries (measured in sales growth, revenue growth, and profit growth)

$X_1$  = Financial literacy (measured by examination score on financial literacy)

$\beta_1$  = coefficient,

$\beta_0$  = Constant term and E = Error term in the equation.

**Table 3: Model Summary**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.725 <sup>a</sup>	.526	.521	1.73021

a. Predictors: (Constant), Financial Literacy

Table 3 provides the value of R (.725) which represents the simple correlation between financial literacy and performance. It indicates a higher degree of correlation. Table 3 also provides the value of  $R^2$  which indicates the explanatory power of independent variable. From the value of  $R^2$ , we can say that 52.6% fluctuation of performance can be explained by the financial literacy. The value of unexplained part is 48.40 %. Thus, further research should be conducted to investigate the other independent variables having the impact on financial performance.

**Table 4: ANOVA**

Model	Sum of Squares	df	Mean Square	F	Sig.
1 Regression	325.783	1	325.783	108.825	.000 <sup>b</sup>
Residual	293.377	98	2.994		
Total	619.160	99			

a. Dependent Variable: Performance

b. Predictors: (Constant), Financial Literacy

Table 4 indicates that the regression model predicts the outcome variable significantly well and good as the p value is less than 0.05. Therefore, the model will significantly predict the outcome variable.

**Table 5: Coefficients**

Model	Un-standardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	5.608	.475		11.813	.000
Financial Literacy	.361	.035	.725	10.432	.000



#### a. Dependent Variable: Performance

The table 5 represents the results of the simple linear regression showing the impact of financial literacy on performance. We can see that both the constant and financial literacy contribute significantly to the model by looking at the Sig. column.

We can derive a simple regression equation from the above table. The equation is as follows: **Performance = 5.608 + 0.725 financial literacy + 0.035**

#### Conclusions

This study concludes that the RSETI training program would give trainees the opportunity of having a greater number of practice hours on the chosen skills during the scheduled classroom hours. Besides focusing on personality development of the trainees, the training imparted on fundamentals of banking and accounting which include the important elements of financial literacy as discussed earlier in this document encourage the trainees to develop their own small business enterprises in their respective areas soon after the training. Thus, the financial literacy training element of the RSETI is playing an important role in enabling the trained beneficiaries to convert themselves into a demographic dividend and establish self-employment ventures with confidence and competence which contributes to inclusive growth in the society in a steady manner.

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## A Comparative Study of Oxidation of Alcohol to Aldehyde by IBX with Some Other Oxidizing Agents and Conversion of the Aldehyde to Quinazoline and Dihydroquinazoline Derivatives

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**Abstract:** 2-Iodoxybenzoic acid (IBX, **1**) is known to be an oxidizing agent for the conversion of alcohol to aldehyde<sup>2</sup>. We studied the oxidation of alcohol (**2a - e**) with different oxidizing conditions e.g., IBX, PCC, Swern Oxidation, Dess and bromine/water, NMO/TPAP, NaOCl (**Scheme 1**). It was found out that IBX is the best oxidizing agent with respect to yield, ease of reaction, ease of isolation of products and rate of oxidation to aldehyde. The aldehyde was converted to N-alkyl-hydro-quinazoline-4-ol (**5 - 13**) and quinazoline derivatives (**4 a - e**) by its reaction with amine (**Scheme 2**).

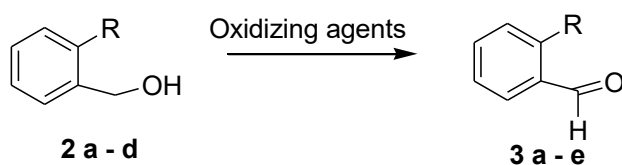
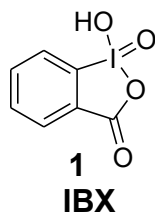
**Keywords:** Oxidation, IBX, alcohol, aldehyde, N-alkyl-hydro quinazoline-4-ol, quinazoline

Abbreviation : (2-Iodoxybenzoic acid) IBX, (Pyridinium chlorochromate) PCC, N-Methylmorpholine-N-Oxide (NMO), Tetrapropylammonium Perruthenate (TPAP)

### 1. Content and Result

Oxidation of alcohol to aldehyde is one of the widely used process in synthetic organic chemistry. It is known to be useful in organic total synthesis of drugs and natural products. Various methods are used to achieve this conversion. IBX, TPAP/NMO, PCC, Swern Oxidation, Dess Martin Periodinane and bromine/water, NMO/TPAP, NaOCl [1] are among few of these.

For the synthesis of few biologically important compounds, we need to use one oxidizing agent to oxidize alcohol to aldehyde. For this purpose, we carried out oxidation of few compounds (**2 a – d**) against different oxidizing agent. We found out IBX [2, 3, 4] (o-iodoxy benzoic acid, **1**) is the best oxidizing agent with respect to the yield, ease of reaction etc. A detailed study is needed for this conclusion. A preliminary result of study is given in the following **Scheme 1** and **Table 1**.



**Scheme 1**

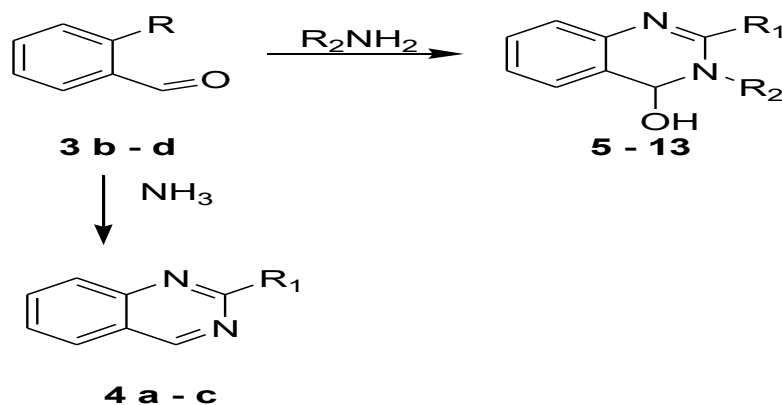
**Oxidizing agents used were IBX, bromine/water, DMSO/triethylamine, PCC, NMO/TPAP, NaOCl.**

Oxidising agents	R = NH <sub>2</sub> 3 a	R = NHCHO 3 b	R = NHCOCH <sub>3</sub> 3 c	R = NHCOC <sub>2</sub> H <sub>5</sub> 3 d
IBX	100 %	100 %	100 %	100 %
Bromine/water	42 %	51 %	48 %	55 %
DMSO/Triethylamine/DCM	46 %	76 %	80 %	78 %
PCC	50 %	67 %	68 %	66 %
NMO/TPAP	78 %	70 %	61 %	62 %
NaOCl	20 %	33 %	25 %	40 %

**Table 1 (Yields of aldehyde by different oxidizing reagents\*).**

The other factors like time of reactions, ease of reactions and ease of work up & purification are also favorable for IBX which is shown in **Experimental** section of this report.

The product aldehydes (**3b – d**) were converted to N-alkyl-hydro quinazoline and quinazoline derivatives (**5 – 13** and **4 a – c**) following **Scheme 2**.



**Scheme 2**

	$R_1$ (5 – 7)	$R_2$ (8 – 10)	$R_3$ (11 – 13)
$R_2 = CH_3$	H	$CH_3$	$C_2H_5$
$R_2 = C_2H_5$	H	$CH_3$	$C_2H_5$
$R_2 = C_3H_7$	H	$CH_3$	$C_2H_5$

**Table 2: Different products of dihydro-quinazoline-4-ol derivatives (5 – 13)**

For quinazoline (**4 a – c**) derivatives  $R_1$  are methyl, ethyl and propyl groups.

The quinazoline and dihydro-quinazoline-4-ol derivatives (**4 a – c** and **5 – 13**) are also important precursors for various biologically important drugs.

## 2. Experimental

### 2.1 Oxidation of alcohol to aldehyde (Compounds **2 a – d** to **3 – d**):

**Oxidation by Bromine/water:** To a suspension of the alcohols (1 mmol) in 5 mL water, bromine (1 mmol) was added. The reaction mixture was stirred for 6 h. at room temperature. The product aldehydes were extracted by ethyl acetate. The crude product was purified by silica gel.

**Oxidation by pyridiniumchlorochromate (PCC):** To a solution of the alcohols (1 mmol) in dry dichloromethane (10 mL), PCC (1.2 mmol) was added and the reaction mixture was stirred for 6 h. The solid was filtered out washing with DCM and DCM was evaporated out. The crude product was purified by silica gel column chromatography.

**Oxidation by DMSO/Triethylamine (Swern oxidation):** Dry DMSO (1 mmol) and triethylamine (1.2 mmol) was added to dry dichloromethane (5 mL) at  $-78^{\circ}\text{C}$ . and the reaction mixture was stirred for 30 mins. To this the alcohols (1 mmol) in dry DCM (5 mL) was added at  $-78^{\circ}\text{C}$ . and the reaction mixture was stirred for another 1 h. The reaction mixture was stirred and allowed to come to room temperature slowly for another 1 h. The reaction mixture was washed with water and dichloromethane was evaporated out. The crude product was purified by silica gel column chromatography.

**Oxidation of by NMO/TPAP:** A solution of the alcohol (1 mmol) in acetonitrile (5 mL) is stirred with 1 mmol of NMO and 0.01 mmol of TPAP for 6 to 8 hr. The solvent was evaporated and the product aldehydes were isolated by silica gel column chromatography.

**Oxidation of by NaOCl:** A suspension of the alcohols in water was added sodium hypochlorite and the reaction mixture was stirred for 30 h. The product aldehydes were isolated by separation with ethyl acetate and ethyl acetate was evaporated out. The products were isolated by silica gel column chromatography.

**Oxidation by IBX (*o*-iodoxy benzoic acid, 1):** To a solution of the compound (1 mmol) in ethyl acetate (10 mL) IBX (2 mmol) was added and the mixture was heated at reflux for 1.5 h. The solid was filtered out and the pure product was isolated by evaporating out the solvent ethyl acetate.

**2.2 Synthesis of quinazoline and N-alkyl-hydro-quinazoline-4-ol (4 a - c) and derivatives (5 – 13):** A mixture of the aldehydes (3 b – d) was heated at reflux with the suitable amine for 3 to 7 h. The solvent was evaporated out and the products were isolated by silica gel column chromatography.

**N.B.** - The product formation was authenticated by TLC with known compounds and few were characterized by  $^1\text{H}$  NMR.

### 3. Discussion

From the above content it is found out that IBX is the most effective reagent with respect to other oxidizing agents. The advantage of using IBX as oxidizing agent is advantageous with other oxidizing agents are the following:

- (1) IBX reaction is very simple. The don't need low or very high temperature. They only need a refluxing temperature of ethyl acetate.
- (2) Isolation of product is very simple. They can be isolated just by filtration. With other oxidizing agents the isolation needs an extensive work and extraction.
- (3) The product coming out after IBX oxidation and filtration is pure enough as shown in HPLC\*\* (in all the cases it is around 99 %). But other reaction condition needs purification by silica gel column chromatography.
- (4) IBX can be re-cycled just after simple reoxidation of the solid isolated by filtration\*\*\*.

### 4. Conclusion

From the above observation we can conclude that IBX is a very potential and useful catalyst for the oxidation of alcohol to aldehyde. It has better efficacy than few other known oxidizing agents when studied with our molecule of interest. Another important factor is that IBX can be recycled and can be used repeatedly with almost similar efficacy after certain simple chemical treatment and thus it is cost effective. The products were converted to important drug precursors to N-alkyl-hydro-quinazoline-4-ol and quinazoline derivatives by its reaction with amine

Notes: \* Isolated yields.

\*\* Incorporation of HPLC result would have made the write up lengthier and also may not be very important for the outcome of the current work. So, the result is not incorporated with this write up.

\*\*\* One of the reviewers asked about the result of re-oxidation with re-cycled IBX. In all the cases the result is same as that of the result shown here. Indeed, the time of reaction is smaller than that of original one. Otherwise, the oxidation is faster with re – cyclized IBX.

### Acknowledgement

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## **Representation of Nation and Nationalism in Rabindranath Tagore's *Gora*: A Study in the Perspective of the Present 'Crisis of Civilization'**

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**Abstract:** Discussion on nation and nationalism has become a burning issue in the contemporary context of civil unrest, violence, disaster and terrorism across the world. A multi-ethnic country like India has always suffered from the curse of caste and gender discrimination. Tagore's concept of nationalism based on cultural-spiritual synthesis and universal peace can be a panacea to the present disease of intolerance and aggression. Tagore's epoch-making novel *Gora* (1910) records his views on nationalism, patriotism, imperialism, religious and political conflicts and finally conveys the message of universal humanism. The novel captures the political and religious conflict between Hinduism and Brahmoism in pre-Independence India which further reflects on the conflict between tradition and modernization. It deals with various issues related to religion, class, caste and gender which complicate the question of nation and identity in the colonial context. The novel is a powerful critique of narrow religious fanaticism. Tagore, a firm believer of spiritual and humanitarian values, opines that true freedom lies not in narrow religious fanaticism but in the ideals of humanism. His view of assimilation, harmony and reconciliation is represented by the eponymous hero of his novel. This paper intends to focus on how *Gora*, a novel of the colonial period of India still enjoys its relevance in our contemporary days when disintegration, sectarianism and ultra-nationalism have posed serious threats to the peace and progress not only of the Indian subcontinent but also the entire world.

**Keywords:** *disintegration, humanism, nation, nationalism, religious and political conflicts*

Discourse on nation and nationalism has become highly relevant in the present-day context of civil unrest, violence, segregation and terrorism across the world. Nationalism, nativism, crisis of identity and location have become burning issues in every continent. In India, the issue of nationalism and identity should be re-explored in the present moment of unrest generated by NRC and CAA. The



anxiety, chaos and calamity which follow these matters remind us of the prophetic utterance of Tagore in one of his brilliant poems, “The Sunset of the Century”:

THE LAST SUN of the century sets amidst the blood-red clouds of  
the West and

the whirlwind of hatred.

The naked passion of self-love of Nations, in its drunken delirium  
of greed, is

dancing to the clash of steel and the howling verses of  
vengeance. (Das 466)

Tagore’s concept of nationalism based on the deep understanding of the tradition with a humanistic insight can be a panacea to the contemporary disease of violence and unrest.

The term ‘nationalism’ is difficult to define in a single bottom line proposition because the implications of the same term change in relation to the respective contexts of its application. For instance, ‘nationalism’ in the imperial context is not the same as it is in the context of the colonized. Generally, the term ‘nation’ is applied to the population of a state; but how that people conceptualize the idea of ‘nation’ is subject to a search for roots and identity and a constant need of differentiation. History has shown that both the processes are moved by a sense of identity, social cohesion, survival, superiority and, ultimately, an urge for autonomy and self-determination. Nationalism thus can have complex implications in relation to the decolonization process, and it can be essentially different from what is envisioned in the imperialist discourse. It is this essential difference between nationalism in the West and nationalism in the East, which gets foregrounded in such typical Kiplingesque clichés as “East is East, and West is West, and never the twain shall meet”, especially when we compare them with Tagore’s vision of nationalism. Western imperialist discourse had reduced the nationalist discourses of the erstwhile colonies to a ‘derivative discourse’ which was supposed to be dependent on the models and language gained from the colonial ruler. But this is a

misrepresentation of the nationalist discourse of the East. In the East, specifically in the colonies, nationalist sensibility was initially an answer to the imperialist assumptions, and hence a loaded term related to the political, social and cultural issues of a nation and its community. In the colonial context, the nationalist feelings got manifested through various patriotic ideas and activities in the society, which found articulation in the nation's literature and arts as well.

In India, during the colonial era, a rising political consciousness among the native Indian social elite boosted an Indian identity and fed a growing nationalist sentiment in the last decades of the nineteenth century. The proposed 1905 partition of Bengal escalated the growing unrest, stimulating radical nationalist sentiments and becoming a driving force for Indian freedom fighters of all shades. Rabindranath Tagore's concept of nationalism can be seen in this context; but at the same time, we should note that it is related to cultural-spiritual values and social service rather than extremist political activism opposing the bifurcation of Bengal. Tagore is strongly critical of any extremist, sectarian, violent, divisive and intolerant politics. He rejects any kind of narrow exclusivist aggressive nationalism which is modelled upon the Kiplingesque / Western paradigm. He has formulated his concept of nationalism from traditional Indian values which hold up the ideal of unity and focus on inner peace and spiritual freedom that bind mankind together. That is why he finds the Western paradigm of 'nationalism' inadequate. In his essay "Nationalism in the West" Tagore defines nation: "A nation, in the sense of the political and economic union of a people, is that aspect which a whole population assumes when organized for a mechanical purpose" (Das 421). Tagore is critical of this mechanical aspect of Western nationalism. In this context, he emphasizes the "spontaneous self-expression of man as a social being". He envisions a society where human beings can develop "ideals of life in cooperation with one another." Comparing Indian nationalism with the Western nationalism Tagore clarifies that "our difficulties being internal, our history has been the history of continual social adjustment and not that of organized power for defence and aggression" (Das 419). He further explains, "Neither the colourless vagueness of cosmopolitanism, nor the fierce self-idolatry of nation-worship is the goal of human history. And India has been trying to accomplish her task through social regulation of differences, on the

one hand, and the spiritual recognition of unity, on the other (Das 419).” However, Tagore is also painfully aware of the social injustice in the form of caste barriers and ‘sins’ which have “crippled her children’s minds and narrowed their lives in order to fit them into her social forms (Das 419).” But still he is hopeful at noting that “for centuries new experiments have been made and adjustments carried out” (Das 419). Tagore’s concept of nationalism is assimilative and not exclusivist. This idea of assimilation is reflected in his famous poem “Bharattirtha”:

*Hethay Arya, hetha Anarya, hethay Dravid, Chin—*

*Shak-Hun-dol Pathan Mugal ek dehe holo leen.*

*Paschime aj khuliache dwar, setha hote sobe aane upohar,*

*Dibe r nibe, milabe milibe, jabe na phire—*

*Ei Bharater mahamanaber sagarteere. (Tagore 507)*

[“Here came the Aryans, the non-Aryans, here came the Dravidians,  
the Chinese—

The Saks, the Huns, the Pathans, the Mughals—and all got merged  
into one body...

The West opens out its doors today, to offer gifts and receive, and  
won’t be

Turned away from this great ocean of humanity.”

(Trans. Kundu 254-55)]

This same spirit of assimilation and unity amidst diversity is echoed in Tagore’s essay “Nationalism in India”: “In spite of our great difficulty, however, India has done something. She has tried to make an adjustment of races, to acknowledge the real differences between them where these exist, and yet seek for some basis of unity. This basis has come through our saints, like Nanak, Kabir, Chaitanya and others, preaching one God to all races of India” (Das 453).

Tagore has recorded his views on nationalism in many of his critical essays, poems, songs, novels and other writings. His epoch-making novel *Gora* (1910) captures his theoretical and ideological views regarding nationalism, patriotism, imperialism, religious and political conflicts of the day and finally conveys the message of universal humanism. As Asit Bandopadhyaya observes: “*Gora* is not only an epoch-making novel of modern Indian literature; it is certainly comparable with any epic novel of Europe in shape and size, in treatment and in execution. *Gora* has an epic dimension, it contains, in essence, the crisis of the whole nation” (qtd. in Kundu 250). Indeed, *Gora* captures the spirit of its age.

From the internal evidence of the text, we come to know that Gora, the hero of the novel, was born at the time of the Sepoy Mutiny (1857), and the time frame of action may be located roughly around 1880 (Gora had just completed his university education when the novel begins). Thus, by calendar, the hero is four years senior to his creator Rabindranath Tagore (b. 1861). The novel captures the political and religious conflict between Hinduism and Brahmoism in pre-Independence India. Meenakshi Mukherjee in her Introduction to the Sahitya Akademi translated edition of *Gora* (1997) observes that the text is “situated within the larger conflict between modernization and the Hindu tradition—inevitable in a British-occupied India where the educated class was simultaneously going through an exhilarating exposure to new intellectual horizons through English education and the humiliating experience of political subjugation...” (ix). The wide spectrum of the novel forbids the readers to categorize it simply as a political, sociological or psychological novel. It deals with various issues related to religion, class, caste and gender which complicate the question of nation and identity.

In the novel, Hinduism is represented by a range of varied characters like Gora’s foster parents Krishnadayal and Anandamoyi, Sucharita’s aunt Harimohini, Gora’s friend Binoy and his staunch follower Abinash. The ethos of the Brahmo Samaj is represented by Poresch Babu, his wife Baradasundari, Sucharita and Haran Babu. Barring a few characters like Abinash and Haran Babu whose religious faith remain static, all the major characters in the novel eventually undergo changes in their views regarding religion through mutual interaction. Gora, like other English-

educated young men of his generation, was initially drawn towards the reformist impulse of the Brahmo Samaj which attempted to purge Hinduism of its elaborate rituals, customs, caste hierarchy and idol worship. The narrator records that Gora was particularly drawn towards the Brahmo Samaj for being influenced by Keshab Chandra Sen's eloquence. At that time, he revolted against his foster father Krishnadayal's (Gora was not aware of his true identity then) observance of excessive religious purism. Later his discussions on Vedantic philosophy with the great scholar Harachandra Vidyabagish brought some changes in him. When a British missionary wrote an article in the newspaper attacking the Hindu community and its ancient texts, Gora flared up in rage. He himself used to criticize the *shastras* and customs of Hinduism but it was impossible for him to tolerate that his religion had been denigrated by foreigners. During his exchanges with the British adversary, Gora clearly states:

We shall not allow our country to stand in the dock like an accused person and be judged in a foreign law-court and according to alien laws. We shall neither feel ashamed nor elated by finding equivalences after detailed scrutiny of western ideals. We shall not in the least feel apologetic to others or to ourselves for any custom, belief, scripture or community which belongs to the country of our birth. Whatever is ours, we shall uphold proudly and forcefully to protect our country and ourselves from all humiliation. (28)

Gora switches over to Hinduism not for religion's sake but for his idea of a united nation. He wants to restore his country to its ancient glory and tradition, and envision it as such. He rigorously follows the customs and rituals of Hinduism in search of his roots. In a way, Gora illustrates the impact of a nascent cultural nationalism which would manifest in the early decades of the twentieth century. In this context, Rama Kundu in her article "*Gora: An Early Nationalist Answer to Imperialist Assumptions*" comments: "... Rabindranath Tagore's consistent, profound and lifelong exploration of the two issues—i.e., religion and nationalism—which necessarily got intersected during those days of newly-awakened cultural nationalism, found reflection in his novel" (251). Gora's

propagation of Hindu rituals and customs is a strong assertion of cultural superiority over the British and a sharp reminder to the westernized natives of his country belonging to the 'bhadralok' class. In his conversation with Sucharita, Binoy remarks about Gora's religious faith vis-à-vis patriotism: "Gora is able to accept everything of the Hindu community without reservation because he is viewing Bharatvarsha from some grand elevation. To him the small and the large have merged as in some great song and appear to him as parts of a whole" (41). Tagore's view of assimilation, harmony and reconciliation is represented by the eponymous hero of his novel.

