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Natural Resources Management for Sustainable Development and Rural Livelihoods

Vol. 1

Editors

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Preface

Natural resources are depleting at alarming rates because of their irrational use pattern. Although, utilization of resources is an intrinsic component of the process of development yet, overexploitation of natural resources has led to environmental degradation and change in pattern of rural economy. Rural communities, in particular, are greatly affected by the increasing use of natural resources. To many of them, development is about livelihood and survival rather than increasing productivity and accumulation of wealth. Management of natural resources seems to be the only way forward to sustain the livability of rural communities.

Management of natural resources requires collaborative works from various stakeholders as the use and un-use of natural resources depend upon a number of factors including historical, political, economic, social and cultural. Through the substantial holistic approach and concrete framework for policy research could be conceptualized, planned and implemented.

Department of Geography and Resource Management, Mizoram University, Aizawl, India, hosted an International Conference on 'Natural Resources Management for Sustainable Development and Rural Livelihoods' (26-28 Oct, 2017) which have addressed ways to boost agricultural productivity for food security and sustainable economic development, while conserving and restoring the natural resource base. Topics were covered include: assessment, management of natural resources for sustainable development, rural livelihoods and food security; integrated management of water and land resources; conserving agriculture systems; climate change mitigation and adaptation strategies including carbon sequestration in soils for different land use systems; and policy frameworks for capacity building to mitigate emerging problems in natural resource management. Developing and transition economies will be increasingly concerned with natural resources management, sustainable development and rural livelihood issues; they will have to solve a three-fold challenge: a better environment, good economic performances and poverty reduction as targeted by the Millennium Development Goals. Developing and emerging countries will also have to tackle with increasing scarcities.

Major objectives of conducting the conference was to evaluate past research efforts in integrated natural resources management for sustainable development and rural livelihoods, to streamline future scientific efforts in support of sustainable livelihood, to draw recommendations for capacity building in land, forest and water management

Invited participants were international and national geographers and scientists, leading farmers and experts from governmental and non-governmental organizations, researchers, representatives of donor organizations, and decision-makers who exchanged views on how to use and manage natural resources for sustainable development and rural livelihoods.

This proceeding, an output an International Conference, contains 109 chapters which are published in three volumes. The first volume is devoted to the theme, 'natural resources use pattern, management and policy perspectives' in which 22 chapters are incorporated. The second volume contains 37 chapters and the theme is 'agriculture and livelihood sustainability'. The third volume has three sections; the first one is 'climate change' with nine chapters. It is followed by the second section 'population and socio-economic development' which also contains nine chapters. The last section is interdisciplinary in nature in which 32 chapters are incorporated. The whole proceedings comprise chapters from different disciplines such as Earth Sciences, Biological Sciences, Environmental Sciences, Social Sciences and Medical Sciences and thus the authors of the proceedings chapters are divers in nature and they contributed chapters from different respective fields.

We received financial support from the national and local level institutions and organizations to host this conference and to publish this book. Among them the major funding institutions were 'North Eastern Council' and NERC-ICSSR from Shillong; ICSSR, SERB and ICAR from New Delhi and NABARD, Mizoram University, APEX Bank, Sarva Shiksha Abhiyan and Koinonia from Aizawl, Mizoram. We gratefully thank them for their valuable supports. Besides, many other agencies from Aizawl city have also assisted us financially. We are thankful of all of them. We are thankful of the Mizoram University for providing us all the logistic and other support. Similarly, the faculties, staffs and students from the Department of Geography and Resource Management have supported us substantially. We are thankful of them. We are also grateful of Today and Tomorrow's Printers and Publishers, New Delhi for publishing these

volumes. In the last but not the least, we are thankful of all of those who supported us to host this conference successfully and to publish this proceeding.

Aizawl

Vishwambhar Prasad Sati

K. C. Lalmalsawmzaupa

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Submissive Role of Power in Resource Access: An Application of “Theory of Access” in Wetland Resource

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Abstract

Power relations within social, economic, legal, political and institutional spheres are fundamental to governance in wetland resource management. Typically, power is derived from the various institutional mechanisms, social identities and traditional beliefs and practices; and leads to access in resources. The key objective of this study was to explore various power relation mechanisms and their impact on wetland resource access in less development country. Based on the Ribot & Peluso's 'Theory of Access', study has applied summative content analysis for analyzing different power relationships within wetland resources. The findings revealed that institutional and social structures are empowering some people's symbolic supremacy and allows them to practice authoritative control over the community members. Financial ability, cast and religion, gender and others cultural factors establish small number of people as leaders; enables them to set organizational norms, accumulation and control over wetland resources; whereas other people, particularly poor and women are excluded from the access and control of this resources. Thus, power

dynamism should be deemed significantly for introducing any wetland related policies.

Keywords: Power structure, Social Relationship, Resource Access, Resources management, Wetland

Introduction

Power means an ability to influence other, coming from different internal or external sources in the process of coercion, incentives or trust (Choudhury and Haque, 2016; Raman et al., 2015). Power often operates based on authoritative and allocative resources. Differential distribution of these resources frames the asymmetrical power structure, which shapes command and control over people and resources access (Neiland, 2009). As a bundle of power of social relationships, access can create different constraints or assistance regarding the entrance in resources (Geheb & Crean, 2003; Ribot & Peluso, 2003). Through the various patterns of social relationships, a few of individuals or organizations get control over resource access; while other fail to have these opportunities (Ribot & Peluso, 2003 page 155; Bene, 2003).

Access deals with disciplinary techniques whereby a person gets manifold advantages (Schusser, 2013). These disciplining institutions and practices generate power and guide people to act in certain ways (Foucault, 1979). For example, in the community based wetland management different stakeholders practice distinct roles including resource access and maintenance for sustainable resources conservation (Ahmed et al., 2009). However, depend on an individual's or group's institutional positions access relations always change (Ribot and Peluso, 2003). Institution means established roles or behaviors including membership in a certain group, kinship, or family ties. Due to technology, capital, markets, knowledge, authority, traditional believes and social identities, poor and less deprived people are often facing various social problems (Ahmed et al., 2008; Ribot and Peluso, 2003). On the other hand, rural elite can gain control over and maintain access to resources by the webs of power (Choudhury et al., 2016). So, it is important to know who indeed benefits from resource management and through what process they can do so.