To understand Gora's views on nation and nationalism, we have to reflect on his creator's own views on the issues. Like many politically conscious elites of his own times, Tagore was deeply impressed by the first wave of the *Swadeshi* movement. Especially Lord Curzon's proposed partition of Bengal in 1905 generated a strong protest among the educated young men of Bengal and gave vent to a high patriotic zeal. Tagore became actively involved in this anti-partition movement through his brilliant and reflective writings. Gora's patriotic zeal is manifest in his conversation with his friend Binoy: "When the captain of a ship is out on the high seas, whether he is working or resting, eating or relaxing, he always keeps in mind the port across the sea. Bharat is always present in my mind in the same way" (21), and not as it was represented in the British "History of India". His rigorous observance of the rituals and customs of Hindu religion which sometimes appears to be religious bigotry is actually a strong protest against the disparagement of his country's ancient culture. His protest is directed not so much at the British but at his westernized countrymen blindly imitating the foreign culture.

Another aspect of Gora's conception of nationalism is represented in his keen desire to connect with the masses. In his intense search for the 'real' India, he visits different parts of rural Bengal and meets the common men at close quarters. He observes the predicament of the poor and realizes that upliftment of this stratum of the society would bring true freedom. The unfair treatment which the villagers of Char-Ghosh Para receive from a British magistrate help Gora to realize—"...what our country was like outside the cultured and affluent segments of Kolikata

society. How isolated, narrow-minded, weak—how completely unaware of its own strength, ignorant of and indifferent to its welfare was this vast and isolated rural Bharatvarsha!” (170). This same concern for the humiliated, ignored, downtrodden mass is echoed in Tagore’s remarkable poem “Ebar Phirao More”:

*...oi je danraye notoshir*

*Muk sobe, mlanmukhe lekha sudhu shoto shatabdir*

*Bedonar korun kahini...*

.....

*...ei-sob murho mlan muk mukhe*

*Dite hobe bhasa; ei-sob shranto shusko vogno buke*

*Dhwaniya tulite hobe asha... (Tagore 219-20)*

[“There they are, with bent head

Speechless, carrying the story of millenia’s suffering scribed

.....

...to restore voice to these dumb dry benumbed lips;

To resonate with hope these tired, withered broken hearts...

(Trans. Kundu 257-58)]

In the course of the novel Gora gradually realizes that true freedom lies not in narrow parochialism, political or religious, but in the ideals of humanism. Undergoing various troubles and turmoil Gora understands the real predicament of his country torn apart by the curse of caste system and different religious beliefs. Analyzing the rituals and customs of both Brahmoism and Hinduism Gora finally reaches the conclusion:

The endless one manifests itself in the endless many—this is what I see in the

world. That is why there are many religious beliefs, following various methods to make us understand the god of all religions. I can assure you that if you were to look out of Bharat's open window at the sky, you would see the sun. There is no need for us to cross the seas and sit at the window of a Christian church. (135)

Gora's journey from communalism, sectarianism, religious conservatism to the ideals of humanism reflects India's longed-for vision of human unity.

Gora's view on women vis-à-vis nation deserves attention in this discussion. Initially Gora had a strong reservation about women and he refuted Binoy's opinion when the latter tried to persuade him that it was a serious shortcoming to exclude women in the context of nation. Till then Gora conceived women as belonging to the domestic space and quite incapable of entering the outer world. But his restrictive attitude starts changing under the influence of Sucharita. He gradually realizes how his perception of nation is incomplete until he acknowledges the role of women in it. In his imagination Sucharita becomes the icon of 'womanhood in Bharat':

In her image was made manifest to him the whole nature of womanhood in

Bharat. This image would invest every home in the country with grace, affection and purity. She was the goddess who nourished the children of Bharatvarsha, tended the sick, consoled the miserable—She whose love redeemed the meanest of men, she who never abandoned even the most wretched among us to our misfortune.... (330)

Under the influence of Sucharita, Góra's extremist views get mellowed and he realizes that service to his motherland would not be sanctified without the active participation of women in it.

When ultimately Gora comes to know about his biological identity, i.e., he was the son of an Irishman, orphaned during the Sepoy mutiny—the discovery at



once releases him from his erstwhile aggressive confusion. He is liberated from his narrow religious bias and arrives at a new perception of the essence of Indian 'nationality'—"Today I am Bharatiya. Within me there is no conflict between communities, whether Hindu or Muslim or Krishtan. Today all the castes of Bharat are my caste ..." (475). The revelation of his true identity helps Gora to detach himself from all religious observations and dedicate his life to the service of his motherland. His identity frees him of all bondages relating to caste and religion and paves his way towards the realization of universal humanism. Just after the revelation he goes to Poresh Babu, the icon of liberal thought in the novel, and earnestly requests him to make him his disciple—"Teach me the mantra of that deity who belongs to all—Hindu, Musalman, Khrishtan, Brahmo—the doors of whose temple are never closed to any person of any caste or race—the deity not only of Hindus but of Bharatvarsha" (476). This is Gora's true initiation to religion—the religion being universal humanism. Analysing the novel, Krishna Kripalani comments: "No other book can claim so masterly an analysis of the Bengali intelligentsia of the period, with their divided loyalties, their aspirations and inhibitions, or of the character of Indian nationalism which draws its roots from renascent Hinduism and stretches out its arms towards universal humanism" (qtd. in Kundu 265).

In an epiphanic moment Gora realizes that the true incarnation of this universal humanism is his foster-mother Anandamoyi. At the end of the novel, after the disclosure of his biological identity, Gora kneels down before this mother figure and cries impassionately—"Ma, you are my only mother. The mother for whom I have looked everywhere—all this time she was sitting in my house. You have no caste, you do not discriminate against people, you do not hate—you are the image of benediction. You are my Bharatvarsha" (477). This vision removes all conflicts, doubts, reservations regarding caste, religion, customs and rituals from Gora's mind and he is on the verge of undertaking a new journey to liberate his motherland from colonial rule and uplift the socially subjugated people of his country. Tagore's thoughts, ideas, and vision of 'Bharatbarsha' is concretized into the benign figure of Anandamoyi—the all-forgiving, all-loving mother. In this context, Rama Kundu observes: "Anandamoyee is the beautiful microcosmic representation of that

macrocosmic India of Tagore's vision, at whose feet the 'great ocean of humanity' can gather, because she can reach out to, and embrace all religions and nationalities through her all-absorbing love" (259). Gora's final realization of the motherland incarnated in the mother / woman figure makes him a true enlightened and emancipated man in the midst of the patriarchal chauvinists of pre-colonial India.

Tagore was the votary of transcendental universalism and humanism. He was strongly critical of all kinds of narrow parochialism and chauvinism. He moved beyond the narrow political perimeters of the Western concept of 'nationalism' and conceived of a kind of cultural and humanistic synthesis, a mutual interaction of all the people of the land. In this context, Himadri Lahiri in his essay "Tagore's Asianist Discourse: Reception and Resistance" observes: "His [Tagore's] concepts of nationalism and internationalism, of the East and the West, of the Orient and the Occident were parts of the network of his thoughts that formed his overall universalist outlook" (26). *Gora* captures Tagore's view of wholeness, unity and assimilation in the context of nationalism. In his frantic search for the 'real' Bharatvarsha, Gora realizes that true liberation of the self as well as the nation lies in sacrifice, tolerance and all-embracing love. This novel of the colonial period of India still enjoys its relevance in our contemporary days when disintegration, sectarianism and ultra-nationalism have posed serious threats to the peace and progress not only of the Indian subcontinent but also the entire world. In this evil day of humanity, Tagore's approach to nationalism based on assimilation and cultural-humanistic synthesis can still offer us the 'kindly light' amidst a gathering darkness. In conclusion, we should give voice to the famous utterance of the poet-prophet Tagore:

Keep watch, India.

Bring your offerings of worship for that sacred sunrise.

Let the first hymn of its welcome sound in your voice, and sing,

'Come, Peace, thou daughter of God's own great suffering.

Come with thy treasure of contentment, the sword of fortitude,

And meekness crowning thy forehead.' ("The Sunset of the Century", Das 466)

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## Hindu Pilgrimage to the Himalayas: Kalelkar to Sadhguru

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**Abstract:** This article studies Himalayan pilgrimages chronicled in travelogues, journals and memoirs by Hindu visionaries from the Gandhian nationalist Dattatreya Balkrishna Kalelkar to the contemporary mystic and spiritualist Sadhguru. It begins with Kalelkar's *The Himālaya* where the Himalayan pilgrimage has been used as a vehicle to travel the vast landscape of Indian myth, history and culture. In fact, Kalelkar was in quest of his nationalism in which the Hindu conception of mystical militarism has been a key factor. The article concludes with reference to Sadhguru's *Himalayan Lust* (2010) that relates his spiritual encounters while accompanying a group of Isha meditators who sets out on a tour of the Himalayas every year. Between Kalelkar and Sadhguru, there are several Hindu authors who have recounted their pilgrimages to the Himalayas in their writings. Among them, Hindi poet and writer Mahadevi Varma's *A Pilgrimage to the Himalayas* and Swami Satchidananda's *Kailash Journal* have received considerable attention here. The article explores Hindu pilgrimages to the Himalayas over the last one hundred years from an anthropological perspective. Furthermore, it examines such pilgrim behavior as rare mystical experiences, self-sacrifice and peer desertion from the perspective of medical and psychological anthropology.

**Keywords:** History, myth, moksha, "mystical nationalism," female pilgrimage, salvific suicide

## 1. Introduction

The earliest explicit reference to Hindu pilgrimage to the Himalayas is found in the Indian epic *Mahabharata* (c.300 BCE–300 CE). Mahaprasthanika Parva<sup>1</sup> in it describes the journey of Draupadi and the Pandavas across India, then in the Himalayas towards Mt. Sumeru. In fact, recorded accounts of pilgrimage, in the Indian subcontinent, itself came into view after the advent of modern education in the 19<sup>th</sup> century. An early record of Himalayan journey by a Hindu writer is Devendranath Tagore's autobiography (posthumously published in Bengali in 1905) that touches upon his travels in the Himalayas around Shimla between 1856 and 1858. A practicing monotheist and intellectual from 19<sup>th</sup> century Bengal, Tagore (1914, 253) saw the Himalayas as "the holy land of Brahma," but his was not a Hindu pilgrimage proper. Perhaps the first full-length account of Hindu pilgrimage to the Himalayas is the Gandhian nationalist Dattatreya Balkrishna Kalelkar's Gujarati classic *Himalayano Pravas* (1924). In recent years there is a flood of such books on Himalayan journeys undertaken by the so-called Hindu seers or mystics including Sadhguru. This article reviews Himalayan pilgrimages documented in travelogues, journals and memoirs by Hindu seers from Kalelkar to Sadhguru. First, it focuses on Kalelkar's *The Himālaya: A Cultural Pilgrimage* translated from the original Gujarati by Ashok Meghani. This part shows how the author has treated the Himalayan pilgrimage as a means of recreating the myth of India, where geographical expanses are contemplated as an extension of the social and cultural past. Major stops made en route to the Himalayas here are Belgaum, Panaji, Mumbai, Vadodara, Jabalpur, Allahabad (Prayagraj), Varanasi, Gaya, Kolkata, Ajodhya, and Almora. The article concludes with reference to Sadhguru's *Himalayan Lust* (2010) that records the spiritual encounters of a group of Isha

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<sup>1</sup> This seventeenth book of the *Mahabharata* is named after the idea of the *mahāprasthāna* or "pilgrimage unto death." Four Pandav brothers, along with their wife Draupadi, perished on their way to the Himalayas; only the eldest reached heaven.

meditators<sup>2</sup> who go on an annual trip to the Himalayas with their mentor. The work, in fact, amalgamates discourses and conversations from several *yātrās* ranging from the specific to the timeless. Between Kalelkar and Sadhguru, there are several Hindu authors who have recounted their pilgrimage to the Himalayas in their writings, such as Mahadevi Varma, Santdas Jhangiani,<sup>3</sup> Swami Satchidananda. There are accounts of pilgrimage to the Himalayan shrines like Kedarnath, Badrinath and Mt. Kailash by monks of the Ramakrishna order and lay devotees as well. Among them, Hindi poet and writer Mahadevi Varma's *A Pilgrimage to the Himalayas and Other Silhouettes from Memory* (1975), translated from the original Hindi *Smriti Ki Rekhayan* (1943), and Swami Satchidananda's *Kailash Journal: Pilgrimage in the Sacred Himalayas of Tibet* (1984), translated from the original Tamil (1959), have here been discussed at length. In fact, the works under consideration here have conspicuously been neglected by social scientists. To bring these works within a theoretical framework, the article frequently alludes to Victor Turner and Edith Turner besides S. M. Bhardwaj, Agehananda Bharati, et al. It seeks to investigate how Hindu pilgrimages to the Himalayas over the last one hundred years happened and how far they conform to Turner's generalizations about pilgrimage symbolism. Besides, attempts have been made to examine such pilgrim behavior as rare mystical experiences, self-sacrifice or salvific suicide and peer desertion from the perspective of medical and psychological anthropology. Drawing on mainly Sigmund Freud and some contemporary clinicians and psychiatrists, the article endeavors to study the conscious or unconscious ideas shared by Hindu pilgrims as individuals during their pilgrimage to the Himalayas.

## **2. Kalelkar's *The Himālaya: A Cultural Pilgrimage***

Oppressed by the British rulers and disillusioned with the appeasement policy of Indian Congress members, Dattatreya Balkrishna Kalelkar, popularly known as Babasaheb Kalelkar, abandoned his nationalist education work and set out for the

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<sup>2</sup>Isha meditators are those who undergo yoga programmes for inner transformation organized by Isha Foundation at the Velliangiri Foothills, Tamil Nadu, India.

<sup>3</sup>Sindhi writer Santdas Jhangiani's *Jai Gangotri* (1966) that describes the author's difficult passage to Gangotri, the source of the Ganga is also a significant contribution.

Himalayas in quest of his “mystical nationalism.”<sup>4</sup> The physical journey described in his *The Himālaya: A Cultural Pilgrimage* happened in a two-month stretch in 1912. His journey from his native place in the Indian state of Maharashtra to the Himalayas can be divided into three parts.

The first part of his journey—*Tristhāli Yātrā*, or the pilgrimage to the three holy places of Prayag, Kashi and Gaya—was prompted by his desire to free himself from the obligation to his late father’s soul. He set out from Belgaum along with Anantbuwa, a member of the Ramdasi sect,<sup>5</sup> and spent ten days in Goa’s pictorial natural setting. After a coastal voyage had brought them to Mumbai, he left for Vadodara and visited his old haunts there. Then, on the birth anniversary of Shivaji the iconic Marathi ruler, they embarked upon their ambitious journey. Prayagraj, the confluence of the Ganga, the Yamuna and the Saraswati, was the first destination of their pilgrimage. The primary objective of Kalelkar’s visit to Prayagraj was to sprinkle his deceased father’s ashes into the waters at the tri-river confluence. Prayagraj is also the confluence of Hindu pilgrims of different dispositions, attires and customs: the Sindhis who take first place among the pilgrims, with their visible religious fervour and sentimental devotion; the Maharashtrians who are consciously concerned about securing the most spiritual benefit from their pilgrimage in the shortest amount of time and at least possible expense; the Gujaratis who always seem to be in quest of better food; the Bengalis who seem to parade their overflowing devotion; the intelligent Madrasis who, with their strange attire and mannerism and poor skill of speaking Hindi, wander like aliens. Leaving Prayagraj, Kalelkar and his companion started for Varanasi, the Eternal City, or Kashi, by train. In the stretch of the west bank of the Ganga between its tributaries, Varuna and Asi, the conspicuous presence of the twin sky-kissing minarets of a mosque set his mind thinking. He reminds the reader here that the Mughal Emperor Aurangzeb built the mosque in the place of Viswanath temple, out of jealousy, but the subsequent Hindu rulers never dreamt of demolishing it. He observes that even the

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<sup>4</sup>The idea has been elaborated on later.

<sup>5</sup> Being inspired by Ram *bhakti*, Ramdas (1608-1661), a Marathi poet, founded this sect with its 1,100 monasteries all over India.

British rulers had no clue about this Hindu belief in the power of love. Getting off the train, Kalelkar and his companion anyhow escaped from the clutches of *pandās*, or Hindu priests, notorious for their mercenary nature, and reached the residence of Anantbhat the reliable professional priest who was also found to be a money-lender. One day during their stay in Kashi, when they took a rowboat trip from the Dashashvamedh Ghat, the sights of varieties of temples and of thousands of people on the bank of the holy Mother Ganga quenched his spiritual thirst. On the following day, they set out to see architectural and sculptural beauties of Kashi that houses numerous religions and sects, such as the Central Hindu College run by the theosophists, the Saraswati temple, Ramakrishna Sevashrama, and so on. After finishing his pilgrimage of Prayagraj Kalelkar headed for Bodh Gaya, also called Uruvela in olden days, where Lord Buddha sat under a peepal tree on the bank of the river Neranjara<sup>6</sup> some 2,500 years ago, fighting *māra*<sup>7</sup> and attained nirvana. While circumambulating the adjacent Mahabodhi Temple and paying respects to the Bodhi tree, Kalelkar experienced a vision in which his entire life flashed before him—some sort of what is known as life review in near-death experiences (NDEs).<sup>8</sup>

The second part of his journey—pilgrimage to Belur Math, the sacred home of Ramakrishna Paramahansa<sup>9</sup> and Swami Vivekananda—may be attributed to his longtime wish to visit the place and pay respects to Shri Mahendranath Gupta, the author of *Shri Ramakrishna Kathamrita*. His heart was bursting with faith and devotion when he visited the Samadhi (memorial) of Swami Vivekananda whose writings had restored his faith in religion. On his way to this holy place, he also noticed the widespread poverty of Bengal; the fastidiousness of the Math inmates

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<sup>6</sup>Also called Nairāñjanā in Sanskrit, it is a small tributary of the Ganga.

<sup>7</sup>*Māra*, in Buddhist cosmology, is synonymous with death, rebirth and desire.

<sup>8</sup> Different researchers and writers like Chris Carter and Dr Sam Parnia have studied at length NDEs (near-death experiences) reported by survivors of life-threatening accidents or illness, such as automobile accidents, near-drownings, cardiac arrests, surgeries, childbirth, etc. Experiences of individuals who come close to death, as writes Carter, are NDEs. Such experiences often involve a life review—a sort of flashback or hallucination in which the individual’s entire past life may unfold before him in a few seconds.

<sup>9</sup>Ramakrishna Paramahansa (1836-1886), well-known as the mentor of the Hindu monk Swami Vivekananda, was a Bengali mystic.



reminded him of the obsession of the Lingayat people of South India with purity of food. He, however, reminds us that purity of food for purity of the soul has been subscribed to in ancient Hindu scriptures. He also visited the nearby town of Khardah, a significant place in Bengal's religious history, a place associated with Sri Chaitanya Mahaprabhu<sup>10</sup> who purified the non-Hindus like Nedanedi.<sup>11</sup> Here, Kalelkar remarks that Indians have stereotyped but localised concepts of cleanliness, purity, modesty—virtuous versus forbidden, clean versus unclean.

The third and final part of his journey—the pilgrimage to Char Dham (the Four Shrines)—Jamanotri, Gangotri, Kedarnath and Badrinath—is a truly spiritual experience. From Belur, Kolkata they headed for Ajodhya, the legendary capital of Lord Ram's golden reign. They visited the presumed birthplace of Lord Ram, and other places mentioned in the Indian epic *Ramayana*. But what saddened him is the intolerance of the past Muslim rulers who were responsible for the loss of the city's ancient glory. Then, on his way to Kathgodam he remembered the original intent of his pilgrimage to the Himalayas was to become a *sanyāsin* or an ascetic—to attain *moksha*, the ultimate deliverance from the cycles of birth. At the same time his encounter with a fake *sādhu* on the railway train made him critical of the parasitical institution of *sādhus* that seemed to be a huge burden of society. Kalelkar is of the opinion that a Hindu is born with a desire to go the Himalayas. The ancient Hindu tradition has also prescribed renunciation of family life and pilgrimage to the Himalayas in old age. As Kalelkar (2014, 59) writes:

When life's work is done, when the senses are weakened, when one is frail of body and the remaining days of life seem burdensome—that is the time to abandon this borrowed worldly existence and return to one's true home to die. This is the thought that motivates countless Hindus to give up all food-intake, and to

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<sup>10</sup>An advocate of the Vaishnava school of *bhakti* yoga, Chaitanya Mahaprabhu (1486-1534) was a Hindu saint and social reformer in eastern India.

<sup>11</sup> Nedanedi were the shaven-headed Buddhists prior to becoming Vaishnavas.

walk in the Himālaya in the Northeasterly direction until their lives end.