Access theory defined by Ribot & Peluso (2003, page 154) classified various mechanisms of gaining, maintaining and controlling a particular access. It also finds various mechanisms where different actors get engaged to gain, control and maintain the flow of advantages and its distributions (Bene et al., 2009). Following this stratification of access,

this study identifies how social identities, like cast and religion, influence unequal resources access; how formal and informal institutional mechanisms accelerate unequal resource access; and how the traditional beliefs related to gender and customs promotes unequal resource access in the wetland fishery.

Thesis Statement, Research Questions and Objectives of the Study

Due to institutional mechanisms, various social stratifications, and cultural dogmatism elite people enjoy more access to control, maintain and gain in wetland resource than those of non-elites. Therefore the study answers to the questions: 1) What are disciplinary mechanisms that could influence access to resource? 2) how do people access these resources? These research questions are spill out in research objective. The main objective of the study is to know the nature and strategies of access in natural resource management, where the specific objects are: to explore the role of institutional mechanisms on resource access; to find out the contribution of social identities including cast and ethnicity on resource control access, and finally; and to explain the role of traditional beliefs such as gender and social norms on resources gaining access.

Policy Importance of the Study

There are some knowledge gaps existing in literature related to power and access dimension. Most of the studies describe either the features or effect of co-management in wetland or forest. A few of them deal with power structure particularly regarding access process. In addition, none of the studies explain the case of access control, maintain and gain in wetland or forest drawing on “theory of access”. On the other hand, access analysis is very crucial for policy making process because it helps to policy maker to clarify why certain groups of people and organizations get benefited from resources and whether other groups or institutions lack rights to do so. Apart from this, various discursive strategies where some are recognized by whole or a part of a society is contributing to gaining benefits from resources will also be determined by this analysis. Finally, analysis of access is important for study of sustainability because it is addressing both legal and illicit rights, relations of production and entitlement relation between actor and others.

Theoretical Framework

The paper draws on the theory of access of Ribot and Peluso (2003). According to the theory of access an individual or an actor can have easy gain and control over access to resources through a special pattern of power

relationship. The pattern of power in another sense means a specific process and relationships known to be ‘webs of power’. On this front, control indicates a process of scrutiny and ways regulating or monitoring to individuals’ or actors’ free action. Access control, therefore, refers to the proficiency to mediate the own access of an individual.

The ability to keep certain types of resources and rights for expending resources are main concern of resources maintenance. So, resource control and resource maintenance considered to be complementary to each other. On the other hand, gaining access is a common process assists an individual to establish a certain access. Several types of instruments like rights-based, illicit, structural and relational mechanism are playing significant role for resources access, control and maintenance. All kinds of legal access are called right based access and right owner have an authoritative power with executive mechanism for access in resources, while illegal access is a process of direct resources access which might be prohibited by the societal norms, law or tradition from certain group. However, it is not unethical in aspects of another specific group.

Structural and rational mechanisms of access contain or reinforce access gained directly by formations of right-based or illicit access. There are several structural and rational factors including technology, capital, markets, labor opportunities, knowledge, authority and social identities. This access framework is used for analyzing and determining some specific resource conflicts or struggles and to understand how those conflicts develop as well as in what ways different actors or individual are gaining or losing miscellaneous benefits (Ribot and Peluso, 2003).

Methodology

In this study, summative content analysis technique is used as a methodological tool. Typically, content analysis has used for analyzing miscellaneous documents (Elo & Kynga, 2007). Summative content analysis in qualitative research, researcher identifying few keywords, meaning or content for understanding certain situation or meaning. These key words either derived from literature review or researcher interest (Hsieh and Shannon, 2005). There are three key themes “Power”, “Resource Access”, “Wetland Resources” are used for unit of analysis. The paper used various secondary sources including journal articles and books as well as a desk-based study that draws on web-based sources including Memorial University of Newfoundland’s e-resources and google scholars. A single case study on less development countries, like Bangladesh, India, Sri Lanka, Cambodia, Kenya, and Cameroon, is considered in the context

of describing power dimensions and nature of access in wetland management.

Result and Discussion

The Institutional Mechanisms for Resource Access in Aetland Area

Institutional structure is a central aspect of natural resource management, which governs the whole decision-making and executive process (Chowdhury et al., 2012). Generally, institutional mechanisms refer to a set of rules and regulations, societal norms, authorized arrangements, systems of social organization, and decision-making processes whereby social actors or individuals interact to gain and maintain their command such as access, use and control over the resources and the benefits extracted from them (Bene, 2003; Ahmed, 2008). In the case of wetland management, two types of institutions, informal and formal, are identified to be active. The informal institutions (for example patron-client relationship) indicate some certain types of existing rules that govern behavior and shape society, while formal institutions (such as the State policy) lead the access of fishing resources (Khondoker et al., 2014; Sekha, 2004; Bene, 2003). However, due to the disputed behaviors and unethical practices among the ruling body various vertical relationships among the groups are produced (Khan, 2011). Consequently, the institutions fail that result in various social conflicts among the resource beneficiaries (Chandra, 2011).

State Policy for Wetland Fishing

In the context of the resource access in the wetland area, several government organizations are externally created and maintained different formal institutions to collect revenue (Khan, 2011). Generally, these formal organizations are more emphasize on the output and most of the case all expenses of management are derived from revenue collections. So, the policies oriented to the wetland managements are mainly focus on revenue earning (Rahman et al, 2015; Roy et al, 2012; Bene & Friend, 2011).

Wetlands are a source of revenue earning in the formal government systems (Khan and Haque, 2010). For example, after the independence of Bangladesh in 1971, the Government of Bangladesh converted wetland revenue earning system from fisheries leasing system to fisheries licensing system expecting to ensure real fishers involvement in the wetland management process. Nevertheless, that policy is considered unsuccessful compared to prior revenue policies due to its failure in generating sufficient revenue. Consequently, the government again changed the policy reintroducing leasing system (Toufique, 1997). This newly introduced

system led to institutionalized exploitation of the fishermen by the rich elite class because it transferred wetland property rights through communal to individual property (Bene, 2003).

The newly formulated wetland leasing policy brought about some significant changes in the context of the wetland management system (Choudhury and Haque, 2016). It encouraged the handover of authority from government to private on temporary basis for exploitation of resources by paying lease on wetland (Khan, 2011). As a result, wetland water bodies often generate as an economic incentive for private investors to maximize profit without envisaging aquatics biodiversity and resource conservation (Khan & Haque, 2010). Khan 2011 (p. n. 80) shows that

“...The wetland management system offers ample scope for investors to maximize and earn hefty profits from their investment... As a result, jalmohals become potential sources of higher profit-making ventures and secure higher returns, ...Outsider non-fishermen investors... intend to maximize their profit within the stipulated leasing period by using destructive types of fishing gears and methods (e.g. fishing net with very small mesh size, dewatering, poisoning). In addition, lessees also exploit other natural resources such as flooded forests, reeds, wildlife to increase profit, though they are not legally authorized to harvest any other natural resources than fish. Lessees are often involved in corrupt practices to manage the leasing authority to continue their illegal exploitation processes of natural resources. It has been reported by the locals that lessees allow professional bird-hunters to hunt migratory as well as resident water birds from the haor area by taking a certain amount of fees from hunters.”

In addition, the competitive leasing policy acts as a crucial tool for privatizing commons, which is disarticulated benefits from poor people to the richer population (Alain et al, 2007). In Cambodia fishing-lots are taken lease by rural elites who control people access in entire water bodies around the year. However, these fishing lots are acknowledged as a common property during open season for fishing with some restriction on particular gears (Bene and Friend, 2011). Therefore, owing to the access restriction not only social disintegration is increasing but also sustainability of resources is damaging in wetland area (Khan, 2011). Another government's policy regarding the community wetland management (CWM) is also failed to protect poor people's access in natural resources in India (Kumar, 2012). Due to the policy of CWM, powerful elites get power and play dominant role including resource access and control in wetland area. Sekhar, (2004) also described that the existing state policy of Orissa in India increasing resources conflicts among local stakeholders and he concluded (p.n.265)

“The state policy interventions and introduction of mechanized boats and nets led to a decline in resources and increased conflicts and competition which was not in the interest of the local communities. Some of the young local fishermen and outsiders operating mechanized boats take advantage of the situation, ignore customary norms and stake legal claims upon the lake resources by acquiring licenses from state agencies.”

Similarly, Thomson and Gray (2009, p.n.539) shows a case study in the Cherai Poyil fishery in the Cochin estuary in Kerala, India where due to “the state Panchayath Raj Act (1960: sections 62, 64, 82, 84 and 149)” local formal institution like Panchayth and communities are involving with fishing co-management. Generally, local Panchayth lease out the local water bodies by contractor and contractor allocates these water bodies among the different fishing groups based on the equity, environmental stewardship and customary rights. However, lack of good governance resources conflict has increased between different stakeholders. Authors shows that:

“...feerates are not set arbitrarily by the contractor alone, but in the presence of nominees from the Panchayath in consultation with the different gear groups who seek access to the fishery... despite local resistance, the contractor granted Fishing permits to a new generation of gillnets... By charging high rents (40% of the total catch) ... negating the legitimate rights of other traditional fishermen. Similarly, under the influence of local Panchayath, the contractor granted access to a group of local marine fishermen in the Poyil. Fishing activities of the seen transferred to the reduction of catches of castnet fishermen.”

Different bureaucratic and other social institution also shaping people access in wetland resource and management process. Few influential persons have taken these advantages and exploit others. This concept is defined as the ‘institutional bricolage’ by Nunan et al. (2015). According to the authors “The concept of ‘institutional bricolage’... reflects how people access fisheries, how they find ways to continue illegal practices despite efforts to control these, and how co-management structures and processes are influenced and shaped by bureaucratic and socially-embedded institutions” (p.n. 212). In Malawi, due to the Fisheries Conservation and Management Act (1997) Director of Fisheries can empower to employ local BVC as a voluntary fishery officer. As a result, corruption and wetland resource depletion has increased radically. Nunan et al. wrote (p.n. 211)

“Enforcement of regulations is enabled and constrained through institutional bricolage, with both formal and local informal rules being used to enforce regulations and influence access to fishing. Bribes to DoF fisheries enforcement officers, BVC members, and chiefs are regularly reported”.

Likewise, Ho et al. (2015) found that Vietnam government has taken decentralized co-management approach where three different types of power including legislative, executive and other judicial are shared among the formal institute and local fishing community. However, they could not excise these power because of weak legal support and the red tape and other bureaucratic constrain. Therefore, states policies equally fail to ensure social justice and equity into wetland management; instead they intensify marginalization of poor communities in the context of wetland resources.

Patron–Client Relationship in Wetland Resources

For governance of wetland management, various power relations within social, economic and institutional spheres are vital (Geheb and Crean, 2003). In the general case, stronger groups exercise power on weaker groups which often facilitates or creates different constrain on overall procedure of resources access or maintain (Alain et al, 2007). Consequently, manifold vertical relationships for example patron-client relationships are formed that lead to social and other exclusion from access and control of natural resources (Schusser, 2013). In wetlands, particularly in fisheries, exploitation is more common due to the patron–client relationship. Nguingiri (2000) describes, for instance, the condition of the *Vili* fishers in Congo where patrons like rich fishing business men usually try to manage a good tie with poor fishermen for their own production. The patrons develop relationships and control fishers through a complex and subtle mixture of generosity-redistribution, pressure, influence, intimidation or even threats. In Asia including Bangladesh and Mekong basin (Cambodia), patron client relationship has developed because of water estates leasing system (Bene, 2003). Water bodies are leased by the auctioning system, where fishermen often fail to afford the lease fees because of their poor socioeconomic condition (Ahmed, 2015). On the other hand, rural elites including past or present members of local political institution, rich farmer or fishermen can be influenced to leasing providing institution (Chowdhury et al., 2012). So, the lease holders usually come from more powerful section of the rural population. The Lease holders are called water-lords who control over the management of the wetland (Alain et al, 2007). They hire fishermen as daily labor to carry out fishing operations on their behalf (Dab & Haque, 2011).