The Himalayas is also the refuge for those without refuge. For him (2014, 60), it is “the fatherland of religions,” the birth place of two major historical or salvation religions in the world—Hinduism and Buddhism. He (2014, 61) reminds us that the ancient Sanskrit poet Kalidasa who described this “soul of the gods, emperor of the mountains” as the standard by which the human world is measured. And he describes his desire to go to the Himalayas as his “inherited national instinct”—“a strong sense of going home.” In a way Kalelkar’s pilgrimage to the Himalayas is a form of what Turner and Turner (1978, 106) called “mystical nationalism.” After their train journey had been over, they started walking to Almora via Bhimtal and the Himalayas cast its spell on them. According to Kalelkar, it is the duty of the people to visit holy shrines to pay their respects to the Creator. Among the five sectors of the Himalayas—Kashmir, Jalandhar, Garhwal (or Uttarakhand), Kumaon and Nepal, the third one is considered home to some of the holiest shrines of Hinduism. As ancient sages decreed, the pilgrimage to the Char Dham was the quintessence of piety. At Bhimtal Kalelkar (2014, 66) saw each of the mountains as “a step on the staircase of heaven.” Following that, they reached Almora, the district seat and the capital of the Kumaon Division, and felt blessed when they saw Mt. Nandadevi with its snow-capped peaks sparkling like a golden dome. It is popularly believed by the Hindus that the Himalayas grows *sādhus* as it does trees. But what appalled Kalelkar was the fact that the common inhabitants of Almora were equally morally bankrupt. That afternoon his (2014, 95) meeting with Khakhibawa at Khagamara fort made him realize the importance of maintaining and improving India’s ancient but ever-fresh institutions to prevent her from becoming “a cultural graveyard.” During their fifteen days’ stay in Almora they communed with nature and met many good people including Sombargiri at Padambori, who was called a living encyclopaedia of the Indian subcontinent. Their next stop was Mukteshwar Mahadev (Shiva) shrine at the top of the mountain with an adjacent Bhairavghati. Members of Bhairav sect<sup>12</sup> used to jump off the cliff

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<sup>12</sup> Followers of Lord Shiva

chanting Bhairav name and end their lives to achieve *moksha*. From Mukteshwar they backtracked their way to Kathgodam on the same road, and took shelter in a *dharmashālā* where he met all sorts people with their pride and prejudices: merchants, government officers, feudal landowners, beggars, vendors and even the policemen. Hindus believe that a holy pilgrimage earns one *punya* (positive points in one's accumulated *karma*), but its amount depends on the way it is earned. The author holds that, when a pilgrim uses an automobile or a railway train to reach the shrine, the pilgrimage produces negative points and amounts to a sin. Then they reached Haridwar, the holy shrine city where the river Ganga reaches the plain, and visited the Ramakrishna Mission and met the inmates of the organization. In the evening they attended the *deep-dān* (the offering of lamps) ceremony at Har-ki-Pauri—the famous *ghāt* of the Ganga in Haridwar where hundreds of thousands of pilgrims flock. The neighbouring Kankhal is home to several *sanyāsin* groups, and the author (2014, 125) observes that one should shed one's "modernistic revulsion" to come in contact with them and appreciate their cleanliness, decency, multifaced knowledge, and tolerance for adversity. He holds that a religious pilgrimage could also serve a military purpose. People in the past felt the necessity of religious people retaining the control over the places strategically located high or the sources of fresh water. Kalelkar endorses here his notion of mystical militarism that is essential for nation building. However, he laments the fact that the religious pilgrimage to the Himalayas became so easy those days, rendering it less adventurous and less profitable in terms of spiritual gain. On their way to Rishikesh, they saw the railway tracks to Dehradun snaking through the dense woods on their left. The *sādhus* in Rishikesh discoursed on Prasthanatrayi—the quintessence of all Hindu scriptures contained in the Upanishads, the Bhagavad Gita and the Brahma Sutra—and also diversely interpreted Shankaracharya's<sup>13</sup> principle that "there is one Universal Truth; this world is but an illusion." As they left Lakshman Jhoola they went beyond the civilized world—the path became hilly, with some serious rise and fall in its course; the mountain folk seemed to be jungle savages. He noticed that rich pilgrims there could afford *jhanpān*, a sort of open palanquin or sedan chair with a single

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<sup>13</sup>[Adi] Shankaracharya (788 AD–820 AD) was a Hindu theologian and philosopher who advocated the doctrine of *Adaitwa*.

shaft, carried on the shoulders of four carriers. Then they entered the city of Devprayag, one of the five holy confluences of the river Ganga. The Alaknanda comes down from Kedarnath here and is joined by the Bhagirathi Ganga that travels from its origin at Gangotri. On their way to Gangotri they trekked for miles to reach the town of Tehri and took shelter in a Sikh *dharamshālā*. After being joined by a Bengali *sādhū* named Madhavananda over the Rari Pass, they headed for the village of Ranagam, known for the wooden temple of Shaniswar Maharaj<sup>14</sup> and found Jamanotri stand out with its cool sanctity and awesome solemnity. Since the next destination of their pilgrimage was Gangotri, they decided to go over the “Uprikot” Mountains associated with the seat of the Pandavas of the *Mahabharata*, and through Uttarkashi where the south-flowing Ganga flows northward. The small temple of Mother Ganga at Gangotri symbolized to him the seeds of inspiration and germination of religious thoughts in the mind of a devoted person in contemplation. He was reminded of the great king Baghirath<sup>15</sup> and the religious conquests of Adi Shankaracharya. Before departing from Gangotri, they collected the holy Ganga water in little urns and started back to Bhatwari so that they could take the road to Kedarnath from there. Here, Kalelkar observes that the Char Dham pilgrimage is a religious weave that binds the country and society inseparably together. Kalelkar’s pilgrimage to the Himalayas here further stresses on the idea of “mystical nationalism.” The influence of the Greek architectural style on the Kedarnath temple with its triangular globe in the front led him to believe that the wise ancestors of India did not reject foreign architectural influences. After sunrise they also took their ritual dip in the river Mandakini. Now they had only Badrinath to visit, for which they should walk for nine days. They took the road to Ukhimath, where Lord Kedar goes to in winter, and climbed Tunganath to reach Joshimath, Lord Badrinarayan’s winter abode. Here Kalelkar justifiably reminds us that Adi Shankaracharya established four *maths* (monasteries) in four corners of India—Dwaraka in the west, Shringeri in the south, Puri in the east and Joshimath in the north. Joshimath was perhaps the first line of defense against a southward spread

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<sup>14</sup>Shaniswar, in the Puranas, is a Hindu deity, responsible for hardships and sufferings in life. He is also capable of conferring blessings to the deserving ones, depending on their *karma*.

<sup>15</sup>Bhagirath, in Hindu mythology, is the king who brought the Ganga down from heaven to earth.

of Mongolian influence across India. This allusion reinforces Kalelkar's conviction that mystical militarism is in the interests of all. Finally, they reached Badrinath, and standing at the Lord Badrinarayan's door he felt the sense of achievement and blessedness like many other pilgrims. As he received *prasād*—the sacramental rice offering—he experienced a strong sense of what Turner and Turner (1978, 13) called “commonness of feeling” or “*communitas*.” As Kalelkar (2014, 237) writes:

Here, at the Lord's door, all are alike. Prince or pauper, rich or poor, Brahmin or low-caste, sinner or virtuous . . . they are alike. Happy, sad, sick and ailing, the so-called low-lives, low-born, fallen, downtrodden, black, white, Vaishnavites or Shaivites, sanyāsi or home-maker, young, old, women, children—they are all equal. There is no discrimination, no caste, no sect, no mine or yours, no duality, no prejudice, no isms, no quarrels, no Samāji or Sanātāni, no reformer or liberator, no East or West here. . . .

This account of pilgrimage contradicts Bhardwaj's (1973, 169) “comparative peregrinology”—that the pilgrims of higher castes and “relative affluence” tend to frequent the upper-level shrines like Badrinath. He performed the *shrāddha*<sup>16</sup> ritual on the Brahma Kapal rock at Badrinath that is also believed to grant *moksha* to all of one's ancestors. As their rites of passage were complete, they took the road back to Almora via Dwarahat, cherishing the dried rice—a gift from the living Lord. Kalelkar observes that the general intent of a Hindu traveling to the Himalayas is religious in nature. In contrast to a western traveler who carries as many implements of convenience as is practical, a Hindu often sees his pilgrimage “as a form of *sādhana*—spiritual discipline” in which the more one suffers the more one gleans the spiritual benefit (Kalelkar 2014, 252). The second important benefit of a pilgrimage to the Himalayas is the opportunity to meet “a Satpurush—a god-realised man of virtue” (Kalelkar 2014, 253). During the pilgrimage the pilgrim experiences the purity of life and intends to continue that life even after returning home. It opens the mind of the pilgrim to change. It offers the pilgrim the opportunity to witness nature's play first-hand. It enables the pilgrim to have a

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<sup>16</sup>Hindu rite intended to nourish, protect, and support the spirits of the deceased ancestors

glimpse of the history of the nation—the Kuru-Panchal civilization to the contemporary Tibetan culture overwhelmed by Col. Younghusband's attack.<sup>17</sup> Travelling through the Himalayan region teaches one much from the geographical and geological points of view as well. It allows the traveler to have a true picture of India's soul and vastness in one sweep. Dean MacCannell (1973) held that pilgrims travel characteristically towards the centre of their belief, whereas the tourist is in quest of the authentic, but vicarious, experiences in other places, times and cultures. Kalelkar, however, appears to be more a secular pilgrim than a religious one—a tolerant, openminded, Hindu nationalist.

### **3. Varma's *A Pilgrimage to the Himalayas***

Often compared to the 16<sup>th</sup> century saint and Hindu mystic poet Mirabai, Mahadevi Varma, in *A Pilgrimage to the Himalayas*, shows how *bhakti* (devotion and dedication) took her on an incredible journey to the Himalayas. In fact, her development of poetry had already reflected her inner spiritual journey. This memoir describes the dangers on the narrow, undulating footpaths to the Himalayan temples of Badrinath and Kedarnath and the loyalty and sacrifice of two coolies belonging to the tribe of Dotiyals<sup>18</sup> in Nepal and Bhutan. It also testifies to the fact that *bhakti* propelled the hearts of rural folk of India in the 1930s and the 40s to go on a pilgrimage to the Himalayas. These poor people often began their journey with the full knowledge that they might not return anymore. When such a pilgrim fell ill, he was left behind by others. In the event of death of a pilgrim, the cremation was performed after begging money for the last rites from other pilgrims; sometimes the corpse was thrown into the deep ravines in want of money. Verma's memoir also throws ample light on the psychology of the poor pilgrim group that ascribed the death of a fellow pilgrim to individual sins. Such instances of peer desertion during pilgrimage is likely to draw the attention of psychological anthropologists. Similarly, if a coolie caught cholera or fever or got severely injured, he was left behind to meet his fate. Mahadevi's (1975) spiritual pilgrimage is thus often

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<sup>17</sup>Francis Younghusband, a British Army officer, led the 1904 invasion of the Tibet that resulted in 7,000 Tibetan deaths.

<sup>18</sup>A tribe living in the central Himalayas, known for their hardiness and simplicity

overcast with the shadows of concern—the “death and sickness hidden in the purified air of the Himalayas.” Unlike tourists, fully equipped with travel paraphernalia, who walk for pleasure, the poor pilgrims walk for their *moksha*. Both the tourists who rode ponies and the rich pilgrims who could afford *dandis*<sup>19</sup> or wicker carriers despised these wretched pilgrims. Her sympathy for the underprivileged or her egalitarianism is the hallmark of her work. The conspicuous presence of the poor pilgrims in her account of the Himalayan pilgrimage also contests Bhardwaj’s (1973, 169) stratification that the pilgrims to the Himalayas tend to be persons of high caste and “relative affluence.” Above all, hers is a female pilgrimage: she independently undertook this expedition as a guide to her aunt who had wanted to go the Himalayas. She acted the role of a brother to her aunt who had no brothers. Herself a feminist in days when Indian women had little connection with the greater world, Varma challenged the conventional notion of Hindu pilgrimage (to the Himalayas) that was principally male dominated.

#### 4. Satchidananda’s *Kailash Journal*

Swami Satchidananda’s *Kailash Journal* chronicles his experiences during the pilgrimage to Mt. Kailash in Tibet in 1958—an eight-hundred-mile journey, on foot, to an altitude of 19,000 feet. Sacred to four religions—Buddhism, Jainism, Bon<sup>20</sup> and Hinduism, Mt. Kailash for centuries has enticed countless pilgrims. The *Rig Veda* sees the Himalayas as a deity. Hindus worship Mt. Kailash as the home of Lord Shiva and his consort Parvati. They believe that a single circumambulation around it cleanses the sins of a lifetime.

Born in the South Indian state of Tamil Nadu, Swami Satchidananda renounced the life of a businessman and householder to accept monastic order. After spending five years at an *āshram*<sup>21</sup> in Ceylon, he along with four other members undertook a journey to Mt. Kailash, the legendary home of his *Ishta Devatā* (personal form of God), Lord Shiva. “A pilgrimage,” as observes

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<sup>19</sup>A wooden palanquin in which the rider is carried on the shoulders of two coolies

<sup>20</sup>The pre-Buddhist Tibetan creed

<sup>21</sup>A spiritual hermitage in the Hindu way of life

Satchidananda (1984, 627), “is also like an obstacle race. Through the obstacles the seeker expands into divine consciousness and comes to understand the game of life.” While a number of routes are taken by pilgrims to reach Mt. Kailash, Satchidananda ascended by the route leading through the Milam Glacier and Undathura Pass and came back through Garbiang and Lippu Lake Pass. In his journal, he describes the spectacular beauty of mountains, valleys and lakes, the vigorous and cooperative native people, the numinous atmosphere, and the challenges and hazards that are unavoidable in such an undertaking. The arduous and gradual ascent up the Himalayas reminded him (1984, 889) that “the path to spiritual attainment is also a slow, steady climb.” For him, the quick downhill journey amounted to the descent of man and mind to lower levels. Water and even rocks attain special significance for pilgrims like him. Pilgrims who bathe at Bhageswaram, the meeting place of the Gomathi and the Sarayu Rivers, feel physically and mentally purified by the holy waters. The Markandayar rock here is associated with a great *rishi* called Markandayar who obtained his great wisdom sitting on that very rock. Satchidananda could hear the sacred verses of the Puranas echoed in the sounds of the river, telling the story of Shiva and Sakti, who pervade the world as Spirit and Nature. Then, they visited the temple of Chandi the Divine Mother<sup>22</sup> on the hilltop at Bhageswaram where devotees offer buffalos to her as sacrifice—a substitute for the ego. Even a bridge on the famous Ram Ganga River, that flows at a height of 4,000 feet, is seen as a symbol of life that connects the gap between birth and death. As Satchidananda and his followers crossed the Gowri Ganga they felt blessed to have the sight of Nanda Devi and Trisuli. Following that, they climbed to the Milam Glacier and Lake Sandilya at the height of approximately 13,000 feet, named after the great saint who performed penance there. At Gurgiyang Gumfa they found that the Buddhist Tibetans also worshipped Shiva and Devi. Then, they reached Tirthapuri, one of the important pilgrimages in Tibet, lying on the banks of the Indus that originates from Manasa Sarovaram. The *pradakshina*, or the devotional walk around the holy peak, is a part of Hindu pilgrimage to the Himalayas. The route they took to walk around Kailash is thirty-two miles long and

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<sup>22</sup>A manifestation of Lord Shiva’s consort Parvati, to destroy evil



goes up and down the slopes at heights ranging from 17,000 to 19,000 feet. Despite all difficulties of the route, they surmounted them with devotion and dedication. Satchidananda sees Mt. Kailash as *Ardhanārīśwara*—a combination of the bodies of Shiva and Sakti. He argues that nature is a blend of *jadam*, the medium through which the essence functions and *chaitanyam*, the all-pervading consciousness, which is also the soul of Shiva. Besides, Mt. Kailash is associated with King Janaka, father of Sita in the *Ramayana*. Legend has it that the Lord of Kailash sat under a banyan tree and imparted knowledge to the king and his followers who sat at His feet. The Tibetans believe that Ravana, king of Lanka, performed penance on the shores of the giant lake near Mt. Kailash. Satchidananda (1984, 1757) calls Mt. Kailash “the Silent Teacher” that reaches and teaches one through silence. Mt. Kailash has also been a holy place of pilgrimage for the Buddhist Tibetans, who call it Gangarin Poshi, for many hundred years. Buddhist monks have performed penance and attained nirvana here. Buddhist Pilgrims also undertake penance and walk the same thirty-two miles of snow, glaciers, hills and rocky slopes around Kailash with full prostration—a ritual known as *sasthānga pradakshina*. Having reached the feet of the holy peak, Satchidananda and his companions circled it in reverence and bathed in the holy waters of Gowri Kund. Following that, they reached the calm Manasa Sarovaram that stands between Mt. Kailash and Manthatha, covering an area of 200 square miles. In Hindu tradition it is called *Anāvathapha*—“that which is warm and motionless.” Buddhist literature views it as “wonder lotus” that spreads divine light all around due to the touch of Lord Buddha’s feet. The lake makes one who takes a dip in its water divine. Men worshipping here perform *tarpanam*—an offering to the departed ancestors. Satchidananda’s pilgrimage on foot which had started on the 8th of June 1958 ended exactly two months later on the 8th of August. Finally, the benefits of the Kailash pilgrimage were complemented by his holy journey to Amarnath, the Lord of Kashmir, in the same year.

### **5. Sadhguru’s *Himalayan Lust***

*Himalayan Lust* relates the annual expedition to the Himalayas undertaken by a group of Isha meditators led by Sadhguru. In fact, it is a combination of several

pilgrimages to the Himalayas over the years. For Sadhguru (2010, 55), a pilgrimage is “a process of humbling [one]self.” Unlike explorers who travel to conquer and to know, or tourists who travel because they need a break from their work or their family, pilgrims travel to humble themselves. And Sadhguru has chosen the Himalayas for a pilgrimage because it makes him feel small; it makes him aware of his “place in this existence”—that he is “a particle of dust in this existence.” Metaphorically extended, life itself is a Himalayan pilgrimage. His usual haunts in the Himalayas are Uttarkashi, the temple town on the bank of the river Bhagirathi; Guptakashi, or the “Secret Kashi”; and Tapovan, the sacred place above the Gangotri glacier. He also speaks of his visit to the Himalayas in the previous life. This belief in previous life or rebirth is attributable to what Sigmund Freud called “the circumstance of the ‘double’” that dates back to a very early mental stage, long since left behind.<sup>23</sup> Far from being just a devotional temple tour, his pilgrimage to Himalayas is an occasion to understand the spiritual anatomy of the sacred landscape. It is an opportunity to demystify ancient inherited traditions and examine their underlying significance. For example, the Bhairaveshwara temple, an occult structure on the way to Kedarnath, as explains Sadhguru, is built in a small and insignificant way because it is not for the normal pilgrims who go up the mountain for worship but for those who are on the path of *kriyā* or *sāadhanā*. For him (2010, 96), the occult is far from spirituality—it is “a subjective technology” to transform individual energies. Situated in the rolling hills of Garhwal, along the banks of the river Alaknanda, Badrinath is the most favourite haunt of Sadhguru. The place evokes a welter of associations for Hindu pilgrims—with Nara and Narayana,<sup>24</sup> with Vishnu and Shiva, with Adi Shankara and Sage Vyasa, with the Pandavas and the river goddess Ganga, among a host of others. He also recounts his strange experience at Kanti Sarovar, near Kedarnath, in which the entire universe

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<sup>23</sup> Drawing on Otto Rank’s “Der Doppelgänger,” Freud held that “the ‘double’ was originally an insurance against the destruction of the ego, an ‘energetic denial of the power of death’” (p. 234). For him, the “‘immortal’” soul is the first “‘double’” of the body. Such ideas originate from the limitless “self-love,” from the “primary narcissism” which controls the mind of the child (six months to five years) as in that of primitive man (p. 235).

<sup>24</sup> This deity pair, in Hinduism, is the twin-brother avatar of Lord Vishnu.

manifested itself to him as sound. From a medical and psychological perspective, one might be prompted to see it as a case of auditory hallucination. He remembers that on his 1993 visit to Badrinath he was offered by a *sādhū* a lemon-size *ekmukhi* rudraksha<sup>25</sup> thumping with energy. So, making this annual excursion, the Isha meditators merely follow in the footsteps of countless generations of pilgrims before them.

## 6. Conclusion

Kalelkar's *The Himālaya* is not only about a pilgrimage but also a unique assessment of Hinduism. On the one hand, he admires and reveres the holy places as they bind pan-India together. For him, the Himalayas is a symbol of Indian nationalism—an assertion of mystical militarism of Hindus. On the other, he condemns the evils of Hinduism—the credulity and superstitious practices of ordinary Hindu pilgrims, the exploitative nature of Hindu priests and businessmen in the so-called sacred places, the fake tradition of *sādhūs*, the orthodoxy of many Hindu pilgrims, and so on. For Varma, *bhakti* is the propellant of her pilgrimage to the Himalayas. Her memoir values the devotion and sacrifice of the poor pilgrims in the face of poverty, death and disease during a pilgrimage to the Himalayas in pre-Independence India. More significantly, hers is a female pilgrimage—an occasion for woman's liberation from the patriarchal Hindu society. Satchidananda's arduous physical journey allegorizes the spiritual one—the quest for direct knowledge of God. His pilgrimage takes place in a peripheral location on the boundary between Hinduism and Buddhism, at the northern frontier of the Indian subcontinent. Sadhguru's pilgrimage to the Himalayas combines the physical and the spiritual, the logical and the mystical, the past and the present, the previous life and the present one. Hindu pilgrimages to the Himalayas chronicled in the works in question here obviously fall under the category of what Turner and Turner (1978, 18) called "*prototypical* pilgrimages." Further alluding to them

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<sup>25</sup>An *ekmukhi* (one-faced) rudraksha, the rarest and most powerful of rudrakshas, supposedly offers the highest form of spiritual benefit. Believed to be Rudra or Lord Shiva's tears, rudraksha seeds, in fact, are used as prayer beads by Hindus and Buddhists. Rudraksha trees grow in plenty in the Gangetic plain at the foothills of the Himalayas.