Usually, local fishermen are come from the poorest section of the rural classes and they do not have enough financial capital to participate in the tender for taking lease of the water estates (Bernier et al, 2016). In the

context of poor fishermen fail to afford the lease of the wetland many informal creditors or local moneylenders play a significant role in financing fishing activities (Geheb & Crean, 2003). In many cases, local moneylenders become lessees and pay credit in the form of sub-leases to fishermen. The sub-lease fee is indeed their principal and a share of the fish catch is their interest. Most of the instances interest rate is very high, ranging from 10 to 20 per cent per month, which compounded amounts to 300–340 per cent per annum (Deb et al., 2014). At Lake Volta in Cameroon, the interest rate is 25–40 per cent bi weeks and around 47 per cent for a month (Béné and Friend, 2011). In addition, apart from the high interest rate of lending, local fishers are also bound to sell their catch to local creditors at a much lower rate than the usual market price. Local fishers thus not only pay a high interest rate for taking credit but they also lose a big share of their income by selling the catch to local moneylenders at a lower price (Ahmed, 2015). Again personal relationship also vital factor for wetland resources access which are formed based on the give and taken relationship. Nunan et al. (2015) found these patterns of relationship in East African Inland and Malawi Fisheries. According to authors:

“...Boat owners and fish agents, who buy fish for the processing plants, have more power and resources than the boat crew employed by boat owners and many of the smaller-scale traders and processors, many of whom are women.”

The Role of Social Identities on Wetland Resource Access

Social identity has profound impacts on the resource access and maintenance. Access is often mediated by different social identities or memberships in a specific community or group including age, ethnicity, religion, place of birth. By whom, how, and which law would apply for resource access or control relay, partially or fully, on different social identities (Ribot and Peluso, 2003). In the wetland fishing, due to the religious and ethnic characteristics, few people get accessed in a certain part of water bodies, using certain types of fishing gear, while other are not allowed (Lobe and Berkes, 2004; Sekhar, 2004; Kremer 1994). Thus, few people are excluded from wetland resources access and control (Bene, 2003).

Resource Access and Control Based on Religious/Caste Criteria in Wetland

Individuals or communities could be marginalized for resource access and control because of their religion or caste (Bene, 2003). Kremer (1994), for example, reveals the case of Bangladesh where Muslim fishing

community, locally called *Maimal of Mostshojibi*, collectively prevents fishermen of other communities from fishing over the open flooded agricultural land. They maintain their fishing territory through physical violence or stealing gears of Hindus untouchable caste of fisher folk known as *Nomosudras*. Likewise, in Sri-Lanka, Atapattu (1993) reports that socio-cultural barriers play a key role in all aspects of fisheries in the wetland area. He also illustrates his point by highlighting that Buddhists compose of 67% of the total population in Sri Lanka, however, they represent only 22% of the fishing population. Sekhar (2004) also shows how cast influences the access to particular resources in *Chilika* lake in India. He finds out that local fishermen by and large treat the lake waters as a common property resource and they managed all sorts of fishing access by themselves through their cast and spatial contexts. According to Sekhar (2004, p.n. 261-262)

“...Conflicts in *Chilika* lake can be seen at three levels: within fishing communities, between communities and state agencies, and between various state agencies... This is due to increased competition for resources as a result of new stakeholders being permitted to use the lake waters and politicians exploiting the socio-economic differences amongst the fishing groups... at the community level some of the fisher folk from minor groups feel that the decision making is dominated by the major groups like the *Khatias*.”

Based on the cast, the access of fishing group is determined by the species they catch. For example, the *Nolia* and *Niary* cast catch marine fish; so, other fishing groups do not catch fish from the open sea water. The *Khatias* is another cast gets accessed to larger areas including the mouth of the lake. In addition, the fishing groups also limit themselves to fishing only certain species. For instance, the *Kandaras* who mostly catch crabs and prawns while *Nolia* catching sea fishes. *Padu* cast system in south India and Sri Lanka is another example of cast oriented resource access. It is a traditional social identity system which is used for granting entitlements to eligible members of a community to undertake specific fishing activities in certain designated fishing grounds of the lagoon during specified seasons. Coulthard (2011, p.n. 406) described the features of *Padu* in South India:

“To become eligible for *Padu* fishing rights and access to *Padu* fishing grounds, a fisherman must first become a member of the *Talekettu*, a form of village membership based on gender (only men can participate), caste (only *Pattinaver* caste can reach *Talekettu* status), age (over 21 years) and marital status (only married men are eligible)”.

This traditional fishing system is creation poverty between the

fishermen because fishermen can only be catching certain fish from particular fishing ground in a specific time and rest of the time fishermen are unemployed. In addition, this system also accelerating on power exertion within local elite class. Coulthard (2011, p.n. 407), for example, shows:

“Padu membership also brings with it status and identity as an elite...The Padu system ...governed by the village Panchayat, an informal (non-state) council, which exerts power by keeping non-members out of the Padu system, sometimes using physical force and the confiscation of fishing gears.”

Similarly, Lobe and Berkes (2004, p.n. 278) also described the weakness of Padu system in resource exclusion in Kerala. According to Lobe and Berkes:

“The Kerala Vallarpadam fishery is ... problematic ... because of the exclusion problem even in the immediate fishing area. There is no mechanism for the three groups of “illicit” fishers to coordinate with one another... there is no mechanism for the overall control of fisher numbers in the area as a whole”

Wetland Resource Gaining and Access Based on Ethnic Criteria

Ethnic identity plays a crucial role in the context of access to the wetland. Minority or newly settled group of people often gets excluded from resource access through the local authority due to their ethnic identities (Ribot and Peluso's, 2003). In the northern part of the Yaere floodplain (Cameroon), for instance, two major ethnic groups such as *Kotoko* and the *Mousgoum* share the fishing grounds. The *Kotoko* group lives in the floodplains area since the 15th century, whereas the *Mousgoum* settled at the beginning of 20th century. The *Kotoko* claims ownership over the depression and the plain through their ancestral rights. Nowadays during flood both *Mousgoum* and *Kotoko* enter the plain to fish. Most techniques including cages, traps, nets, fishing-hooks are allowed for all fishermen for catching fish. However, two techniques that obtain the highest catches with a low-labor intensity are under clear restriction by the *Kotoko* (Bene, 2003). Thomas (1996) provides an example of restricted access in the inland fisheries in *Hadejia-Jama* floodplains in Nigeria based on ethnic grounds. During the rainy season, most of the lowest part of this wetland is open for everybody for fishing. However, one of the native ethnic groups named the *Bede* control fishing access. Consequently, other ethnic groups like *Hausa* are denied access to this type of fishery. In India, Sinha and Sampath (1994) also found that fisherwomen cannot get involved in fisheries cooperatives because of their very low status in social hierarchy.

A resource conflict has found by Bene et al. (2001) in Turks and Caicos Islands where both Haitian and Dominican fishermen were trying to control marine fisheries based on their ethnicity. Authors described that (p.n. 371):

“Economic difficulties in both Haiti and the Dominican Republic have led to a large influx of immigrants (both legal and illegal); many have moved into the fishery... the ‘belonger’ fishermen resent the presence of non-belongers in the fishery, a situation compounded by a number of complex legal loopholes ...”

The Role of Traditional Beliefs on Wetland Resource Access

Cultural aspects such as norms, values, traditions, and customs are also the crucial factors for resource access in rural area. The powerful, privileged socio-economic class often uses various traditional customs to strengthen their position and legitimizes inequality through notions of social rules and regulation (Chandra, 2011). Different traditional rules like as gender and social norms are also the determinate factor for wetland resources management particularly in participation and access process (Deb and Haque, 2011).

Social Norms, Kinships and Wetland Resource Control

Social norms refer to certaintypes of rules and regulations that are acceptable for a group or a society. If an actor does not follow the norms he/she may be shunned or suffer consequences (Schafer and Lamm, 1997). Various social norms are identified to be influential on public access in the natural resources. A comparative analysis between the Chari Delta (Chad) and the western shore of the Nigeria by Nasongo et al., (2015) reveals that the access of household in the water resources is regulated by social norms. The study finds that due to the different direct or indirect social norms rich and middle strata people can access in entire water estate, while poor household have only access to the marginal part of the water resources. Direct social norms come from various legal and/or illegal taxes that are imposed for the access to the water-bodies. These different fees impose various financial barriers for the poorest and create multiple constraints for entering the fisheries. In addition, these poorest households also maintain indirect social norm (technical restrictions of access) because of their lack of adequate fishing gears and boats necessary to fish water-bodies.

Kinships, interpersonal relationship is another vital and influential factor for wetland resource access. Typically, few people can illegally access on wetland fishing due to their kinship or friendship relationship with

management authority. Nunan et al. (2015) described how social norms and kinship relationship has been promoting on unlawful access in inland finishing in East Africa and Malawi. Authors stated (p.n. 212)

“...These institutions influence who stands for election, who voters support, and who is listened to within decision-making for a... Friendship, kinship, and peer relations create unwillingness of some fisheries stakeholders, including members of community-based co-management structures, to enforce regulations where there is a relationship to the offender”.

Due to the mussel power and social positions certain groups of people illegally involved with wetland fishing exaction and enforcement agencies even could not take effective initiatives against them. In case of dynamite fishing in northern Tanzania Wells (2009, p.n. 22) explored that:

“...Whilst dynamiters constitute a small proportion of any given fishing community, they are able to escape sanctions by being locally well-connected, a member of an influential family, or having well-placed patrons. This often obstructs enforcement efforts, and there are numerous examples of arrested culprit's not being effectively prosecuted, receiving light fines or charges being dropped”.

Gender and Wetland Resources Access

Gender is a socially constructed identity which is developed on the biological differences between men and women (Schafer and Lamm, 1995). Women are often excluded from the participatory management of wetland resources because of family endowment and limited ability of coping with hegemonic norms (Deb et al., 2014). They are also excluded by powerful social forces due to their dominated class position and cultural dogmatism (Choudhury et al, 2016). For example, attending meetings in the community-based fishery management project is often a physical activity. Women are identified to be no able to perform physical activities and thus, get excluded the notions of gender roles, gendered division of labor, and gendered bodies are often restricted women's physical mobility (Ahmed et al, 2008). Deb et al, (2014, p. n. 309) for instance found that:

“The socio-cultural construction of the women's roles in domestic chores is ‘they are born to serve men so long as they are physically sound’. Fisherwomen ...contribute in three fundamental ways: first, through their direct productive roles; second, as biological reproducers of members of ethnic collectivities for sustaining fishing activities; and third, through carrying out special responsibilities in the absence of their male husbands and sons at home”.

Nasongo et al. (2015) examined this gender dimension in Kenyan's wetland resources management project. They showed that the male

dominance in fishing is partly rationalized based on their physical strength to staying overnight on the open waters, whereas women are assumed as a helpless. Therefore, they are not allowed to stay out at night. Women also get excluded because of the vulnerability to sexual abuse by men. A. Moreover, men have more resources like money to buy fishing boats and finishing gears while women can only afford the less expensive traditional fishing gears. The complex system of social relationships and interests also produces different barriers for female member to utilizing and exercising their agencies (Deb et al, 2014). In Bangladesh community-based wetland resource management, for instance, female members reported that the executive members of the resource management have illegal access in fish sanctuary. However, female members cannot raise their voices against this illicit access for fear of losing social patronage by the powerful or the *Murobbis* – the elderly who are socially valued and highly respected (Choudhury et al, 2016).