(1978, 8), it may be said that the pilgrims here are initiands, entering into a new and profounder level of existence than they have known in their habituated setting. The geography of the Himalayas described in those accounts of pilgrimage may be seen as “powerful religious sacra”—shrines, images, liturgies, curative waters, fossils, fruits or seeds, ritual circumambulations of the holy objects. The present study also conforms to Bharati’s (1963) observations that certain natural elements assume primary importance in pilgrimage symbolism. Turner and Turner’s (1978, 8) other generalizations about sacred site symbolism also are traceable here. The pilgrims’ devotion to one or more supernatural entities or universal concepts (Vishnu, Shiva, Sakti, Shaniswar, *moksha*), for example, may be attributed to the animistic concept of Hindu life. It is also in agreement with William Crooke’s (1919, 24) statement that “pilgrimage in India is the result of the animistic basis of the popular beliefs, reflected in the higher forms of Hinduism.” A physical ascent, or an effort to climb the mountain shrine in the Himalayan pilgrimages here, does “represent the soul’s ascent through penance and patience” to the goal, to use the words of Turner (1974, 224). At least two accounts of Himalayan pilgrimage here contests Bhardwaj’s (1973, 169) statement that pilgrims to the Himalayas tend to be persons of high caste and financial affluence. Religious delusions and hallucinations also contribute to the nature of pilgrim behavior in Himalayan journeys. The article thus examines both the historical and the contemporary patterns of Hindu pilgrimage to the Himalayas at various levels.

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## Strategic Importance of Indo-Bhutan Bilateral Relations

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**Abstract:** *According to Ernst B. Haas (1971), regional co-operation has been defined as the process through which national states 'voluntarily mingle, merge, and mix with their neighbours so as to lose the factual attributes of sovereignty while acquiring new techniques for resolving conflicts among themselves.' Though some scholars view regional co-operation simply as the process by which states within a certain region increase their level of interaction with regard to economic, security, political or social, and cultural issues. The bilateral relations between India and Bhutan had been limited primarily. But a major achievement was made in the 80s when being the founding member of SAARC; Bhutan became involved in useful working group discussion on agriculture, rural development, science and technology, health and population and above all, trade and industrial co-operation with other South-Asian countries. Ever since the inception of SAARC, India and Bhutan have firmly supported and promoted the activities of the organization and worked towards making the South-Asian region self-dependent. They, together, have also expressed a keen interest in economic co-operation and various peace-making efforts in this region.*

*The present paper is aimed at understanding the relations between the two countries. This study tries to analyse their bilateral terms from the very beginning. It is an attempt to highlight the treaties they have signed long before, as well as, the obstacles they face in the context of changing international scenario.*

**Keywords:** Bilateral, peace-making, regional cooperation, SAARC, sovereignty

### Introduction

The South Asian Association for Regional Cooperation (SAARC) is a regional inter-governmental organization and geopolitical union of nations in South Asia. Its member states include India, Pakistan, Afghanistan, Bangladesh, Bhutan, Nepal, Maldives, and Sri Lanka. SAARC comprises of 3 % of the world's area, 21% of the world's population and 3.8% (USD 2.9 trillion) of the global economy. It was

founded in Dhaka on 8 December 1985. Its secretariat is based in Kathmandu (Nepal). The organization promotes the development of economic and regional integration. SAARC maintains permanent diplomatic relations at the United Nations as an observer and has developed links with multilateral entities, including the European Union.

**Objectives of the Study:** The prime objectives of the study are as follows:

- 1) What are the factors which link the two countries?
- 2) Are Indo-Bhutan relations really free of tensions?
- 3) Is the “perpetual peace and friendship” phrase used in the 1949 treaty to describe Indo-Bhutan relations really true for all time to come?
- 4) What are the challenges that the relations will face in the future in the context of the changing domestic, regional, and international environment?
- 5) Which factors, in spite of the challenges, will keep the two countries together in the face of the choices that they have?

This paper attempts to answer these questions to understand the unique relations that the two countries share.

### **Methodology**

The present paper is solely based on secondary sources of data. The study would be based on content-analysis. Different books, journals, periodicals, and websites are considered to highlight the exact scenario of the relations between the two states. The study covers the National, State, and Regional newspapers as a source of data.

### **Discussion and Analysis**

With land area of roughly 46,000 sq. km and located between India and China, Bhutan is a small Himalayan kingdom with a total population of 6,95,819 and is of great strategic consequence for India’s neighbour-hood policy. Bhutan’s population can be conveniently categorised into three groups: the Sharchops, Lhotshampas, and the Ngalungs (often called Drukpas). While the Sharchops and the Ngalungs live in the Eastern and Western Bhutan respectively, Lhotshampas reside in the Southern region. The Ngalungs are the ruling group who control the monarchy and

the National Assembly, with a prominent place in the economy. The existence of Bhutan dates back to the 12<sup>th</sup> century when the immigrating Tibetans conquered the local tribals and established their supremacy. It took four centuries for the fending migrant Tibetans to delineate the geographical boundaries of the country and set up a politico-religious system of governance corresponding with that of theirs. Culturally, ethnically and politically, it emerged as a homogenous entity in the 17<sup>th</sup> century conducting its economic as well as political relations (1).

### **Historical Bonding between India and Bhutan**

India and Bhutan have been sharing ties since 1910 when Bhutan became a protectorate of British India, allowing the British to “guide” its foreign affairs and defence. When India declared independence in 1947, Bhutan was among the first nations to recognise it. Since then, the relations between the countries have become stronger, especially because Bhutan also has a historically tense relations with China. Besides sharing a 699 Kilometres border, India and Bhutan also share deep religious-cultural links. Guru Padmasambhava, a Buddhist saint played an influential role in spreading Buddhism and cementing traditional ties between people in both nations. India opened an office of a Special Representative in Thimphu in 1968, Bhutan reciprocated in 1971. The two offices of special representatives were upgraded to full-fledged embassies in 1978.

Through the years Bhutan has cherished India for its economic assistance and the relations between the two nations has helped Bhutan shape a unique developmental path based on gross national happiness. Bhutan’s economy has grown substantively in recent years (2). However, the developmental relations between the two countries can be meritoriously divided into three significant waves. The first wave (1960s-1970s) concentrated on building the social and physical infrastructure. The second wave (1980s—1990s) witnessed substantive efforts towards democratisation and decentralisation. The third wave (after 1990s) of the relations focused on developing hydel projects, which has now expanded into other areas of cooperation such as information technology, disaster risk management, education and research (3). The basis for bilateral relations between India and Bhutan is formed by the Indo-Bhutan Treaty of 1949.



### **The Treaty of 1949**

On August 8, 1949 Bhutan and India signed the Treaty of Friendship, calling for peace between the two nations and non-interference in each other's internal affairs. The very first Article tries to perpetuate Indo-Bhutanese friendship for all time to come by stating, "There shall be perpetual peace and friendship between the Government of India and the Government of Bhutan." However, the most important provision in the treaty is its Article 2, according to which, "The Government of India undertakes to exercise no interference in the internal administration of Bhutan. On its part, the Government of Bhutan agrees to be guided by the advice of the Government of India in regard to its external relations." The point that had provoked some amount of criticism or controversy pertains to the second part of this Article since it tries to qualify Bhutan's external relations. The treaty also established a free trade regime between India and Bhutan. Further, the citizens of both countries residing in each other's territory will be treated on par with own citizens. The treaty also had provisions for extradition of Indian citizens in Bhutan and of Bhutanese citizens in India when required, and the procedure for the same has been spelt out.

Diplomatic relations between India and Bhutan were established in 1968 with the appointment of a resident representative of India in Thimphu. Before this, our relations with Bhutan were looked after by our Political Officer in Sikkim. Formal bilateral relations between Bhutan and India were established in January 1968 with the appointment of a special officer of the Government of India to Bhutan. The India House (Embassy of India in Bhutan) was inaugurated on May 14, 1968 and Resident Representatives were exchanged in 1971. Ambassadorial level relations began with the upgrading of residents to embassies in 1978. Bhutan gradually began to diversify its relations with the international community, thereby projecting its status as an independent and sovereign nation. With India sponsoring Bhutan's application for UN membership in 1971, the leaders of the two countries demonstrated that Article 2 of the Indo-Bhutan Treaty was not a restricting factor in the exercise of Bhutan's foreign policy.

### **The Treaty of 2007**

The treaty of 1949 between India and Bhutan was updated and signed during the visit to India of His Majesty Jigme Khesar Namgyel Wangchuck in February 2007. The most significant change was in Article 2. The new Article 2 is worded as follows: “In keeping with the abiding ties of close friendship and cooperation between Bhutan and India, the Government of the Kingdom of Bhutan and the Government of the Republic of India shall cooperate closely with each other on issues relating to their national interests. Neither Government shall allow the use of its territory for activities harmful to the national security and interest of the other.” The new treaty says that Bhutan can import arms as long as Indian interests are not harmed and there is no re-export of the weapons, either by the government or individuals.

Below is the full text of the treaty: The Government of the Republic of India and the Government of the Kingdom of Bhutan:

- Reaffirming their respect for each other’s independence, sovereignty and territorial integrity;
- Recalling the historical relations that have existed between our two countries;
- Recognizing with deep satisfaction the manner in which these relations have evolved and matured over the years into a model of good neighbourly relations;
- Being fully committed to further strengthening this enduring and mutually beneficial relations based on genuine goodwill and friendship, shared interests, and close understanding and cooperation;
- Desiring to clearly reflect these exemplary relations as it stands today; and having decided, through mutual consent, to update the 1949 Treaty relating to the promotion of, and fostering the relations of friendship and neighbourliness between India and Bhutan have agreed as follows:

Article 1 – There shall be perpetual peace and friendship between India and Bhutan.

Article 2 – In keeping with the abiding ties of close friendship and cooperation between Bhutan and India, the Government of the Kingdom of Bhutan and the Government of the Republic of India shall cooperate closely with each other on issues relating to their national interests. Neither Government shall allow the use of its territory for activities harmful to the national security and interest of the other.

Article 3 – There shall, as heretofore, be free trade and commerce between the territories of the Government of Bhutan and the Government of India. Both the Governments shall provide full cooperation and assistance to each other in the matter of trade and commerce.

Article 4 – The Government of India agrees that the Government of Bhutan shall be free to import, from or through India into Bhutan, whatever arms, ammunition, machinery, warlike material or stores as may be required or desired for the strength and welfare of Bhutan, and that this arrangement shall hold good for all time as long as the Government of India is satisfied that the intentions of the Government of Bhutan are friendly and that there is no danger to India from such importations. The Government of Bhutan agrees that there shall be no export of such arms, ammunition and materials outside Bhutan either by the Government of Bhutan or by private individuals.

Article 5 – The Government of Bhutan and the Government of India agree that Bhutanese subjects residing in Indian territories shall have equal justice with Indian subjects, and that Indian subjects residing in Bhutan shall have equal justice with the subjects of the Government of Bhutan.

Article 6 – The extradition of persons wanted by either state for crimes and for unlawful activities affecting their security shall be in keeping with the extradition agreements between the two countries.

Article 7 – The Government of Bhutan and the Government of India agree to promote cultural exchanges and cooperation between the two countries. These shall be extended to such areas as education, health, sports, science and technology.

Article 8 – The Government of Bhutan and the Government of India agree to continue to consolidate and expand their economic cooperation for mutual and long-term benefit.

Article 9 – Any differences and disputes arising in the interpretation and application of this Treaty shall be settled bilaterally by negotiations in a spirit of trust and understanding in consonance with the historically close ties of friendship and mutually beneficial cooperation that form the bedrock of Bhutan-India relations.

Article 10 – This Treaty shall come into force upon the exchange of Instruments of Ratification by the two Governments which shall take place in Thimphu within one month of the signing of this Treaty. The Treaty shall continue in force in perpetuity unless terminated or modified by mutual consent. In witness whereof, the undersigned being duly authorized thereto by their respective Governments, have signed this Treaty done at New Delhi on the Eighth Day of February Two Thousand and Seven, in two originals each in Hindi, Dzongkha and English languages, each text being equally authentic. However, in case of difference, the English text shall prevail for the Government of The Republic of India the Kingdom of Bhutan.

Article 6 and 7 in the current treaty encompass the issue of ‘national treatment’ and equal privileges for citizens on each other’s soil.

The updated India-Bhutan Friendship Treaty not only reflects the contemporary nature of the relations but also lays the foundation for their future development in the coming century. Amongst others, the Treaty provides for perpetual peace and friendship, free trade and commerce, and equal justice to each other’s citizens. India’s bilateral political relations with Bhutan have matured over the years and are characterised by close trust and understanding and extensive cooperation in the field of economic development, particularly in the mutually beneficial sector of hydroelectric power.

### **Strategic Importance of Bhutan**

The geopolitical and geostrategic position of Bhutan - a landlocked Himalyan Kingdom covering an area of 46,000 sq. km and has maximum extent (East-West)

of 300 km and maximum depth (North-South) of 170 km - is important for India because it shares common borders with India and China - the two giant Asian nations in the post-second world war scenario (4). In addition to it, Bhutan is situated in close proximity to Nepal and Bangladesh with some geo-strategic possibilities. However, Bhutan has not developed so much of cordiality and warmth in its relations with them as it has with India (5).

1. Traditionally, the Himalayan kingdom acted as a buffer state between India and China. Bhutan shares a 470 km long border with China and a 605 kilometres border with India.

2. The Chumbi Valley is situated at the trijunction of Bhutan, India and China and is 500 km away from the “Chicken’s neck” in North Bengal, which connects the northeast with rest of the country.

3. Bhutan has in the past cooperated with India and helped to flush out militant groups like United Liberation Front of Asom (ULFA) and National Democratic Front of Bodoland (NDFB) from the Himalayan nation.

4. China is interested in establishing formal ties with Thimphu, where it does not yet have a diplomatic mission. Bhutan is strategically important for both India and China. Chinese territorial claims in western Bhutan are close to the Siliguri Corridor.

### **Bhutan’s Significance to India**

#### **Geographical Significance**

Bhutan shares border with four Indian States: Assam, Arunachal Pradesh, West Bengal, and Sikkim.

Nestled in the Himalayas, Bhutan serves as a buffer between India and China.

Security of Bhutan’s present borders especially its western border is very important for India.

#### **Economic Significance**

Bhutan provides a market for Indian commodities and is a destination for Indian investment.

Also for India, Bhutan is a rich source of hydropower.

#### Political Significance

A politically stable Bhutan is important to India. An unstable and restive Bhutan can provide a safe haven to anti-India activities and anti-India militant groups.

### **India's Significance to Bhutan**

#### Economic Assistance

India is Bhutan's leading development partner. Since the launch of First Five Year Plan of Bhutan in 1961, India has been extending financial support to Bhutan's FYPs. India has allotted Rs 4500 crore to Bhutan's 12th FYP.

#### **Water Resources**

India is playing an important role in development of hydro-power projects. This not only provides Bhutanese with electricity for domestic use but also revenue from surplus electricity exported to India.

So far, Government of India has constructed three Hydroelectric Projects (HEPs) in Bhutan. Currently, India is helping Bhutan in the development of power plant on Mangdechhu River.

This hydropower cooperation comes under 2006 Agreement on Cooperation in Hydropower. Under a protocol to this agreement, India has agreed to assist Bhutan in the development of minimum of 10,000 MW of hydropower and import of surplus electricity from same by year 2020.

Also, there is a Joint Group of Experts (JGE) on flood management between India and Bhutan. India aided Project Dantak, launched in 1961, helped construct a comprehensive network of important infrastructure in roads, Paro airfield, micro wave links with outside world, broadcasting station, elements of the Chukha project, and facilities in education and health (6).

### **Challenges**

There have been instances when India has meddled in Bhutan's internal affairs. This has led to negative perception of India in the minds of Bhutanese.

There is a growing feeling in Bhutan that India's development of Bhutan's hydropower production is driven by self-interest as it is getting Bhutan's surplus power at relatively cheap rates.

Bhutan's concern regarding profitability of its Hydropower projects in the wake of India's shift to renewable sources of energy like wind, solar, etc.

From internal security perspective, illicit establishment of camps by militant outfits in the dense jungles of south-east Bhutan is a cause of concern for both the nations.

China's continuous claims to important border areas such as Chumbi valley and Doklam and its continuous efforts for establishing strong diplomatic and economic relations with Bhutan have been continuous source of concern for India. In 1958, China had not only claimed Indian Territory, its maps also showed 200 sq. miles of Bhutanese territory as part of Tibet (7).

In 2012–13 fiscal, India's budgetary support to Bhutan stood at INR 30 billion. It steadily rose over the years to reach INR 61.60 billion in 2015-16 making Bhutan the largest beneficiary of India's foreign aid. Bhutan's Prime minister, Tshering Tobgay, secured an additional aid package from India worth INR 54 billion for his nation during his visit to New Delhi in August 2013. Five-sixth of this amount (INR 45 billion) has been earmarked for Bhutan's 11th Five-Year plan. INR 4 billion was for the pending projects of the previous plan period. The remaining INR 5 billion was part of India's "Economic stimulus package" for Bhutan's slowing economy. India operates 3 hydro power projects, of 1,416 MW in Bhutan and 3 more of 2,129 MW are under construction (8).

### **Conclusions**

The rationalized India-Bhutan Treaty not only reflects the contemporary nature of the relations but also lays the basis for their future growth and development in the days to come. The Treaty of 2007 provides for long-lasting peace and friendship,

free trade and commerce, and equal justice to each other's citizens. Both the countries are dependent on each other from various perspectives like political, economic, geographical, cultural, security, and religious point of view. India's bilateral political relations with Bhutan have matured over the years and are characterised by close trust and understanding and wide cooperation in the field of economic development, particularly in the mutually beneficial sector of hydroelectric power. Both countries have been benefitted from the Hydel power project. Above all, due to strategic location of Bhutan, the direct attach of China on India is not possible. We have to continue congenial relations with Bhutan in order to make our country safe and secured in the near future.

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## Ecological sustainability of an exploited prey-predator model with a stage-structure for prey

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**Abstract:** *In this research work we have proposed and analyzed a three-dimensional prey predator model induced by Holling type II functional response of predation and modified Leslie–Gower type functional response of consumption with the stage structure in prey population. Here mature prey and predator populations are harvested. Dynamic behavior of the model system like positivity, boundedness, stability etc. is discussed rigorously. Combined harvesting effort of prey and predator populations is used as control to develop a dynamic framework to investigate the optimal utilization of the resource. We have used Pontryagin's maximal principle in order to solve optimal control problem. Finally, some numerical simulations are derived and experimental results are discussed to validate the theoretical results.*

**Keywords:** *Harvesting, Hopf Bifurcation, Prey-predator model, Stage structure, modified L-G and Holling type-II functional response*

### 1. Introduction:

The population of the whole world is growing at an increasing rate, that's why they need production of more goods and foods. Some of these goods or the foods come from the renewable resources. The fishery system can be treated as a renewable resource and there is a necessity to materialize a good management policy for the reservation or the preservation of the system. Many researchers are working in this field to enrich the system for long term sustainable development with maximum benefit. Fishing is an important livelihood for the human population in so many developing countries in the world. Recently, bio-economic model for the

exploitation of biological resources like fisheries, forestries and Wild life has gained importance.

In mathematical biology, the dynamical analysis of the predator-prey model plays an important role. Ton and Hieu [1] studied a prey predator model consisting of one prey and two predators system with Beddington–DeAngelis functional responses and established sufficient conditions for the permanence and extinction of the system. Kar and Chattopadhyay [2] studied the long-run dynamics of a prey-predator model in the presence of an alternative prey. Tian and Xu [3] investigated a stage structured predator-prey system with Holling type II functional response and proved that the predator-extinction equilibrium is globally asymptotically stable when the coexistence equilibrium is not feasible. They also derived sufficient conditions for the global stability of the coexistence equilibrium. Chakraborty et al. [4] described a stage structured prey–predator fishery model where adult prey and predator populations are harvested in the system. They used fishing effort as a control to develop a dynamic framework to investigate the optimal utilization of the resource. The optimal management of renewable resources in fishery, which has a direct relationship to sustainable development, has been extensively studied by (Clark [5-6] and Kot [7]) and references therein [8-11].

In this research work, a three-dimensional pre-predator system is formulated and analyzed. The positivity and the boundedness of the solution of system are examined. Conditions for the existence of interior equilibrium are derived and then the local as well as global stability of the system are investigated. The bifurcation phenomenon has also investigated there. Then, using pontryagin’s maximal principle, the optimal control problem is examined and solve. Finally, some numerical simulations are derived through the iterative method of R-K fourth order scheme and experimental results are discussed leading to validate the theoretical analysis.

## 2. Qualitative properties of the system and model formulation:

Here we propose a prey-predator system consisting of three species viz. the juvenile or the immature prey, the mature or the adult prey and the predator with their population size at any instant  $t$  are  $x(t)$ ,  $y(t)$  and  $z(t)$  respectively.

The biological relevance and the ecological set up of the system are based on the following assumptions:

- ❖ At any instant the birth rate of the immature prey population is assumed to be proportional to the density of existing mature prey with proportionality constant  $r$  and the rate of transformation of the adult or the mature prey population is proportional to the density of the existing immature prey with the proportionality constant  $\sigma$ .
- ❖ The mature prey is also consumed by the predator population. Not only that, this biomass is also decreased due to the interspecific competition between the same species, due to natural death and also harvesting by the combined harvesting effort.

- ❖ It is to be noted that immature prey populations very easily catchable in compare to mature prey by the predator due to their physical weakness. Here we assumed that the predator consumed immature and mature prey according to Holling type-I (i.e.  $\alpha_1 xz$ ) and Holling type-II (i.e.,  $\alpha_2 yz/(a + y)$ ) functional response of predation respectively where  $\alpha_1$  and  $\alpha_2$  are the consumption rate of the predator population to immature prey and mature prey population respectively and  $a$  is the Michelson-morliee half saturation constant.
- ❖ The predator population is assumed to be modified Leslie–Gower type. In this regard, it is to be noted that the Leslie–Gower formulation is based on the assumption that reduction in a predator population has a reciprocal relationship with per capita availability of its preferred food (prey biomass). Although, Leslie introduced a predator prey model where the carrying capacity of the predator is proportional to the number of preys. He says that there are upper limits to the rates of increase of both prey and predator, which are not recognized in the Lotka–Volterra model. However, in the case of severe scarcity, predator can switch over to other population, but its growth will be limited by the fact that its most favourite food, the prey, is not available in abundance. The situation can be taken care of by adding a positive constant to the denominator, hence the growth function is considered to be modified Leslie–Gower type.  $\omega$  is the growth rate of the predator population and the growth is considered as the term  $\omega z(1 - \alpha_3 z/(px + qy + e))$ .
- ❖ Harvesting has generally a strong impact on the dynamics of the system. The severity of this impact depends on the harvesting strategy implemented which in turn may range from the rapid depletion to the complete preservation of a population. Non-selective combined harvesting effort is used to harvest the species. Here it is assumed that the mature prey and predator population are harvested by the combined fishing effort  $E$ .

Keeping these aspects in view, the dynamics of the system may be governed by the following system of impulsive differential equations:

$$\begin{aligned} \frac{dx}{dt} &= ry - \alpha x - \alpha_1 xz \\ \frac{dy}{dt} &= \alpha x - \frac{\alpha_2 yz}{a + y} - \gamma y^2 - dy - q_1 Ey \\ (2.1) \end{aligned}$$

$$\frac{dz}{dt} = \omega z \left( 1 - \frac{\alpha_3 z}{px + qy + e} \right) - q_2 Ez$$

where  $\gamma$  is the inter specific constant,  $d$  is the natural death rate of the mature prey population and the constants  $q_1$  and  $q_2$  are the catchability coefficient. The above ordinary differential equations are associated with the following initial conditions:  $x_0(0) > 0, y_0(0) > 0, z_0(0) > 0$ . (2.2)

### 3. Positivity and Boundedness of the system

In this section we are trying to find the conditions to have positive as well as bounded solution of the system (2.1).

**Theorem 3.1:** *All the solutions of equation (2.1) are positive.*

**Proof:** From the first equation of (2.1) we get,

$$\frac{dx}{x} = \left( r \frac{y}{x} - \sigma - \alpha_1 z \right) dt = \phi(x, y, z) dt \quad \text{where} \quad \phi(x, y, z) = \left( r \frac{y}{x} - \sigma - \alpha_1 z \right).$$

Taking integration in the region  $[0, t]$ , we get,

$$x(t) = x(0) e^{\int \phi(x, y, z) dt} > 0, \forall t.$$

Similarly, from second and third equation from (2.1) we can write

$$y(t) = y(0) e^{\int \psi(x, y, z) dt} > 0, \forall t \quad \text{where} \quad \psi(x, y, z) = \left( \sigma \frac{x}{y} - \frac{\alpha_2 z}{a + y} - \gamma y - d - q_1 E \right),$$

$$z(t) = z(0) e^{\int \xi(x, y, z) dt} > 0, \forall t \quad \text{where} \quad \xi(x, y, z) = \left( \omega \left( 1 - \frac{\alpha_3 z}{px + qy + e} \right) - q_2 E \right) \text{ and}$$

$$x(0) > 0, y(0) > 0, z(0) > 0.$$

Hence all the solutions of the system (2.1) are positive.

Now, we are going to discuss regarding the boundedness of the system.

**Theorem 3.2:** *All the solutions of the system (2.1) are uniformly bounded.*

**Proof:** Let us construct the following function,

$$W = x + y + \frac{1}{q_2 E} z \quad (3.1)$$

The time derivative of equation (3.1) is

$$\begin{aligned} \frac{dW}{dt} &= \frac{dx}{dt} + \frac{dy}{dt} + \frac{1}{q_2 E} \frac{dz}{dt} \\ &= ry - \sigma x - \alpha_1 xz + \sigma x - \frac{\alpha_2 yz}{a + y} - \gamma y^2 - dy - q_1 Ey + \frac{\omega}{q_2 E} z - \frac{\omega \alpha_3 z^2}{px + qy + e} - z \\ &\leq (r - d - q_1 E)y - \alpha_1 x^2 - \gamma y^2 - \left( 1 - \frac{\omega}{q_2 E} \right) z \quad \text{since for the existence of the} \end{aligned}$$

system  $x > z$ .

Now, for each  $\mu > 0$ , we have

$$\frac{dW}{dt} + \mu W \leq \mu x + (r + \mu - d - q_1 E)y - \alpha_1 x^2 - \gamma y^2 - \left(1 - \mu - \frac{\omega}{q_2 E}\right)z \quad \text{Taking}$$

$\mu = 1 - \frac{\omega}{q_2 E}$ , we get  $\frac{dW}{dt} + \mu W \leq \varepsilon$ , where  $\varepsilon = \frac{\mu^2}{4\alpha_1} + \frac{(r + (q_2 - q_1)E - \omega - d)^2}{4\gamma}$ .

Applying the theory of differential inequality (BirKoff and Rota [12]) we obtain

$$0 \leq W(x, y, z) \leq \frac{\varepsilon}{\mu} + \frac{W(x(0), y(0), z(0))}{e^{\mu t}} \text{ and for } t \rightarrow \infty, 0 \leq W \leq \frac{\varepsilon}{\mu}.$$

Thus, all the solutions of the system (2.1) enter into the region

$$M = \left\{ (x, y, z) : 0 \leq W \leq \frac{\varepsilon}{\mu} + \delta, \text{ for any } \delta > 0 \right\}. \text{ This completes the proof.}$$

#### 4. Qualitative nature of the solution

In this section we study some properties of the system (2.1). We determine the steady states analytically by setting  $\dot{x}(t) = \dot{y}(t) = \dot{z}(t) = 0$ . Here we try to calculate only the interior point of the system for biological importance only. Then we investigate the stability and bifurcation.

##### 4.1 Interior equilibrium and local stability:

From the system (2.3), we first calculate the interior equilibrium point  $P^*(x^*, y^*, z^*)$ .

From the above set of equation of the system we get,

$$y^* = \frac{x^* \{ \alpha_1 (\omega - q_2 E) p x^* + \alpha_1 e (\omega - q_2 E) + \sigma \alpha_3 \}}{\alpha_3 r - \alpha_1 (\omega - q_2 E) q x^*}, \quad (4.1a)$$

$$z^* = \frac{\{ (\omega - q_2 E) (p r + \sigma q) \alpha_1 x^* + r \omega \alpha_1 e (\omega - q_2 E) \}}{\alpha_1 (\alpha_3 r - \alpha_1 (\omega - q_2 E) q x^*)} \quad (4.1b)$$

and  $x^*$  is the positive solution of the equation

$$A_5 x^{*5} + A_4 x^{*4} + A_3 x^{*3} + A_2 x^{*2} + A_1 x^* + A_0 = 0 \quad (4.2)$$

where  $A_5 = \alpha_1^4 p^3 \gamma (\omega - q_2 E)^3$

$$\begin{aligned}
 A_4 &= \alpha_1^3 p^2 (\omega - q_2 E)^3 (\gamma (\alpha_1 \omega e - \alpha_1 e q_2 E + \sigma \alpha_3 - a \alpha_1 q \omega - a \alpha_1 e q_2 E) - \alpha_2 q) + \alpha_1^2 (\omega - q_2 E)^2 \\
 &\quad (2 \alpha_1 p^2 \gamma (\omega - q_2 E) (\alpha_1 \omega e - \alpha_1 e q_2 E + \sigma \alpha_3) + (\sigma + p q (d + q_1 E))) \\
 A_3 &= \alpha_1^3 p^2 \gamma \alpha_3 a (\omega - q_2 E)^2 + \alpha_1^3 p \gamma (\omega - q_2 E) (\alpha_1 e (\omega - q_2 E) + \sigma \alpha_3)^2 + r \alpha_3 (d + q_1 E) (\omega - q_2 E) \\
 &\quad + 2 \sigma \alpha_3 r q (\omega - q_2 E) + \alpha_3 r (\alpha_1 e (\omega - q_2 E) + \sigma \alpha_3) - \alpha_1 q (d + q_1 E) (\alpha_1 e (\omega - q_2 E) + \sigma \alpha_3) \\
 &\quad + (\alpha_1 e (\omega - q_2 E) + \sigma \alpha_3 - \alpha_1 a q (\omega - q_2 E)) (\alpha_1 p \gamma (\omega - q_2 E) (\alpha_1 e (\omega - q_2 E) + \sigma \alpha_3) + \alpha_1 p (\omega - q_2 E)^2 \\
 &\quad (\gamma \alpha_1 e (\omega - q_2 E) + \sigma \gamma \alpha_3 - \alpha_1 q (\omega - q_2 E))) - (\alpha_1^2 \sigma - \alpha_1^2 \alpha_2 \alpha_3 r p^2) (\omega - q_2 E)^2 - \alpha_1^2 p q^2 \sigma (\omega - q_2 E)^3 \\
 A_2 &= \alpha_1^2 \alpha_2 \alpha_3 r p^2 \sigma (\omega - q_2 E) - \alpha_1 q (\omega - q_2 E) (\alpha_1^2 \alpha_2 p e r (\omega - q_2 E)^2 + \alpha_2 \alpha_1 (\alpha_1 e (\omega - q_2 E) + \sigma \alpha_3) \\
 &\quad (\omega - q_2 E) (p r + \sigma q)) + a \alpha_1 \alpha_3 r (\alpha_1 p \gamma (\omega - q_2 E) (\alpha_1 e (\omega - q_2 E) + \sigma \alpha_3) + \alpha_1 p (\omega - q_2 E) \\
 &\quad (r \alpha_1 e (\omega - q_2 E) + r \sigma \alpha_3) - \alpha_1 q (d + q_1 E) (\omega - q_2 E) - \alpha_1^2 \sigma (\omega - q_2 E)^2) + \alpha_1 ((\alpha_1 e (\omega - q_2 E) + \sigma \alpha_3) \\
 &\quad - \alpha_1 a q (d + q_1 E) (\omega - q_2 E) ((\alpha_1 e (\omega - q_2 E) + \sigma \alpha_3)^2 + (\omega - q_2 E) (\alpha_1 \alpha_3 r (d + q_1 E) + 2 \alpha_1 \alpha_3 r \sigma q) \\
 &\quad + (\alpha_1 e (\omega - q_2 E) + \sigma \alpha_3) (d + q_1 E) (\alpha_3 r - \alpha_1 q (\omega - q_2 E)))) \\
 A_1 &= \alpha_3 r (\alpha_1^2 e \alpha_2 p r (\omega - q_2 E)^2 + \alpha_2 p r (\alpha_1 e \omega - \alpha_1 e q_2 E + \sigma \alpha_3) + \alpha_1 \sigma q (\omega - q_2 E)) \\
 &\quad - q_1 \alpha_1 \alpha_2 r e (d + q_1 E) (\omega - q_2 E)^2 + a \alpha_1 \alpha_3 r \gamma (\alpha_1 e (\omega - q_2 E) + \sigma \alpha_3)^2 + \alpha_1 \alpha_3 (d + q_1 E) (\omega - q_2 E) \\
 &\quad + 2 r q \sigma \alpha_3 (\omega - q_2 E) + \alpha_3 r (d + q_1 E) (\alpha_1 e (\omega - q_2 E) + \sigma \alpha_3) - \alpha_1 q (d + q_1 E) (\omega - q_2 E) \\
 &\quad (\alpha_1 e (\omega - q_2 E) + \sigma \alpha_3) \\
 A_0 &= \alpha_2 \alpha_3 r^2 (\alpha_1 e \omega - \alpha_1 e q_2 E + \sigma \alpha_3) (\alpha_1 e \omega - \alpha_1 e q_2 E)
 \end{aligned}$$

Therefore, after getting the positive solution of  $x^*$  from equation (4.2), it is easy to obtain the

interior positive solution of  $y^*$  and  $z^*$  from equations (4.1a) and (4.1b), provided

$$\frac{\omega}{q_2} > E \text{ i.e. .}$$

Now, the characteristic equation at the interior equilibrium point  $P(x^*, y^*, z^*)$  is

$$\begin{aligned}
 \text{given by} \quad f(\lambda) &= \lambda^3 + a_1 \lambda^2 + a_2 \lambda + a_3 = 0, \\
 (4.3)
 \end{aligned}$$

$$\text{where } a_1 = \alpha_3 \alpha_4 \omega + \sigma \frac{x^*}{y^*} + \gamma y^* - \frac{\alpha_2 y^* z^*}{(a + y^*)^2} + r \frac{y^*}{x^*}$$

$$\begin{aligned}
 a_2 &= \gamma \left( r \frac{y^{*2}}{x^*} + \alpha_3 \alpha_4 \omega \sigma \right) + \alpha_3 \alpha_4 \omega \left( r \frac{y^*}{x^*} + \sigma \frac{x^*}{y^*} \right) + \frac{\alpha_2 \alpha_3 \alpha_4^2 q y^*}{a + y^*} - \left( r \frac{y^*}{x^*} + \alpha_3 \alpha_4 \omega \right) \frac{\alpha_2 y^* z^*}{(a + y^*)^2} \\
 &\quad - \alpha_1 \alpha_3 \alpha_4^2 \omega p x^*
 \end{aligned}$$

$$\begin{aligned}
 a_3 &= \gamma \left( \alpha_3 \alpha_4 \omega r \frac{y^{*2}}{x^*} + p \alpha_1 \alpha_3 \alpha_4^2 \omega x^* y^* \right) + \frac{\alpha_2 \alpha_3 \alpha_4^2 \omega r q y^{*2}}{a + y^*} + \frac{\alpha_2 \alpha_3 \alpha_4^2 \omega r p y^*}{a + y^*} + \alpha_1 \alpha_3 \alpha_4^2 \omega \sigma q x^* \\
 &\quad + p \alpha_1 \alpha_3 \alpha_4^2 \omega \frac{x^{*2}}{y^*} - \left( p \alpha_1 \alpha_3 \alpha_4^2 \omega x^* + \alpha_3 \alpha_4 \omega r \frac{y^*}{x^*} \right) \frac{\alpha_2 y^* z^*}{(a + y^*)^2}.
 \end{aligned}$$

**Theorem 4.1:** *The model system (2.1) is locally stable at the interior equilibrium point  $P(x^*, y^*, z^*)$  if*

$$i) \quad \alpha_3 \alpha_4 \omega + \sigma \frac{x^*}{y^*} + \gamma y^* + r \frac{y^*}{x^*} > \frac{\alpha_2 y^* z^*}{(a + y^*)^2}$$

$$ii) \quad \gamma \left( \alpha_3 \alpha_4 \omega r \frac{y^{*2}}{x^*} + p \alpha_1 \alpha_3 \alpha_4^2 \omega x^* y^* \right) + \frac{\alpha_2 \alpha_3 \alpha_4^2 \omega r q y^* (y^* + 1)}{a + y^*} + \alpha_1 \alpha_3 \alpha_4^2 \omega x^* \left( \sigma q + p \frac{x^*}{y^*} \right) \\ > \left( p \alpha_1 \alpha_3 \alpha_4^2 \omega x^* + \alpha_3 \alpha_4 \omega r \frac{y^*}{x^*} \right) \frac{\alpha_2 y^* z^*}{(a + y^*)^2}$$

and iii)  $P\gamma^2 + Q\gamma + R > 0$  where

$$P = y^* \left( r \frac{y^{*2}}{x^*} + \alpha_3 \alpha_4 \omega \sigma \right),$$

$$Q = y^* \left( \alpha_3 \alpha_4 \omega \left( r \frac{y^*}{x^*} + \sigma \frac{x^*}{y^*} \right) + \frac{\alpha_2 \alpha_3 \alpha_4^2 q y^*}{a + y^*} - \left( r \frac{y^*}{x^*} + \alpha_3 \alpha_4 \omega \right) \frac{\alpha_2 y^* z^*}{(a + y^*)^2} - \alpha_1 \alpha_3 \alpha_4^2 \omega p x^* \right) \\ + \left( r \frac{y^{*2}}{x^*} + \alpha_3 \alpha_4 \omega \sigma \right) \left( \alpha_3 \alpha_4 \omega + \sigma \frac{x^*}{y^*} - \frac{\alpha_2 y^* z^*}{(a + y^*)^2} + r \frac{y^*}{x^*} \right) \\ + \left( \alpha_3 \alpha_4 \omega r \frac{y^{*2}}{x^*} + p \alpha_1 \alpha_3 \alpha_4^2 \omega x^* y^* \right)$$

$$R = \left( \alpha_3 \alpha_4 \omega \left( r \frac{y^*}{x^*} + \sigma \frac{x^*}{y^*} \right) + \frac{\alpha_2 \alpha_3 \alpha_4^2 q y^*}{a + y^*} - \left( r \frac{y^*}{x^*} + \alpha_3 \alpha_4 \omega \right) \frac{\alpha_2 y^* z^*}{(a + y^*)^2} - \alpha_1 \alpha_3 \alpha_4^2 \omega p x^* \right) \\ \left( \alpha_3 \alpha_4 \omega + \sigma \frac{x^*}{y^*} - \frac{\alpha_2 y^* z^*}{(a + y^*)^2} + r \frac{y^*}{x^*} \right) + \left( \frac{\alpha_2 \alpha_3 \alpha_4^2 \omega r y^* (q y^* + p)}{a + y^*} + \alpha_1 \alpha_3 \alpha_4^2 \omega \sigma q x^* \right) \\ \left( + p \alpha_1 \alpha_3 \alpha_4^2 \omega \frac{x^{*2}}{y^*} - \left( p \alpha_1 \alpha_3 \alpha_4^2 \omega x^* + \alpha_3 \alpha_4 \omega r \frac{y^*}{x^*} \right) \frac{\alpha_2 y^* z^*}{(a + y^*)^2} \right)$$

**Proof:** According to Routh-Hurwitz criterion, we know that the system is locally asymptotically stable if  $a_1 > 0$ ,  $a_3 > 0$  and  $a_1 a_2 - a_3 > 0$ , where  $a_1, a_2$  and  $a_3$  are the respective coefficient of the characteristic equation at the interior equilibrium point  $P(x^*, y^*, z^*)$ , defined earlier in the text. So, the desire result of the theorem for the stability are obtained from these conditions.

## 4.2 Bifurcation Analysis:

When a stable steady state goes through a bifurcation, it will lose its stability or may extinct. Even if the system ends up in another steady state the transition to that state will often involve the extinction of one or more level of food chain. The entire system may survive in a non-stationary state, but another bifurcation may lead to local extinction of every population. To preserve the system in its natural state, crossing bifurcation should be avoided. Thus, the estimation of critical values of the bifurcation parameter is a crucial part of the analysis of a system.

In 1994, Liu [13] derived a criterion of Hopf bifurcation without using the eigen values of the variational matrix of the interior equilibrium point.

**Liu's criterion:** *If the characteristic equation at the interior equilibrium point  $E^*(x^*, y^*, z^*)$  is given by  $\lambda^3 + a_1(\zeta)\lambda^2 + a_2(\zeta)\lambda + a_3(\zeta) = 0$  where  $a_1(\zeta)$ ,  $\Delta(\zeta) = a_1(\zeta)a_2(\zeta) - a_3(\zeta)$ ,  $a_3(\zeta)$  are smooth functions of  $\zeta$  in an open interval about  $\zeta^* \in \mathbb{R}$  such that i)  $a_1(\zeta^*) > 0$ ,  $a_3(\zeta^*) > 0$  and ii)  $\Delta(\zeta^*) = 0$  but iii)  $\left(\frac{d\Delta}{d\zeta}\right)_{\zeta=\zeta^*} \neq 0$  then a simple Hopf bifurcation occur at  $\zeta = \zeta^*$ .*

Now, we have studied the system leading to investigate the bifurcation of the system assuming  $\gamma$  as the bifurcation parameter and obtained the following result.

**Theorem 4.2:** Let us assume that the positive equilibrium point is locally asymptotically stable with the condition

$$\begin{aligned} & \alpha_3\alpha_4\omega\left(r\frac{y^*}{x^*} + \sigma\frac{x^*}{y^*}\right) + \frac{\alpha_2\alpha_3\alpha_4^2qy^*}{a+y^*} + \alpha_1\alpha_3\alpha_4^2\omega px^*\left(\alpha_3\alpha_4\omega + \sigma\frac{x^*}{y^*} - \frac{\alpha_2y^*z^*}{(a+y^*)^2} + r\frac{y^*}{x^*}\right) \\ & + p\alpha_1\alpha_3\alpha_4^2\omega\frac{x^{*2}}{y^*}\left(\frac{\alpha_2\alpha_3\alpha_4^2\omega r q y^{*2}}{a+y^*} + \frac{\alpha_2\alpha_3\alpha_4^2\omega r p y^*}{a+y^*} + \alpha_1\alpha_3\alpha_4^2\omega\sigma q x^*\right) \\ & > \left(r\frac{y^*}{x^*} + \alpha_3\alpha_4\omega\right)\frac{\alpha_2y^*z^*}{(a+y^*)^2}\left(\alpha_3\alpha_4\omega + \sigma\frac{x^*}{y^*} - \frac{\alpha_2y^*z^*}{(a+y^*)^2} + r\frac{y^*}{x^*}\right) \\ & + \left(\frac{\alpha_2\alpha_3\alpha_4^2\omega r q y^{*2}}{a+y^*} + \frac{\alpha_2\alpha_3\alpha_4^2\omega r p y^*}{a+y^*} + \alpha_1\alpha_3\alpha_4^2\omega\sigma q x^*\right)\left(p\alpha_1\alpha_3\alpha_4^2\omega x^* + \alpha_3\alpha_4\omega r\frac{y^*}{x^*}\right)\frac{\alpha_2y^*z^*}{(a+y^*)^2} \end{aligned}$$

then a simple Hopf bifurcation occurs at the unique positive value

$$\gamma = \gamma^* = \frac{-Q + \sqrt{Q^2 - 4PR}}{2P}, \quad P, Q \text{ and } R \text{ are given above.}$$

### 4.3 Global stability

In this section, we will use Lyapunov theorem to derive the sufficient conditions for global stability of the system at the positive equilibrium.