Due to the gender structure, sometime women are considered as an exchange goods, for instance in Nyanza (Kenya) women (wives or non-related fisher women) are bound to sexual relation with boat owners or fisher men for fish, which is called sex for fish. In Nyanza, poor women who are agree with sexual relationships by fishermen; they have got a preferential access to fish, for example, to first choice of fish, larger quantities of fish or simply a guaranteed supply of fish. (Mojola, 2011). Bene and Merten (2008) also shows that 49% of world fish-for-sex incidents have happened in different Sub-Saharan African inland fisheries. Similarly, in case of Lake Victoria Nunan (2010) wrote:

Relationships are also key to women gaining access to fish at new landing sites to buy for onward trading... A further relationship mediating access to fish is between women and fishers or boat owners, where women may have to, or choose to, engage in sexual relations in order to...gain access to fish for processing and sale... sexual relations are unprotected, and women exposed to the possibility of pregnancy as well as to the possibility of losing access to fish if favours change.

Conclusion

Power operates through the social relationships between groups and individuals, and is manifested through social interaction in the form of domination and subordination. Institutional and social statues facilitate some people's symbolic power, allowing them to practice authoritative control over the community members. Financial ability, cast and religion, gender and others cultural factors establish some people as leaders and

enables them to devise the organizational norms, resource accumulation and control, whereas other people particularly poor and women are excluded from access, control and maintain of wetland resources due to these same factors.

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2

Integrated Watershed Management by Mississippi Watershed Management Organization in Minnesota, United States of America

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Abstract

This paper provides an overview of surface water planning in the State of Minnesota, United States of America (USA) from the perspective of a local watershed management organization. History of Minnesota watershed management law which created the Mississippi Watershed Management Organization (MWMO) is provided. Basic water policy and structures, e.g. state agency roles vs. local units of government roles is also described. An overview of MWMO's organizational structure is described and how it operates at the local level to set environmental standards and goals, raises funds, and implements communication and outreach activities, planning, research and assessments, modeling, monitoring and implements projects by focusing on some of the current collaborative projects, initiatives and actions the MWMO undertakes to implement its Comprehensive Watershed Management Plan.

Introduction

The State of Minnesota is one of the states in the Midwest States

of USA. It borders with Canada on its north, state of Wisconsin in east, state of Iowa in south and states of North and South Dakota in west. The metropolitan area of twin cities of Minneapolis and St. Paul is the most populated area of the state. More than half of the state's population lives in the twin cities metropolitan area.

The Mississippi Watershed Management Organization (MWMO) is a Joint Powers local unit of government that includes area in seven cities of twin cities metropolitan area, most of which was fully developed by the mid 20th century. Minnesota law recognized that surface waters often do not match political boundaries. To effectively and efficiently manage the surface waters, planners and managers of surface water resources need to address problems and protection at the local watershed scale. In Minnesota, a watershed in the seven-county metropolitan urban area is typically 30 to 75 square miles or 770 to 19425 hectares in size. The MWMO covers approximately 40 square miles or 10360 hectares.

MWMO had planned and implemented surface water management through financial incentives, education and training, water resources monitoring, evaluation, and feedback to its members for the last 15 years. Working in an integrated, collaborative approach to address watershed and storm water management can be a successful strategy when all impacted systems traffic, housing, sanitary, stormwater and water supply, etc. are thoughtfully planned, prioritized and coordinated.

Minnesota Water Policy and Structure

The State of Minnesota has a long history of coordinated water management by state and local government. MWMO as a local implementer works with following five main state agencies: (1) Minnesota Department of Natural Resources (DNR), (2) Minnesota Pollution Control Agency (MPCA), (3) Minnesota Department of Agriculture (MDA), (4) Minnesota Department of Health (MDH), and (5) Minnesota Board of Water and Soil Resources (BSWR) to protect and improve surface waters. Each oversees and regulates a different area of water for the State of Minnesota; however, there are some areas of overlap. As a local implementer MWMO also work with other federal, state, regional and local governmental bodies.

The DNR works to integrate and sustain the interdependent values of a healthy environment, a sustainable economy, and livable communities. DNR's integrated resource management strategy shares stewardship responsibility with citizens and partners to manage for multiple interests. The DNR issues public waters work permits and water use permits. The

DNR oversees floodplain management, dams and dam safety, shoreland management and collects and maintains information regarding the public waters inventory, stream and river flow, water use, groundwater level data and climate data.

The MPCA monitors environmental quality (air, water, and waste), offers technical and financial assistance, and enforces environmental regulations. The agency finds and cleans up spills or leaks of hazardous material that can affect our health and environment. MPCA develops statewide policy, and supports environmental education. MPCA sets state-wide water quality standards and is the state agency often responsible for state enforcement of federal regulatory standards.

MDA is responsible for or involved in many water quality programs and initiatives. These include but are not limited to the following: (1) Agricultural Best Management Practices Loan Program A low interest loan program run by the MDA that helps finance water quality practices, (2) Minnesota Clean Water Legacy Act. The MDA currently oversees several research and other projects aimed at making cleanup efforts more effective and (3) Comprehensive Groundwater Protection Act of 1989. The MDA regulates most matters relating to pesticides and fertilizers.

MDH provides guidance values and standards for contaminants in drinking water, is responsible for source water protection, and tracks water contaminants of emerging concern.

The principle agency the MWMO works with to plan and implement its surfacewater Management plan is the BWSR. The BWSR is the state's administrative agency for 90 soil and water conservation districts, 46 watershed districts, 23 metropolitan watershed management organizations, and 80 county water managers. The BWSR mission is to improve and protect Minnesota's water and soil resources by working in partnership with local organizations and private landowners. Core functions include implementing the state's soil and water conservation policy, comprehensive local water management, and the Wetland Conservation Act as it relates to the 41.7 million acres of private land in Minnesota.