**Theorem 4.2:** The interior equilibrium point  $P^*(x^*, y^*, z^*)$  is globally asymptotically stable if the interior equilibrium is locally stable with

$$4ry^*xy((\alpha x^* + \gamma y^*)(a+y)(a+y^*) - \alpha_2 z^* y y^*) > x^*(a+y)(a+y^*)(ry + \alpha x)^2$$

and  $\det A > 0$ .

The square matrix  $A$  is given by

$$A = \begin{bmatrix} \frac{ry^*}{xx^*} & -\frac{1}{2}\left(\frac{r}{x} + \frac{\sigma}{y}\right) & \frac{1}{2}(\alpha_1 - pz^*\Phi) \\ -\frac{1}{2}\left(\frac{r}{x} + \frac{\sigma}{y}\right) & \left(\frac{\alpha x^*}{yy^*} + \gamma - \frac{\alpha_2 z^*}{(a+y)(a+y^*)}\right) & \frac{1}{2}(\alpha_2 - qz^*\Phi) \\ \frac{1}{2}(\alpha_1 - pz^*\Phi) & \frac{1}{2}(\alpha_2 - qz^*\Phi) & \frac{\omega\alpha_3\Phi}{q_2E} \end{bmatrix}$$

$$\text{where } \Phi = \frac{1}{(px + qy + e)(px^* + qy^* + e)}.$$

**Proof:** To show the global stability of the system (2.1) let us construct a suitable Lyapunov function

$$V(x, y) = l_1 \left[ (x - x^*) - x^* \log\left(\frac{x}{x^*}\right) \right] + l_2 \left[ (y - y^*) - y^* \log\left(\frac{y}{y^*}\right) \right] + l_3 \left[ (z - z^*) - z^* \log\left(\frac{z}{z^*}\right) \right] \quad (6.1)$$

where  $l_1, l_2$  and  $l_3$  are suitable constants to be determined in the subsequent steps. It can be easily verified that the function  $V$  is zero at the equilibrium  $(x^*, y^*, z^*)$  and is positive for all other positive values of  $x$  and  $y$ . The time derivative of  $V$  along the trajectories of (2.1) is

$$\begin{aligned} \frac{dV}{dt} &= (x - x^*) \left[ r \left( \frac{y}{x} - \frac{y^*}{x^*} \right) - \alpha_1 (z - z^*) \right] + (y - y^*) \left[ \sigma (x - x^*) - \alpha_2 \left( \frac{z}{a+y} - \frac{z^*}{a+y^*} \right) - \gamma (y - y^*) \right] \\ &\quad + \omega\alpha_3 (z - z^*) \left[ - \left( \frac{z}{px + qy + e} - \frac{z^*}{px^* + qy^* + e} \right) \right] \\ &\leq -X^T A X, \quad X = \begin{bmatrix} (x - x^*) & (y - y^*) & (z - z^*) \end{bmatrix}^T \end{aligned}$$

where  $A$  is defined above and for the stability of the system the square matrix  $A$  must be positive definite and this ensures the above result.

## 5. Optimal Control Theory

In commercial exploitation of renewable resources, the fundamental problem from the economic point of view is to determine the optimal trade-off between present and future harvests. It is observed that the marine fishery sector become more important not only for domestic purpose but also from the imperatives of exports. The emphasis of this section is on the profit-making aspect of fisheries. It is an elaborate study of the optimal harvesting policy and the profit earned by harvesting, focusing on the conservation of fish population by constraining to always stay above a critical threshold.

In this section our goal is to optimize (maximize) the total discount net revenue from the fishery. It is assumed that price is a function which decreases with increasing biomass. Symbolically our strategy is to maximize the total discounted net revenues from the system like fishery. Let  $p_i, i = 1, 2$  are the constant price per unit biomass of mature prey and the predator respectively and  $-v_i, i = 1, 2$  represent the decline of their price in presence of sufficient harvested biomass and  $c$  be the constant fishing cost per unit effort. As the rate of selling price decreases in abundance of every species, we consider the economic revenue from each population in the form  $(p_i - v_i h)h, i = 1, 2$ ,  $h$  is the amount of harvested biomass of each species. Thus, the net economic revenue to the fishermen is

$$(p_1 - v_1 q_1 E y) q_1 E y + (p_2 - v_2 q_2 E z) q_2 E z - cE$$

.

Our strategy is to maximize the present value  $J$  which is to be formulated as:

$$J(E) = \int_{t_0}^{t_f} e^{-\delta t} [(p_1 - v_1 q_1 E y) q_1 E y + (p_2 - v_2 q_2 E z) q_2 E z - cE] dt$$

$\delta$  is the instantaneous annual discount rate.

The problem is subjected to the population equation (2.1) and the control constants  $0 \leq E \leq E_{\max}$  can be solved by the Pontryagin's Maximum principle. The convexity of the objective function with respect to  $E$ , the linearity of the differential equations in the control and the compactness of the range values of the state variables can be combined to give existence of the optimal control. Suppose  $E_\delta$  is an optimal control with the corresponding states  $x_\delta, y_\delta$  and  $z_\delta$ . We are seeking to derive the optimal control  $E_\delta$  such that:

$$J(E_\delta) = \max \{J(E) : E \in U\},$$

Where  $U$  is the control set defined by:

$$U = \{E : [t_0, t_f] \rightarrow [0, E_{\max}] \mid E \text{ is Lebesgue measurable}\}.$$

The Hamiltonian of this control problem is

$$H = [(p_1 - v_1 q_1 E y) q_1 E y + (p_2 - v_2 q_2 E z) q_2 E z - c E] + \lambda_0 [r y - \sigma x - \alpha_1 x z] \\ + \lambda_1 \left[ \sigma x - \frac{\alpha_2 y z}{a + y} - \gamma y^2 - d y - q_1 E y \right] + \lambda_2 \left[ \omega x \left( 1 - \frac{\alpha_3 z}{p x + q y + e} \right) - q_2 E z \right]$$

where  $\lambda_i(t_f), i=0,1,2$  the adjoint variable and adjoint equations are given below: The transversality conditions give  $\lambda_i(t) = 0, i = 0,1,2$  and it is possible to find the characterization of the optimal control  $E_\delta$ . On the set  $\{t \mid 0 < E_\delta(t) < E_{\max}\}$ , we have at  $E = E_\delta(t)$ ,

$$\frac{\partial H}{\partial E} = ((p_1 - 2v_1 q_1 E y) q_1 y + (p_2 - 2v_2 q_2 E z) q_2 z) - c - \lambda_1 q_1 y - \lambda_2 q_2 z = 0 \quad \text{which gives}$$

$$E_\delta = \frac{(p_1 - \lambda_1) q_1 y_\delta + (p_2 - \lambda_2) q_2 z_\delta - c}{2(v_1 q_1^2 y_\delta^2 + v_2 q_2^2 z_\delta^2)}.$$

Now the adjoint equations at the optimal equilibrium point are

$$\frac{d\lambda_0}{dt} = \delta \lambda_0 - \frac{\partial H}{\partial x} = (\delta + \sigma + \alpha_1 z) \lambda_0 - \sigma \lambda_1 - \frac{\omega \alpha_3 p z^2}{(p x + q y + e)^2} \lambda_2$$

$$\frac{d\lambda_1}{dt} = \delta \lambda_1 - \frac{\partial H}{\partial y} = -r \lambda_0 + \left( \delta + \frac{a \alpha_2 z}{(a + y)^2} + d + 2\gamma y + q_1 E \right) \lambda_1 - \frac{\omega \alpha_3 q z^2}{(p x + q y + e)^2} \lambda_2 - (p_1 - 2v_1 q_1 E y) q_1 E$$

$$\frac{d\lambda_2}{dt} = \delta \lambda_2 - \frac{\partial H}{\partial z} = \alpha_1 x \lambda_0 + \frac{\alpha_2 y}{(a + y)} \lambda_1 + \left( \delta - \omega + \frac{2\omega \alpha_3 z}{(p x + q y + e)} + q_2 E \right) \lambda_2 - (p_2 - 2v_2 q_2 E z) q_2 E$$

Thus, we have established the existence of an optimal equilibrium solution that satisfies the necessary conditions of the maximum principle.

In this regard, it is to be noted that we have formulated the optimal control problem through considering fishing effort as control parameter and the optimal control problem will be numerically solved using a forward-backward sweep technique of 4<sup>th</sup> order Runga–Kutta method to pursue numerical simulations in the next section. Therefore, we can write the following theorem based on the above analysis:

**Theorem 4.3:** There exist an optimal control  $E_\delta$  and corresponding solutions  $x_\delta, y_\delta$  and  $z_\delta$  that maximizes  $J(E)$  over  $U$ . Furthermore, there exist adjacent functions  $\lambda_0, \lambda_1$  and  $\lambda_2$  satisfying the above-mentioned equations with transversality conditions  $\lambda_i(t_f) = 0, i = 0,1,2$ . Moreover, the optimal control is given

$$\text{by } E_\delta = \frac{(p_1 - \lambda_1) q_1 y_\delta + (p_2 - \lambda_2) q_2 z_\delta - c}{2(v_1 q_1^2 y_\delta^2 + v_2 q_2^2 z_\delta^2)}.$$

## 6. Numerical Simulation and Numerical Analysis:

It is quite difficult to have numerical value of the parameters of the system based on real world observations. As our present work is not a case study, no real-world data is available. Hence for the purpose of simulation, we have used a simulated set of parameters in appropriate units. The main features described by the simulations presented in this section should be considered from a qualitative, rather than a quantitative point of view. MATLAB and Mathematica are the main software used for the purpose of simulation experiments. For the purpose of simulations, we consider the following set of simulated parameters:

$$\tilde{P} = \{r = 0.85; \sigma = 0.632; \alpha_1 = 0.005; a = 5; \alpha_2 = 0.535, \gamma = 0.011; q_1 = 0.05; q_2 = 0.02; E = 0.065; \omega = 0.15; \alpha_3 = 0.12; p = 0.035; q = 0.129; e = 0.156\}.$$

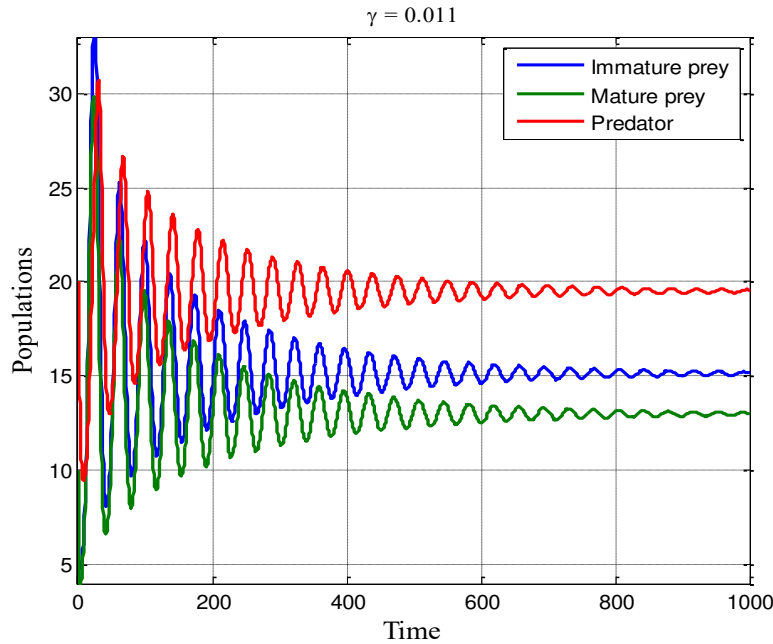
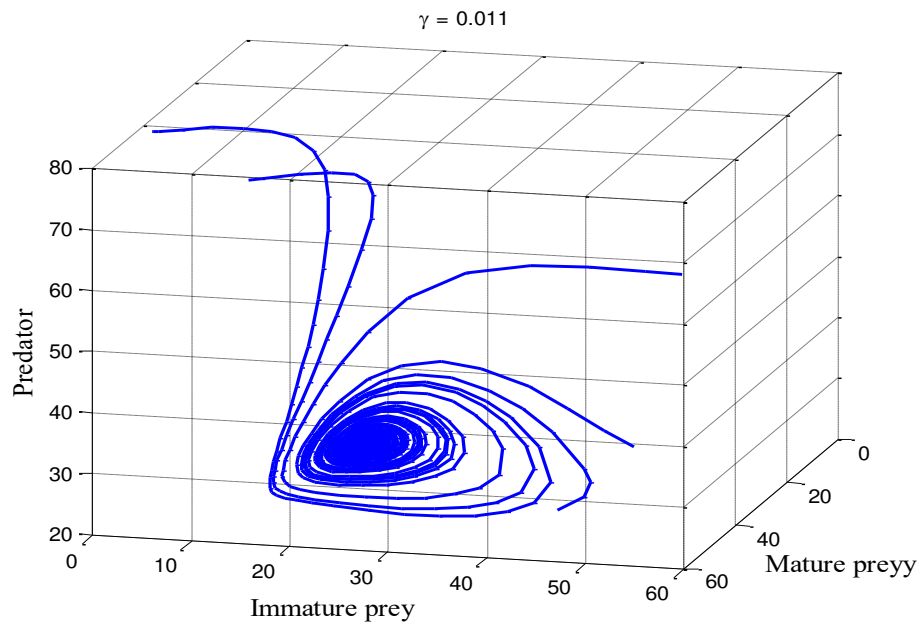
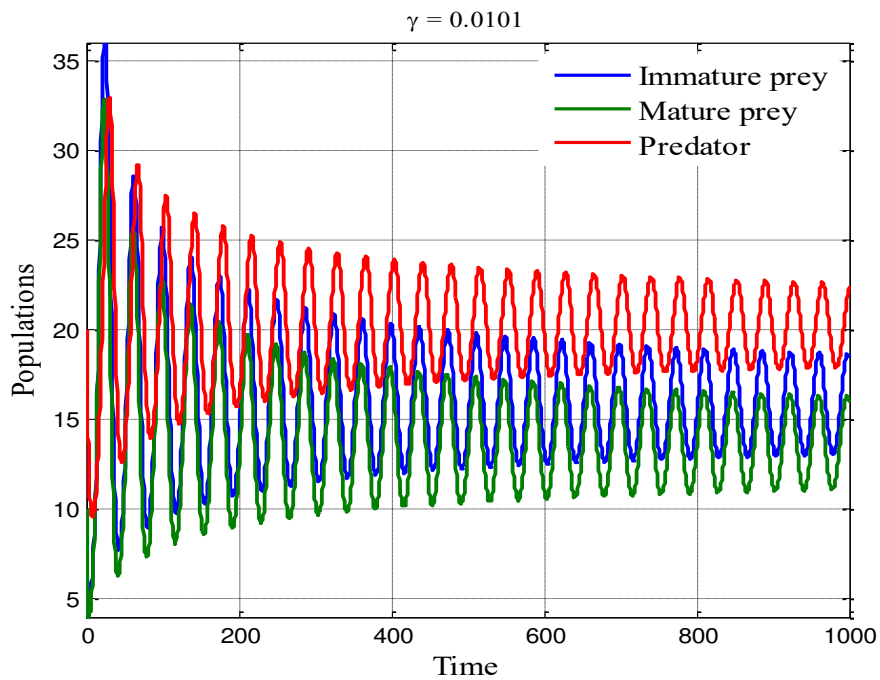


Figure 1: Solution curves of immature prey population, mature prey population and predator population with time when  $\gamma = 0.011$ .

The interior coexistence equilibrium with respect to this parameter set is  $P^*(15.6157, 13.4616, 20.1497)$  which is stable. The time plot of the populations in Figure 1 shows that the system is stable with respect to the above parameter set. Absence of limit cycle in the corresponding phase plot in Figure 2 confirms this stability.



**Figure 2:** Phase plane trajectories of different biomasses with the different initial levels when  $\gamma = 0.011$ .



**Figure 3:** Solution curves of immature prey population, mature prey population and predator population with time when  $\gamma = 0.0101$ .

Next, we try to establish bifurcation of the system (2.1) with respect to  $\gamma$ . We have already shown that for the value  $\gamma = 0.011$  the system is locally asymptotically stable. But if we decrease gradually the value of  $\gamma$  keeping other parameter fixed the system becomes unstable when it passes through its critical value  $\gamma^* = 0.0105$  (approx.) which is obtained from Theorem 4.2. If we consider  $\gamma = 0.0101$ , then the system near  $P^*$  loses its stability and the corresponding time plot in Figure 3 shows that the system is unstable there. There is a periodic orbit observed in the corresponding phase plane diagram in Figure 4 which confirms this instability.

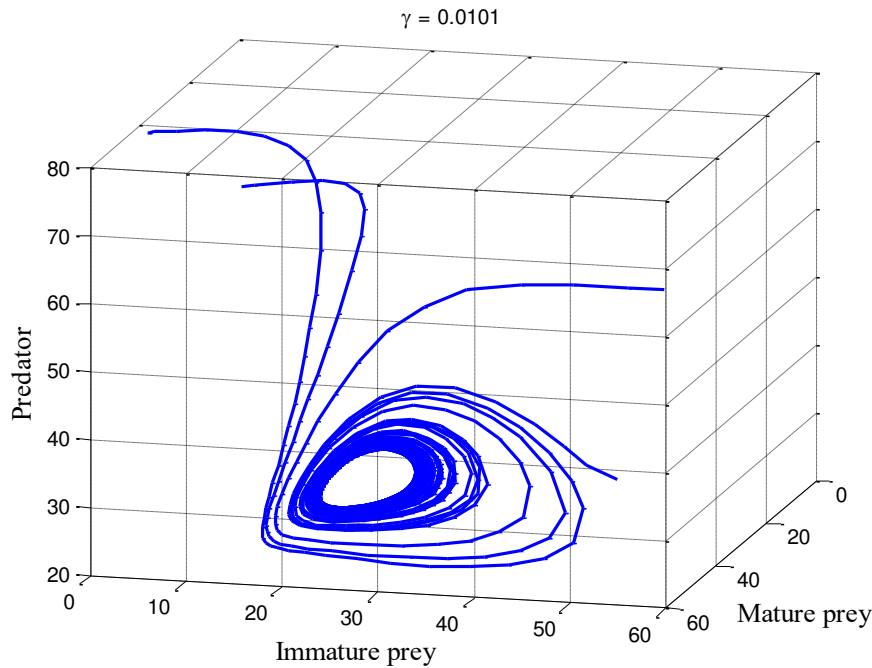


Fig.4. Phase plane trajectories of different biomasses with the different initial levels when  $\gamma = 0.0101$ .

## 7. Conclusion:

This paper deals with a prey predator fishery model incorporating the stage structure in prey population. The predator population is dependent on the prey population. One real example is the North East Antarctic Cod fishery. The NEAC is the most important cod stock in Norwegian fisheries and its main habitat is in the Barents Sea. The Barents Sea capelin is the most important prey item for the stock of NEAC in the Barents Sea, and cod is also the most important predator on capelin in this area. Barents Sea cod stock is potentially the largest cod stock in the world (Jakobsson [14]). The Barents Sea is one of the richest ocean areas. It is capable of maintaining large fish populations including cod, capelin and approximately 150 other fish species. The Barents Sea capelin population is being increasingly harvested over the recent years. As the capelin population is the main source of

food for cod, large capelin catches are bound to affect the growth of both the capelin and cod populations. Again, cod is considered as the most valuable predator. It may be noted that we expect a greater harvest of cod than capelin. However, we need to consider the value of the prey eaten by the predator. Therefore, it is necessary to control the harvesting of the populations by introducing some regulatory mechanism.

Several results are established through analyzing the system. It is established that the system is positive definite and bounded. The criterion for the existence of coexistence equilibrium is obtained. It is observed that if the biotechnical productivity (the ratio of the biotic potential ( $\omega$ ) to the catchability coefficient ( $q_2$ )) of predator population is greater than the harvesting effort then the coexistence equilibria exist. It is also observed that the system is asymptotically stable at the interior equilibrium point. The conditions for the global stability of the system around coexistence equilibria are obtained. We have also found out the value of combined harvesting effort for maximum sustainable yield.

Prey populations are competing with each other for existence which plays an important role towards achieving a sustainable ecosystem. It is clear that when density-dependent competitive coefficients for the prey population is large, both the prey and predator populations reach periodic oscillations around the equilibrium in finite time then converge to their equilibrium values. However, as the density-dependent competitive coefficients for the species decreases, oscillations also increase and generates a limit cycle, i.e., the positive steady state disappears. Decreasing rate of competition for existence of prey population leads the system unstable from stable, even may extinct. It may also be concluded that density-dependent competitive coefficients decrease the probability of extinction of the species of an ecosystem. To optimize (maximize) the total discount net revenue from the fishery, optimal control problem is solved and obtained the optimal control value of harvesting.

It may also be pointed out that in this paper several important parameters, such as ecological fluctuations, refuge, interaction with other species, tax regulation on harvesting etc., are disregarded. Hence, further research is necessary to accomplish the needs in this field.

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## A food chain model with Allee effect and time delay

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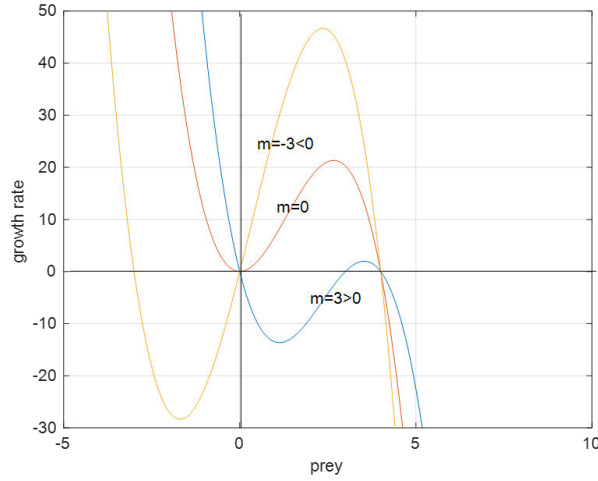
**Abstract:** *In this paper a two-dimensional food chain model is proposed where the prey species is subject to strong Allee effect. Time delay is incorporated into the model and influence of harvesting on the model is studied. Local and global stability of the interior equilibrium point and bifurcation analysis are discussed. Numerical simulations are given to support the validity of the theoretical results.*

**Keywords:** *Allee effect, delay, food chain, harvesting, Hopf-bifurcation*

**1. Introduction:** Allee effect has crucial importance for ecological conservancy and management because it is strongly related to population extinction. It has also a great influence on many endangered species. There are two main types of Allee effects, depending how strong the per capita growth rate is depleted at low population size. In strong Allee effect (see Fig. 1) or critical depensation [1], a critical density exists below which per capita growth rate is negative and extinction tends to occur. The critical population is often called Allee threshold. In weak Allee effect (see Fig.1) or pure depensation [1], there does not exist a threshold that must be surpassed by a population to grow. After the pioneering work of Allee ([2], [3]), many scientists introduce Allee effects into the models they are dealing with ([4], [5], [6], [7]).

In the food chain model, the growth rate of any species is not instantaneous. Some time lag is required, called delay [8] (for example, gestation period or time required to become adult from juvenile). So, the models with delay are more realistic than ordinary models such as ([9], [10]).

For economic interest, people carry out harvesting of the species resource which have great economic value. This may lead to the population extinction. So, for the consideration of the harvesting model the aim is to determine how much species can be harvested maintain the sustainability of the population. Models with harvesting have been studied by many scientists ([11], [12], [13], [14]).



**Fig.1.** The growth function of the prey in the absence of predator. The weak Allee effect (for  $m = -3$  and  $m = 0$ ) and strong Allee effect (for  $m = 3$ ) are shown.

## 2. Model Formulation:

We consider a prey-predator food chain model where a multiplicative Allee effect in prey population growth is considered as follows:

$$\frac{dx}{dt} = r_1 x \left(1 - \frac{x}{k}\right) (x - m) - \frac{a_1 xy}{x + k_1} - c_1 x$$

$$\frac{dy}{dt} = y \left[ r_2 - \frac{a_2 y(t-\tau)}{x(t-\tau) + k_2} \right] - c_2 y$$

2.1

with initial conditions:  $x(\theta), y(\theta) \geq 0, \theta \in [-\tau, 0)$  and  $x(0) > 0, y(0) > 0$  where  $x$  and  $y$  represent the population densities of prey and predator at time  $t$ .  $r_1, r_2$  are intrinsic growth rate of prey and predator and  $k, k_2$  denote respective carrying capacities.  $m$  represents Allee threshold for the prey.  $a_1$  is the maximal consumption rate of the predator and  $k_1$  is the half saturation level,  $a_2$  is a constant.  $c_1, c_2$  are the harvesting coefficients of prey and predator respectively.  $\tau$  represents the time delay for the predator population.

### 2.1. Existence of Equilibrium points and Stability.

The most important equilibrium for a two species population is the coexistence of the species. So, we consider the interior equilibrium point  $P(x^*, y^*)$  which is the

coexistence of predator and prey where  $y^* = \frac{(r_2 - c_2)(x^* + k_2)}{a_2}$  and  $x^*$  is the positive root of the equation

$$Q_1 x^3 + Q_2 x^2 + Q_3 x + Q_4 = 0 \text{ where}$$

$$Q_1 = a_2 r_1$$

$$Q_2 = a_2 r_1 \left( \frac{kk_1 - m - k}{k} \right)$$

$$Q_3 = a_2 r_1 \left( \frac{mk - mk_1 - kk_1}{k} \right) + a_1(r_2 - c_2) + a_2 c_1$$

$$Q_4 = a_2 r_1 m k_1 + a_1(r_2 - c_2)k_2 + a_2 c_1 k_1$$

We see that  $Q_1 > 0$  and  $Q_4 > 0$  always. If  $Q_2 > 0$  as well as  $Q_3 > 0$  then no positive roots exist, otherwise there always exist two positive roots.

### Case 1. $\tau = 0$ .

Introducing perturbations  $x(t) = X(t) + x^*$ ,  $y(t) = Y(t) + y^*$  in (2.1) and neglecting 2<sup>nd</sup> and higher order products of  $X(t)$  and  $Y(t)$ , still denoting  $X(t)$  and  $Y(t)$  by  $x(t)$  and  $y(t)$  respectively, we get

$$\frac{dx}{dt} = \alpha x(t) + \beta y(t)$$

$$\frac{dy}{dt} = \gamma x(t) + \delta y(t) \quad (2.2)$$

$$\text{Where } \alpha = \frac{r_1(m+k-2x^*)x^*}{k} + \frac{a_1 x^* y^*}{(x^* + k_1)^2}, \quad \beta = -\frac{a_1 x^*}{x^* + k_1}, \quad \gamma = \frac{a_2 y^{*2}}{(x^* + k_2)^2}, \quad \delta = -\frac{a_2 y^*}{x^* + k_2}$$

Hence the Jacobian matrix at  $P^*(x^*, y^*)$  for the linearized system (2.2) is

$$J(x^*, y^*) = \begin{pmatrix} \alpha & \beta \\ \gamma & \delta \end{pmatrix}$$

The characteristic equation of the linearized system (2.2) is given by

$$\lambda^2 - p\lambda + q = 0 \quad (2.3)$$

$$\text{where } p = \text{trace } J(x^*, y^*) = \alpha + \delta,$$

$$q = \det J(x^*, y^*) = \alpha\delta - \beta\gamma. \quad (2.4)$$

$$\text{Thus, } p = -\frac{r_1\{2x^*-(m+k)\}x^*}{k} + \left[ \frac{a_1x^*}{(x+k_1)^2} - \frac{a_2}{x^*+k_2} \right] y^*$$

$$q = \frac{r_1\{2x^*-(m+k)\}x^*}{k} + \frac{a_1a_2(k_1-k_2)x^*y^{*2}}{(x^*+k_1)^2(x^*+k_2)^2}$$

$p < 0$  if  $x^* > \frac{m+k}{2}$  and  $a_2 > \max\left\{a_1, \frac{a_1k_2}{2k_1}\right\}$ . Also  $q > 0$  if  $k_1 \geq k_2$  and  $x^* > \frac{m+k}{2}$ .

Hence, we have the following theorem.

**Theorem 2.1** The interior equilibrium point  $P(x^*, y^*)$  of the system (2.1) will be asymptotically stable whenever  $(x^*, y^*)$  lies in the region  $x > \frac{m+k}{2}$  and  $k_1 \geq k_2$  and  $a_2 > \max\left\{a_1, \frac{a_1k_2}{2k_1}\right\}$ .

Now we discuss the global stability of the system (2.1). Let us consider the system (2.1) without delay as  $\frac{dx}{dt} = F(x, y)$ ,  $\frac{dy}{dt} = G(x, y)$  where

$$F(x, y) = r_1x\left(1 - \frac{x}{k}\right)(x - m) - \frac{a_1xy}{x+k_1} - c_1x,$$

$$G(x, y) = y\left[r_2 - \frac{a_2y}{x+k_2}\right] - c_2y$$

Let us choose the function  $H(x, y) = \frac{1}{xy}$ . Then,

$$HF = \frac{r_1}{y}x\left(1 - \frac{x}{k}\right)(x - m) - \frac{a_1}{x+k_1} - \frac{c_1}{y}$$

$$HG = \frac{r_2}{x} - \frac{a_2y}{x(x+k_2)} - \frac{c_2}{x} \quad \text{and}$$

$$\begin{aligned} \Delta &= \frac{\partial}{\partial x}(HF) + \frac{\partial}{\partial y}(HG) \\ &= -\frac{r_1}{ky}\{2x - (m+k)\} - \frac{(a_2 - a_1)x^2 + (2a_2k_1 - a_1k_2)x + a_2k_1^2}{x(x+k_1)(x+k_2)} \end{aligned}$$

According to the condition of local asymptotic stability,  $\Delta < 0$ . Therefore, by the Bendixson-Dulac criteria, there will be no limit cycle around the interior equilibrium point  $P^*(x^*, y^*)$  of the system (2.1) and this proves that the model (2.1) is globally asymptotically stable in the region  $x > \frac{m+k}{2}$  and  $k_1 \geq k_2$  and  $a_2 > \max\left\{a_1, \frac{a_1k_2}{2k_1}\right\}$ .

Hence, we may state the following theorem.

**Theorem2.2.** Whenever the equilibrium point  $P(x^*, y^*)$  lies in the region  $x > \frac{m+k}{2}$  and  $k_1 \geq k_2$  and  $a_2 > \max\left\{a_1, \frac{a_1 k_2}{2k_1}\right\}$  which is locally asymptotically stable then it is globally asymptotically stable.

**Case2.  $\tau \neq 0$**

**Theorem2.3:** The equilibrium  $E^*(x^*, y^*)$  of the system (2.1) is asymptotically stable for  $\tau < \tau_0$  and unstable for  $\tau > \tau_0$ . Further as  $\tau$  increases through  $\tau_0$ ,  $E^*(x^*, y^*)$  bifurcates into small amplitude periodic solutions.

**Proof:** Let us consider the linearized system (2.2) with delay as

$$\begin{aligned} \frac{dx}{dt} &= \alpha x(t) + \beta y(t) \\ \frac{dy}{dt} &= \gamma x(t - \tau) + \delta y(t - \tau) \end{aligned} \quad (2.5)$$

where  $\alpha, \beta, \gamma, \delta$  are given by (2.2). The characteristic equation of (2.5) is

$$\lambda^2 + A\lambda + (B + C\lambda)e^{-\lambda\tau} = 0 \quad (2.6)$$

Where

$$A = -\alpha, \quad B = \alpha\delta - \beta\gamma, \quad C = -\delta.$$

(2.7)

Substituting  $\lambda = \mu(\tau) + i\omega(\tau)$  in (2.6) and separating real and imaginary parts, we get

$$\begin{aligned} \mu^2 - \omega^2 + A\mu + (B + C\mu)e^{-\mu\tau} \cos \omega\tau + C\omega e^{-\mu\tau} \sin \omega\tau &= 0 \\ 2\mu\omega + A\omega - (B + C\mu)e^{-\mu\tau} \sin \omega\tau + C\omega e^{-\mu\tau} \cos \omega\tau &= 0 \end{aligned} \quad (2.8)$$

Here  $\lambda, \mu, \omega$  are functions of  $\tau$ . Now we will examine the change of stability of  $P(x^*, y^*)$  which occurs at the values of  $\tau$  for which  $\mu(\tau) = 0$  and  $\omega(\tau) \neq 0$ . Let for  $\tau = \tau_0$ ,  $\mu(\tau_0) = 0$  and  $\omega(\tau_0) = \omega_0 \neq 0$ , then (2.8) becomes

$$\begin{aligned} B \cos \omega_0 \tau_0 + C\omega_0 \sin \omega_0 \tau_0 - \omega_0^2 &= 0, \\ C\omega_0 \cos \omega_0 \tau_0 - B \sin \omega_0 \tau_0 + A\omega_0 &= 0. \end{aligned} \quad (2.9)$$

Squaring and adding the above two equations, we get

$$\omega_0^4 + (A^2 - C^2)\omega_0^2 - B^2 = 0. \quad (2.10)$$

Positive root of the equation (2.10) is given by

$$\omega_0^2 = \frac{1}{2} \left[ (\delta^2 - \alpha^2) + \sqrt{(\delta^2 - \alpha^2)^2 + 4(\alpha\delta - \beta\gamma)^2} \right]. \quad (2.11)$$

Again from (2.9), we get

$$\tan \omega_0 \tau_0 = \frac{C\omega_0^2 + AB}{(B - AC)\omega_0}. \quad (2.12)$$

Solving for  $\tau_0$ , we get

$$\tau_{0n} = \frac{1}{\omega_0} \arctan \left[ \frac{C\omega_0^2 + AB}{(B-AC)\omega_0} \right] + \frac{2n\pi}{\omega_0}, \quad (2.13)$$

where  $n = 0, 1, 2, 3, \dots$

The smallest  $\tau_0$ , is obtained by choosing  $n = 0$  (denoting  $\tau_{00} = \tau_0$ ), then from (2.13), we get

$$\tau_0 = \frac{1}{\omega_0} \arctan \left[ \frac{C\omega_0^2 + AB}{(B-AC)\omega_0} \right] = \frac{1}{\omega_0} \arctan \left[ \frac{\delta\omega_0^2 + \alpha(\alpha\delta - \beta\gamma)}{\beta\gamma\omega_0} \right]. \quad (2.14)$$

We now show that

$$\left. \frac{d\mu(\tau)}{d\tau} \right|_{\tau=\tau_0} > 0. \quad (2.15)$$

This will signify that there will be at least one eigen value with positive real part for  $\tau > \tau_0$ . Moreover, the condition for Hopf bifurcation is then satisfied yielding the required periodic solution. Now differentiating (2.6) with respect to  $\tau$ , we get

$$\left( \frac{d\lambda}{d\tau} \right)^{-1} = -\frac{2\lambda + A}{\lambda(\lambda^2 + A\lambda)} + \frac{C}{\lambda(B + C\lambda)} - \frac{\tau}{\lambda}.$$

Thus sign of  $\left[ \frac{d(Re \lambda)}{d\tau} \right]_{\lambda=i\omega_0} = \text{sign of} \left[ Re \left( \frac{d\lambda}{d\tau} \right)^{-1} \right]_{\lambda=i\omega_0}$

$$\text{Now, } Re \left( \frac{d\lambda}{d\tau} \right)^{-1} = Re \left[ -\frac{2i\omega_0 + A}{i\omega_0(-\omega_0^2 + iA\omega_0)} + \frac{C}{i\omega_0(B + Ci\omega_0)} - \frac{\tau}{i\omega_0} \right]$$

$$= \frac{2\omega_0^2 + A^2}{\omega_0^2(\omega_0^2 + A^2)} - \frac{C^2}{B^2 + C^2\omega_0^2}$$

$$= \frac{C^2\omega_0^4 + 2B^2\omega_0^2 + A^2B^2}{\omega_0^2(\omega_0^2 + A^2)(B^2 + C^2\omega_0^2)}.$$

(2.16)

Therefore

$$\left[ \frac{d(Re \lambda)}{d\tau} \right]_{\lambda=i\omega_0} = \left. \frac{d\mu(\tau)}{d\tau} \right|_{\tau=\tau_0} > 0. \quad (2.17)$$

Therefore, the transversality condition holds, hence Hopf bifurcation occurs at  $\omega = \omega_0, \tau = \tau_0$ .

Thus, the Hopf bifurcating periodic solution arising at the parametric relation  $\tau = \tau_0$ .

### 3. The effect of harvesting.

Now we discuss the influence of harvesting on the system (2.1), in three different aspects.

#### Case1: Only prey species is harvested.

Since only prey species is harvested, so in this case  $c_2 = 0$ . Then the interior equilibrium point  $P(x^*, y^*)$  changes to  $P_1(x_1^*, y_1^*)$ , where  $x_1^*$  is a positive root of

$$Q_{11}x^3 + Q_{21}x^2 + Q_{31}x + Q_{41} = 0 \text{ and } y_1^* = \frac{r_2(x_1^* + k_2)}{a_2} \text{ where}$$

$$Q_{11} = a_2 r_1$$

$$Q_{21} = a_2 r_1 \left( \frac{kk_1 - m - k}{k} \right)$$

$$Q_{31} = a_2 r_1 \left( \frac{mk - mk_1 - kk_1}{k} \right) + a_1 r_2 + a_2 c_1$$

$$Q_{41} = a_2 r_1 mk_1 + a_1 r_2 + a_2 c_1 k_1$$

Obviously  $x_1^*$  and  $y_1^*$  are all continuous differentiable function of the harvesting parameter

$$c_1 \text{ and } \frac{dx_1^*}{dc_1} = - \frac{a_2(x_1^* + k_1)}{3Q_{11}x_1^{*2} + 2Q_{21}x_1^* + Q_{31}}, \frac{dy_1^*}{dc_1} = - \frac{r_2(x_1^* + k_1)}{3Q_{11}^2 + 2Q_{21}x_1^* + Q_{31}}$$

Let us consider

**H1:** If  $3Q_{11}^2 + 2Q_{21}x_1^* + Q_{31} > 0$ , then  $\frac{dx_1^*}{dc_1} < 0$  and  $\frac{dy_1^*}{dc_1} < 0$ , then both the species decrease with the increase of harvesting of prey species.

**H2:** If  $3Q_{11}^2 + 2Q_{21}x_1^* + Q_{31} < 0$ , then  $\frac{dx_1^*}{dc_1} > 0$  and  $\frac{dy_1^*}{dc_1} > 0$ , then both the species increase with the increase of harvesting of prey species.

#### Case2: Only predator species is harvested.

Since only prey species is harvested, so in this case  $c_1 = 0$ . Then the interior equilibrium point  $P(x^*, y^*)$  changes to  $P_2(x_2^*, y_2^*)$ , where  $x_2^*$  is a positive root of

$$Q_{12}x^3 + Q_{22}x^2 + Q_{32}x + Q_{42} = 0 \text{ where}$$

$$Q_{12} = a_2 r_1$$

$$Q_{22} = a_2 r_1 \left( \frac{kk_1 - m - k}{k} \right)$$

$$Q_{32} = a_2 r_1 \left( \frac{mk - mk_1 - kk_1}{k} \right) + a_1(r_2 - c_2)$$

$$Q_{42} = a_2 r_1 m k_1 + a_1 (r_2 - c_2) k_2$$

Obviously  $x_2^*$  and  $y_2^*$  are all continuous differentiable function of the harvesting parameter  $c_2$  and

$$\frac{dx_2^*}{dc_2} = \frac{a_1(x_2^* + k_2)}{3Q_{12}x_2^{*2} + 2Q_{22}x_1^* + Q_{32}},$$

$$\frac{dy_2^*}{dc_2} = \frac{(r_2 - c_2)}{a_2} \left[ \frac{dx_2^*}{dc_2} - \frac{x_2^* + k_2}{r_2 - c_2} \right].$$

Let us consider

**H3:** If  $3Q_{12}^2 + 2Q_{22}x_1^* + Q_{32} > 0$ ,

then  $\frac{dx_2^*}{dc_2} > 0$ . Hence,  $x_2^*$  is monotone increasing function of  $c_2$ .

Two sub cases arise:

**Subcase1:** If  $\frac{dy_2^*}{dc_2} > \frac{x_2^* + k_2}{r_2 - c_2}$ , then both  $x_2^*$  and  $y_2^*$  are increasing function of  $c_2$ .

**Subcase2:** If  $\frac{dy_2^*}{dc_2} < \frac{x_2^* + k_2}{r_2 - c_2}$ , then  $x_2^*$  is increasing and  $y_2^*$  is decreasing function of  $c_2$ .

**H4:** If  $3Q_{12}^2 + 2Q_{22}x_1^* + Q_{32} < 0$ ,

then both  $\frac{dx_2^*}{dc_2} < 0$  and  $\frac{dy_2^*}{dc_2} < 0$ . Hence, both the species decrease if the harvesting of predator increase.

**Case3: When both prey and predator species are harvested.**

Let us consider for simplicity that  $c_1 = c_2 = c$ . This is called non selective harvesting. In this case let the interior equilibrium point be  $P_1(x_3^*, y_3^*)$ , where  $x_3^*$  is a positive root of

$$Q_{13}x^3 + Q_{23}x^2 + Q_{33}x + Q_{43} = 0 \text{ where}$$

$$Q_{13} = a_2 r_1$$

$$Q_{23} = a_2 r_1 \left( \frac{kk_1 - m - k}{k} \right)$$

$$Q_{33} = a_2 r_1 \left( \frac{mk - mk_1 - kk_1}{k} \right) + a_1(r_2 - c) + a_2 c$$

$$Q_{43} = a_2 r_1 m k_1 + a_1(r_2 - c)k_2 + a_2 c k_1$$



Obviously  $x_3^*$  and  $y_3^*$  are all continuous differentiable function of the harvesting parameter  $c$ . Differentiating  $x_3^*$  and  $y_3^*$  with respect to  $c$  we get

$$\frac{dx_3^*}{dc} = \frac{(a_1 - a_2)x_3^* + (a_1 - k_1 a_2)}{3Q_{13}x_3^{*2} + 2Q_{23}x_3^* + Q_{33}}, \quad \frac{dy_3^*}{dc} = \frac{(r_2 - c)}{a_2} \left[ \frac{dx_3^*}{dc} - \frac{x_3^* + k_2}{r_2 - c} \right]$$

Let us consider:

**H5:** If  $Q_2^2 < 3Q_{13}Q_{33}$  and  $a_1 > \max\{a_2, k_1 a_2\}$ ,

then both the numerator and denominator of  $\frac{dx_3^*}{dc}$  are greater than zero. Hence,  $\frac{dx_3^*}{dc} > 0$ .

Two sub cases arise:

**Subcase1:** If  $\frac{dx_3^*}{dc} > \frac{x_3^* + k_2}{r_2 - c}$ , then both  $x_3^*$  and  $y_3^*$  are monotone increasing function of  $c$ .

**Subcase2:** If  $\frac{dx_3^*}{dc} < \frac{x_3^* + k_2}{r_2 - c}$ , then  $x_3^*$  is increasing and  $y_3^*$  is decreasing function of  $c$ .

**H6:** If  $Q_2^2 > 3Q_{13}Q_{33}$  and  $a_1 < \max\{a_2, k_1 a_2\}$ ,

then both  $\frac{dx_3^*}{dc} < 0$  and  $\frac{dy_3^*}{dc} > 0$ . Hence both  $x_3^*$  and  $y_3^*$  are monotone decreasing function of  $c$ .