The following Water Planning Timeline gives a brief summary of important laws for local implementation:

1937: MN Soil Conservation Law

1938: MN's 1st Soil & Water Conservation District formed

1955: MN Watershed Act

1957: MN's 1st Watershed District

1982: MN Metro Surface Water Management Act

1985: MN Comprehensive Local Water Management Act (County Water Planning)

2012: One Watershed, One Plan (1W1P) legislation passed

2013-2014: One Watershed, One Plan Program Development

2015: Comprehensive Watershed Management Planning legislation passed

The result of the aforementioned laws resulted in the three most common types of watershed management organizations in Minnesota; they are Watershed Districts, County, and Joint Powers Watershed Management Organizations.

The Minnesota Legislature authorized the creation of watershed districts in 1955, through the Watershed Act, with the idea that water management policies should be developed on a watershed basis, because water does not follow political boundaries. The statutory purposes of watershed districts are to conserve the natural resources of the state by land use planning, flood control, and other conservation projects by using sound scientific principles for the protection of public health and welfare and the provident use of natural resources. The specific duties of Watershed Districts vary across the state — some focus mainly on flood damage reduction, while others have a broad range of programs and services to protect and improve water quality.

Each watershed district is governed by a board of managers appointed by the county boards of commissioners with land in the watershed district. Each watershed district is also required to have a citizen advisory committee to provide input to the managers on projects and activities. Many watershed districts have paid, full-time staff; others rely on contract employees, primarily for engineering and legal services.

Watershed districts have been given broad authorities, including the authority to:

- Adopt rules with the power of law to regulate, conserve, and control the use of water resources within the district.
- Contract with units of government and private and public corporations to carry out water resource management projects.

- Hire staff and contract with consultants.
- Assess properties for benefits received and levy taxes to finance district administration.
- Accept grant funds, both public and private, and encumber debt.
- Acquire property needed for projects.
- Acquire, construct, and operate drainage systems, dams, dikes, reservoirs, and water supply systems.
- Enter upon lands within and without the district to make surveys and conduct investigations.

Watershed districts are formed at the request of local citizens, county boards or cities by petitioning the Minnesota Board of Water and Soil Resources (BWSR) under the procedures set forth in the Watershed Act. Watershed districts range in size from the Carnelian-Marine District with 43 square miles, to the Red Lake Watershed District with 5,990 square miles.

In 1982, the Minnesota Legislature approved the Metropolitan Area Surface Water Management Act, creating Watershed Management Organizations (WMOs) (Minnesota Statutes 103B.201 to 255; can be found at <https://www.revisor.mn.gov/statutes/?id=103B>) and requiring local units of government in the seven-county Metro Area to prepare and implement comprehensive surface water management plans through membership in a WMO.

WMOs are based on watershed boundaries, and may be organized in one of three ways:

- As a joint powers agreement between the municipalities and townships within the watershed;
- As a watershed district — a special unit of local government operating under Minnesota Statutes Chapter 103B, and concurrently operating under Minnesota Statutes Chapter 103D; and
- As a function of county government, usually administered by the county planning department.

Watershed management organizations differ from watershed districts in a number of ways:

- WMOs are mandatory, not voluntary;

- WMOs deal only with surface water, whereas watershed districts manage surface water and groundwater (metro area counties handle groundwater planning);
- WMOs do not have individual taxing authority, unless their joint powers agreement specifically grants this authority and they obtain special district taxing authority from the State of Minnesota, however, most are funded by the municipalities that make up their membership; and
- Joint Powers WMOs are governed by a board appointed by the member municipalities and townships.

With the passage of the 1985 MN Comprehensive Local Water Management Act counties across the state were also required to complete comprehensive surface water management plans. While there are some differences in authorities, counties, WMOs, and WDs also have many similarities; most importantly, the requirement to conduct their activities according to an approved watershed management plan.

The Board of Water and Soil Resources developed rules (Minnesota Rules Chapter 8410) (<https://www.revisor.mn.gov/rules/?id=8410&view=chapter>) for plan content. The original rules went into effect on August 1, 1992. WMOs used these rules in plan revisions, which are required every 5 to 10 years. The rules require, among other items, to specify as how stakeholder participation will be incorporated, control of erosion and sedimentation, wetland assessment, and the design of new storm water conveyance, ponds, and treatment systems are incorporated. The rules also require that a WMO establishes the necessary authorities to ensure implementation of their programs.

Although the BWSR encourages integrated water planning, surface water planning, water supply planning, groundwater planning and sanitary planning are essentially dealt with separately in the metropolitan area. This has, at times, lead to inefficiencies in water management that only now is beginning to be addressed. The interaction of surface water and groundwater is now considered in comprehensive surface water planning through the Comprehensive Local Water Planning Act and planners across all areas are looking at an integrated systems approach to water management.

In July of 2015, the BWSR updated Minnesota Rules, Chapter 8410 governing Metropolitan Local Water Management. The amendment of Minnesota Rules, Chapter 8410 became effective on July 13, 2015. It is the first and only time, to date, that the original rules have been amended.

The rules affect watershed management organizations and their watershed management plan. Also, the rules affect local water plans for all cities and towns in the seven-county metropolitan area.

Highlights of changes resulting from the rule amendment can be found at http://www.bwsr.state.mn.us/planning/metro/Highlights_of_Changes_to_Minnesota_Rules.pdf and some significant items will likely require action by the WMOs in the near future (BWSR Metro Area Surface Water Management).

As noted earlier, Minnesota has a long history of water management by local governments. The recent change in water resources planning to One Watershed, One Plan (<http://www.bwsr.state.mn.us/planning/1W1P/index.html>) is rooted in this history and in work initiated by the Local Government Water Roundtable (Association of Minnesota Counties, Minnesota Association of Watershed Districts, and Minnesota Association of Soil and Water Conservation Districts). Roundtable members recommended that the local governments charged with water management responsibility should organize and develop focused implementation plans on a watershed scale.