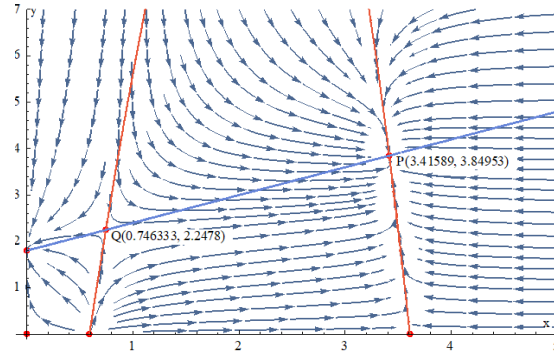
#### 4. Numerical Simulation

In this section we present some numerical simulations of the system (2.1) to verify the analytical predictions obtained in the previous sections.

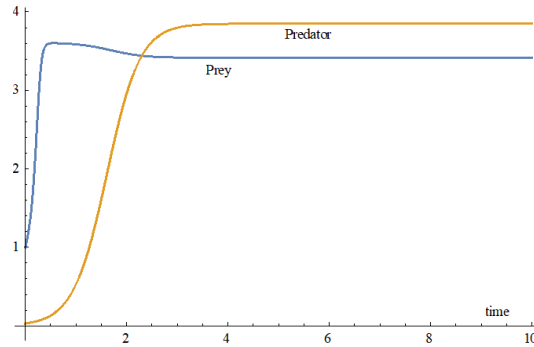
(i) Let us take  $r_1 = 9, r_2 = 7, m = 0.2, a_1 = 3, a_2 = 5, k = 4, k_1 = 6, k_2 = 3, c_1 = 3, c_2 = 4$ . Then the system (2.1) has two positive interior equilibria  $P(3.41589, 3.84953), Q(0.7463, 2.2478)$ . When  $\tau = 0$ , the interior equilibrium point  $P(3.41589, 3.84953)$  is globally asymptotically stable and the point  $Q(0.7463, 2.2478)$  is unstable (see Fig.2 and Fig.3)

(ii) We see that when only prey species is harvested that is  $c_2 = 0$ , then for  $r_1 = 9, r_2 = 7, m = 0.2, a_1 = 3, a_2 = 5, k = 4, k_1 = 6, k_2 = 3$ , H1 holds i.e., both the prey and predator population decrease when  $c_1$  increase (see Fig.4). When only predator species is harvested i.e.,  $c_1 = 0$ , then for  $r_1 = 9, r_2 = 7, m = 0.2, a_1 = 3, a_2 = 5, k = 4, k_1 = 6, k_2 = 3$ , H3 and subcase 2 hold. That is increasing the value of  $c_2$ , prey population increases and predator population decreases (see Fig. 5).

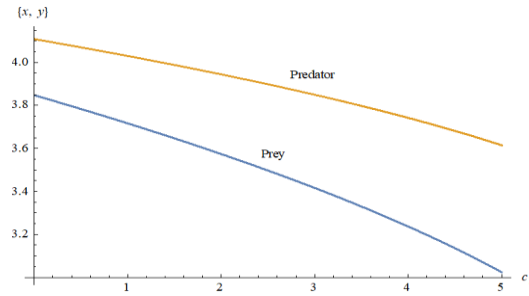
(iii) When  $\tau \neq 0$ , we get  $\omega_0 = 3.0967$  and  $\tau_0 = 0.507198$ . The positive interior equilibrium point  $P(x^*, y^*) \approx P(3.41589, 3.84953)$  is asymptotically stable when  $0 \leq \tau < \tau_0$  [see Fig. 6] more over the system becomes unstable when  $\tau > \tau_0$  [see Fig. 7].



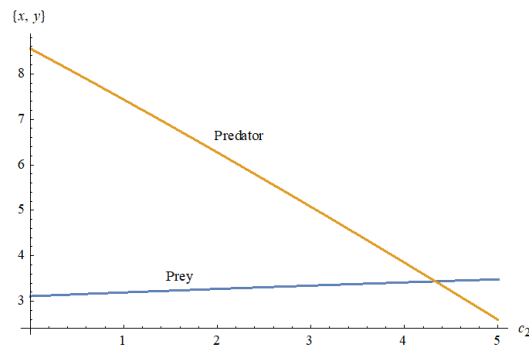
**Fig.2** For the parametric values  $r_1 = 9, r_2 = 7, m = 0.2, a_1 = 3, a_2 = 5, k = 4, k_1 = 6, k_2 = 3, c_1 = 3, c_2 = 4$  the two equilibria P and Q exist where P is stable and Q is unstable.



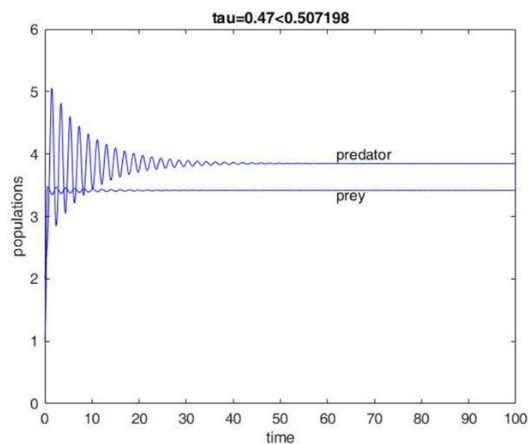
**Fig.3** For the parametric values  $r_1 = 9, r_2 = 7, m = 0.2, a_1 = 3, a_2 = 5, k = 4, k_1 = 6, k_2 = 3, c_1 = 3, c_2 = 4$  the graph shows that the point P is asymptotically stable.



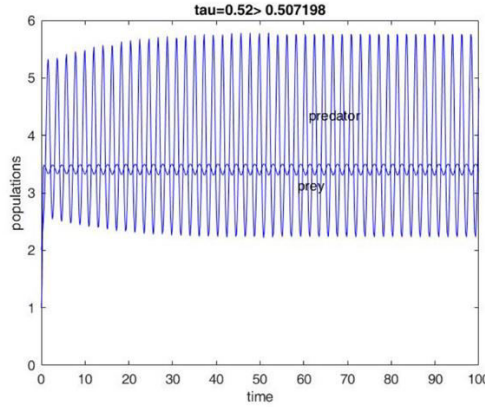
**Fig. 4** This figure shows that when  $c_2 = 0$ , then for the ascending values of  $c_1$  and for the parametric values  $r_1 = 9, r_2 = 7, m = 0.2, a_1 = 3, a_2 = 5, k = 4, k_1 = 6, k_2 = 3$  both the prey and predator population decrease.



**Fig. 5** This figure shows that when  $c_1 = 0$ , then for the ascending values of  $c_2$  and for the parametric values  $r_1 = 9, r_2 = 7, m = 0.2, a_1 = 3, a_2 = 5, k = 4, k_1 = 6, k_2 = 3$  prey population increase and predator population decrease.



**Fig.6** This figure shows that for the parametric values  $r_1 = 9, r_2 = 7, m = 0.2, a_1 = 3, a_2 = 5, k = 4, k_1 = 6, k_2 = 3, c_1 = 3, c_2 = 4$  and  $\tau = 0.47 < \tau_0 = 0.507198$  system (2.1) is stable.



**Fig.7** This figure shows that for the parametric values  $r_1 = 9, r_2 = 7, m = 0.2, a_1 = 3, a_2 = 5, k = 4, k_1 = 6, k_2 = 3, c_1 = 3, c_2 = 4$  and  $\tau = 0.52 > \tau_0 = 0.507198$  system (2.1) is unstable.

## 5. Conclusion

Recently, Allee effect has drawn considerable attention in almost every aspect of ecology and conservation. In this paper, we investigate the stability and Hopf bifurcation of a delayed predator-prey food chain model where prey species is subject to strong Allee effect. Different aspects of harvesting on the model are discussed. It is numerically and graphically verified that when only prey species is harvested, both the species decrease with the increase of capturing of prey species. Also, when only predator species is harvested, prey species increases but predator species decreases with the increase of capturing of predator species.

Attempts are made to understand the effect of delay on the stability of the system considering delay as bifurcation parameter. We see that a Hopf bifurcation occurs whenever delay increases a critical value. That means, the system is stable when delay is less than a critical value and it becomes unstable when delay crosses this critical value. This is verified numerically and graphically also.

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## Food and Power in the Food-stories of Mahasweta Devi

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**Abstract:** Negotiation of the food-ways and eating by the powerful and the powerless emerges as the distinguishing factor between two classes. An examination of the exercise of power over the act of eating reveals how power operates through food and the act of eating in the short stories of Mahasweta Devi.

**Keywords:** *class, food, oppression, power, rice, starvation*

Citing literary occurrences as instances, ranging from the *Bible* (the *Genesis*) to Dickens's *Great Expectations* and Lewis Carroll's *Alice's Adventures in Wonderland*, Mervyn Nicholson, in his article "Food and Power: Homer, Carroll, Atwood and Others" (1987), describes how food is a "power crystal" round which revolves the relationship between the divinity and the mere mortals (or the ruler and the ruled, or the powerful and the powerless) with the former allotting the latter food befitting the position of the mortal in the hierarchy of beings. Obedience to these acts of apportioning marks an acceptance of one's own place in this order, whereas disobedience to these—as in the case of Adam and Eve—becomes an archetypal crime punishable without mercy. Strict adherence to the rule of obedience in terms of food is of paramount importance, because food "is the material means of growth, where growth may be defined as gaining power" (39): a threatening phenomenon for the ruler/ the powerful/ the divinity. In Mahasweta's stories like "Rice" ("Bhaat", First pub. in 1975), "Rice" ("Bhaat", First pub. in 1982), "Salt" ("Noon", First pub. in 1978), "Fish" ("Maachh", First pub. in 1978), "Flood" ("Baan", First pub. in 1968), "Birthday Party" ("Janmatithi", First pub. in 1975) and "The Fairy Tales of Mohanpur" ("Mohanpurer Rupkatha", First pub. in

1978), where the issues of food, hunger and eating remain at the centre of the story, it is the rich and the powerful who regulate, control and manipulate what the poor, the hapless, the beggar, the refugees from the flood, the tramp, the ones at the margin of the casteist Indian society eat and how they do that. The powerless either starve or die, or over-eat and die or are left greatly disappointed when their hope for a good meal is shattered by the heartlessness of the rich and the wealthy. Having no clout in the ways of food-and-eating these hapless people yearn for a good meal and frequently take recourse to fantasies of food. Sometimes they make an act of solitary revolt by stealing from the master or the rich, an act that only reveals desperation rather than determination and courage on the part of this deprived lot. Sometimes they give up their struggle for a hearty meal and are left at the mercy of the powerful. Negotiation of the food and the act of eating by these two different sets of people emerges as the distinguishing factor between the two classes: the powerful and the powerless. An examination of the exercise of power over the act of eating reveals how power operates through food-ways and eating in the short stories of Mahasweta Devi. This paper seeks to examine how the powerful sometimes a) monopolizes access to certain food-items to assert power over the powerless, b) determines which food remains to be a luxury for the powerless and thereby marks that food as the sole privilege of the powerful (rice, ghee and fish for instance), c) allows the powerless to feed only when it is connected to some mean benefit of the rich (the tantric cult of feeding a hapless to save an ailing rich patriarch in the short story “Rice” pub. in 1975), and d) regulates the psychological world of the powerless by inducing fantasies of food in them (“Rice” pub. in 1982, “Flood”, “Fish”, “Birthday Party”, and “The Fairy Tales of Mohanpur”). The paper seeks to foreground the significance of food and eating in delineating the subaltern existence of Mahasweta’s characters.

**“Not by hand, or by bread, *nimak se marega* –I’ll kill you by salt...”:  
Monopolizing over food in “Salt”**

Published in the year 1978, “Salt” tells a strange story of deprivation where the people of a village of indigenous tribes are barred from purchasing salt by the local

money-lender, Uttamchand Bania. Uttamchand does that for resisting him from extorting wage-less labour from the *adivasis* – something he considers he is entitled to by tradition of this region. Being the wholesale distributor of grocery items as well as the most wealthy and influential person of the Jhujar belt, an area surrounding the village Jhujar in the Palamau Reserve Forest, the bania forbids every grocer of the region not to sell salt to the rebellious people from the Jhujar village. The effect of this blockade turns painful for the village people, whose *khato*—the traditional country-wine the indigenous people of that region prepare and drink as their staple beverage—turns tasteless without salt in it. The other health hazards appear gradually as the sudden disappearance of essential minerals due to the absence of salt from their diet starts making them delirious, cramped in the muscles and weak in their gait and work. When all means fail to give access to salt, a handful of them, driven to desperation, meddle with the nature: they start stealing salt from the salt-pits deep into the forest that are stocked up by the forest department for the wild elephants of the reserve forest. This brings the desperate *adivasis* to a confrontation with nature, which is something they customarily avoid under normal circumstances. A rogue tasker marks out the thieves in their act and with its superior intelligence and patience hunts them down. Eventually the tasker also has to be put down by government order and the village elder, a person who can see the flow of events from the blockade of the bania, rues that all the lives that are lost, including that of the elephant, are just because of mere salt (one of the cheapest of food articles in India). The story is a commentary upon the exploitation and extortion that the hapless, marginal indigenous people of the forest have to bear in the independent India under the very nose of a democratically elected government. But, besides that, “Salt” underlines how an act of oppression can be carried out by regulating the ways of eating of a clan that is too powerless to stand up to the forces of oppression. Salt, despite being one of the cheapest of commodities in India, can act as a weapon of punishment in the hands of the powerful and can easily create havoc in the lives of the marginal and the powerless, because, as Emma Parker holds in the context of Atwood’s writings, “consumption embodies coded expression of power” and the act of “eating is unequivocally political” (349).



**Rice is special: Chinibas in “Flood” and Uchchhob in “Rice”**

The phenomenon of one food being prioritized over another or seen as more comforting, fulfilling than the other does not always necessarily involve the issues of nutrition or present availability. An unaccountable emphasis on one food (like rice) sometimes relates to the cultural memory of a race or class harking back to a period or era of plenty, an era that has passed by without notice and has been supplanted by a new age of exploitation and deprivation. As a matter of fact, the choice of and obsession over one food is often determined by a complex play of ideological practices like class, race, gender, religion and others and this is what makes an examination of issues related to food so urgent, because as Wenying Xu holds: “The fact that food practices always function in a dialectical relationship with ideological practices, be they class, race, gender, religion, nationalism, health, or beauty, makes them all the more important to contemporary literary studies that center on human beings as political creatures” (164).

The story of “Flood” (1968) is set against the backdrop of 16<sup>th</sup> Century Bengal, where the Goudiya Vaishnavism movement of Sri Chaitanya Mahaprabhu frequently uses the metaphor of flood to indicate the spirited spread of the religious phenomenon. But to the family of Chinibas, an innocent outcaste boy of Purbasthali, a place often afflicted by severe floods, the metaphor only appears confusing, as the floods of the rivers seem more tangible to them than the far-off figure of Sri Chaitanya and his movement. Under the influence of the movement Acharya, the wealthiest upper-caste behemoth of the village, promises to throw a feast for the poor villagers when Sri Chaitanya passes through that path. The idea of Acharya is to draw the attention of Sri Chaitanya, the powerful cult figure of the time, and to get closer to him. Chinibas waits for the feast with all his heart. On the given day he smells the aroma of the boiling rice, a food that—despite all the food-stuffs that his family forages from the fields, the numerous ponds and rivulets for everyday meals—remains coveted and elusive. The arrival of Sri Chaitanya, however, eludes the village and as a result to that the feast is cancelled to the great disappointment of the villagers. Chinibas and his likes are given *Muri* (baked rice)

and batasa (a simple dry sweet made by crystalizing sugar) instead of a meal comprising rice and other delicacies and are driven away from the yard of Acharya summarily. Deeply disappointed, Chinibas throws all the muri-batasa in the dirt and bursts out in childish anger. He pours all his frustration on his poor, widowed mother for not being able to make a meal of rice for him. In “Rice” (1982) Uchchhob, a refugee from the flood-hit Sundarbans, has been appointed for a day’s hard, household works in a wealthy landed family that is holding a *jogyo*, a religious ritual, to resuscitate the old and ailing patriarch of the house. Uchchhob is assured a good meal of rice and other delicacies after the ritual is over. Starved and tired Uchchhob drags himself through the chores in expectation of the much-coveted rice. But disappointment comes when the patriarch dies in between the ritual leaving the entire day’s program cancelled. Out of desperation Uchchhob steals a brass-container full of rice he was asked to dump in the gutter and gulps from it voraciously. Not very far from the house of the family he falls asleep exhausted clutching the pot and is discovered by people looking for the container. He is beaten up for stealing the brass-container and is sent to police. It is worth noticing that although Chinibas is poor, he and his family, comprising his mother and his grandmother, get by somehow and avoid starvation under normal circumstances. But despite that a good meal of rice is much coveted. It appears that such a meal is the prerogative of the wealthy alone (like Acharya), who not only have an access to it, but also exercise a control over it, determining whom and when to allow somebody a meal of rice. Marginal outcastes like Chinibas can have access to such a meal only if the Acharya permits them to. Uchchhob dedicates himself to the hard labour in the rich household not because of a lucrative offer, but because there is promise of rice at the end of the day. In his yearning for the rice, he even begs for a handful of uncooked rice to chew about (and is denied of course). A description of the abundance of rice in that household leaves Uchchhob awestruck and leads him to farther covet the food. Basini, the housemaid, tells Uchchhob about the numerous delicate varieties of rice that are cooked on daily basis in that wealthy household. She narrates to Uchchhob the farming riches of the family and the luxury that the wealth from farming offers to these people. The bearing of Chinibas

and Uchchhob stands in sharp contrast to the wealthy entities like the ones that control the access over rice.

**Death by Eating/ Eating Kills: The death of Sonyesicharan by over-eating**

In “Rice” (1975) Sonyesicharan is a hapless starving beggar who is suddenly summoned to a wealthy household for a sumptuous lunch of rice and other stuffs. He does not understand why people like these, who would normally refuse to show the slightest benevolence to a beggar like him, would all of sudden invite him to a meal. Sonyesicharan, however, bathes in the very morning and dries his only piece of cloth that covers his body by remaining naked for the while. Reaching the wealthy household early he waits in the portico eagerly for the meal. What goes on inside the house is a tantric ritual, which supposedly will resuscitate the ailing patriarch of the house thereby allowing an opportunity to rectify his will before dying. The rectification will benefit his legitimate children disavowing the rights of his powerful illegitimate son, Madan. The tantric ritual hints at adding years to the ailing patriarch by drawing life from the one they would feed that day, namely Sonyesicharan. The hapless Sonyesicharan does not bother to know all these and keeps immersed in his dreams about rice, hot rice, the aroma of it. At the end of the ritual, he is fed. He eats voraciously and recklessly only to die later unnoticed of overfeeding in the park where he spends his nights. But before his dead body is discovered people around him get busy as the patriarch also dies the same night. It is worth noticing that the wealthy household is unkind enough to imagine that harm to a beggar like Sonyesicharan for the mean monetary benefit to them does not matter the least. Those who on an ordinary day will heartlessly ignore Sonyesicharan feeds him to his death. They are successful in doing that so easily because of their control over the much-coveted food: rice. Although starved on most of the days Sonyesicharan is lured to his death because of the special significance he (like many other wretched beggars) attaches to a meal of rice – a meal that only the wealthy has an access to. The gateway to the pleasure derived from a meal of rice is controlled by the powerful and the rich and they either deny them access to such pleasure or when, on rare occasions, they do allow access to such pleasure to

the poor and hapless it is most often for some sinister designs which can even be fatal to the poor and the powerless. The rich and the powerful thus do not care starving the powerless to death, neither do they care killing them by over-feeding.

### **Controlling the Psychological World of the Poor and the Hapless with Food Fantasies: Aandi-buri, Chinibas, Uchchhob, Kuron and his mother**

The powerful not only deny the food the powerless desire but also plays with their mind by manipulating that desire. The poor and the hapless are made to wait for the food of their desire. The delirious and yet painful wait for a meal of rice or for just a belly-full of anything in Mahasweta's achingly realistic narratives often ends in complete cold-blooded denial (as in "Birthday Party" and "Rice") or fizzles out as something else, something inferior to what they yearn after (as in "Flood" or "Rice"). In "Birthday Party" (1975) after a day's wait with acute hunger Kuron falls asleep exhausted at the gate of the apartment of the rich only to be woken up by the clamour of the catering service people attempting to take away all the left-over food from the party not allowing Kuron and his mother access to it lest beggars like them mess up the side-walks of that posh neighbourhood. Sonyesicharan, Uchchhob, Chinibas and his mother Ruposi Bagdi, Kuron and his mother dream of a good meal and fantasize on it. Deprivation does not stop at poking dreams and fantasies in these hapless figures, but creates strange delusions: Aandi Buri with her blurred vision in "The Fairy Tales of Mohanpur" (1978) yearns for fish and catches a water snake instead. Even after being snubbed by her sons and daughters-in-law she fails to believe that she caught something other than a fish. To her the fish turning into a snake is part of a fairy tale that entangles all deprived people like her in their poor unfortunate lives. This hunger-ridden world of fantasy and delusional beliefs of Mahasweta's characters is built out of cruel denial, exploitation, oppression and power-play on part of the powerful people of the world and is resultant of the politics that plays out on food and the simple act of eating. Quite obviously Mahasweta's short stories centering on food raise the questions that contemporary critical concerns on food-writing touch upon like "[w]ho gets to eat? Who's denied

food? What are the systems by which we legitimize denial”? (Roy xviii). The stories also remind the readers—like stories written by so many others—that food is not merely what we eat, but “food is also about what’s withheld, unavailable, banned” (Roy xiv) and all these discourses on denial and manipulation on food, hunger and the act of eating direct us toward the operation of power in an unequal society.

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