The recommendation was followed by legislation that authorized the BWSR to adopt methods to allow comprehensive plans, local water management plans, or watershed management plans to serve as substitutes for one another; or to be replaced with one comprehensive watershed management plan as well as required BWSR to establish a suggested watershed boundary framework for these plans. This legislation is referred to as One Watershed, One Plan (Minnesota Statutes §103B.101, Subdivision 14). Further legislation defining purposes and outlining additional structure for One Watershed, One Plan, officially known as Comprehensive Watershed Management Planning Program (Minnesota Statutes §103B.801) was passed in May 2015.

BWSR's vision for One Watershed, One Plan is to align local water planning on major watershed boundaries with state strategies towards prioritized, targeted, and measurable implementation plans – the next logical step in the evolution of water planning in Minnesota. BWSR and watershed management organizations in the metropolitan area are still determining how One Watershed, One Plan will be implemented.

MWMO Organizational Structure

The Mississippi Watershed Management Organization (MWMO) is a joint powers local unit of government that includes area in seven cities

(Minneapolis, St. Anthony Village, Fridley, Colombia Heights, Hill Top, Lauderdale, and St. Paul) that drain to the Mississippi River (MS 471.59). Most of the land was fully developed by the 1960s for industrial, commercial and residential purposes. The MWMO is non-regulatory. The MWMO has implemented its' surface water management through financial incentives, education and training, water resources monitoring, evaluation, and feedback to its members for the last 15 years.

The MWMO joint powers agreement lays out the purpose and authorities for the MWMO. As a joint powers watershed management organization, the MWMO Board of Commissioners, are appointed by the member city councils or city park board.

The members agreed when creating the joint powers agreement to the following purpose statement for the MWMO:

The purpose of the Mississippi Watershed Management Organization, as provided for in this Agreement, is to provide for the wise, long-term management of water and associated land resources within the watershed through implementation measures that realize multiple objectives, respect ecosystem principles, and cultural and historical community values. The Mississippi Watershed Management Organization seeks to: (a) protect, enhance, and restore the quality and quantity of surface and ground water resources within the Mississippi Watershed Management Organization jurisdiction; (b) protect, preserve, and use natural surface and ground water storage and retention systems; (c) efficiently utilize public capital expenditures needed to correct and control flooding and water quality problems; (d) identify and plan for means to use protect and improve surface and ground water quality; (e) establish more uniform local policies and official controls for surface and ground water management; (f) promote ground water recharge; (g) protect and enhance fish and wildlife habitat and water recreation opportunities; (h) secure the other benefits associated with the proper management of surface and ground water; and (i) promote and encourage cooperation among Members and among other organizations in coordinating local comprehensive water management programs.

In addition the purpose, the Agreement defines the board's powers and duties, duration of the agreement, how it raises funds, and legal description of the watershed (MS 275.066, Sec 21).

The final document that drives MWMO's local work is the MWMO Comprehensive Water Management Plan (Plan). This is tool to clarify the mission and goals of the organization. It is the process used to prioritize work for the next ten year period.



Under MN Statute 103B and MN Rules 8410, WMOs are responsible for preparing plans that:

- protect, preserve, and use natural surface and groundwater storage and retention systems;
- minimize public capital expenditures needed to correct flooding and water quality problems;
- identify and plan for means to effectively protect and improve

surface and groundwater quality;

- establish more uniform local policies and official controls for surface and groundwater management;
- prevent erosion of soil into surface water systems;
- promote groundwater recharge;
- protect and enhance fish and wildlife habitat and water recreational facilities; and
- secure the other benefits associated with the proper management of surface and groundwater.

The initial Plan written for the watershed took nearly 3 years to write. Following an extensive public and partner input process planning staff aggregated the public comments and issues into the following ten key focus areas and nineteen related focus area statements from which all of the final goals, strategies, and actions of the plan resulted.

After review at the local level, a regional planning agency–The Metropolitan Council, and a number of state agencies review the plan. Once the plan is approved by the Board of Water and Soil Resources, the WMO formally adopts the plan and requires each city within the MWMO to create and implement their own local water management plan consistent with the MWMO plan.

The Plan and its updates have resulted in two key advances in comprehensive surface water resource management. First, the plans required the adoption, amendment, or update of a variety of local controls to reduce erosion and sedimentation, and establish stormwater design standards to protect streams, rivers, lakes, and wetlands. Second, during the planning and implementation of the plans, communities within the watersheds developed stronger working relationships.

While the MWMO Comprehensive Watershed Management Plan lays out the general work flow for the organization, it does not provide the year-to-year specific planning and activity detail necessary to implement the goals of the plan. In addition to the Plan, the Board periodically carries out strategic planning that must be incorporated into the annual workplan of staff. Each year, MWMO staff develops an annual workplan to present to the Board of Commissioners. The annual workplan provides a schedule and details of the projects and activities to be completed in a given year. The process takes place concurrently with the MWMO budget process to ensure funds are directed to the priority projects and activities.

The MWMO conducts an annual prioritization and selection of projects and activities based on available funding for capital projects, planning initiatives, research and watershed studies, communication and outreach initiatives and monitoring. These projects and activities advance the organization's goals, strategies, and implementation actions, while responding to changing resource conditions; and financial constraints of the MWMO.

The MWMO also continues to seek out opportunities to collaborate and develop partnerships with other organizations to expand the reach of our and their activities, to leverage additional funds, and to prevent duplication of services and project efforts within the Watershed (Table 20).

Evaluations measure the impact of MWMO's efforts and are a critical part of improving its projects and activities. Evaluations will clearly state objectives, measure results, and serve as a valuable tool in documenting the success of the MWMO's implementation plan. The MWMO will include results of the evaluations as part of its annual report and financial summary.

The summary below describes each of the activity areas and implementation actions taken by staff at the MWMO.

Capital Projects

Purpose: The MWMO builds structural solutions to address its water resource protection and improvement goals, because it is the most efficient and effective way to attain the water quality and quantity goals of the MWMO. Nutrient storage, volume storage, rate attenuation, and drought attenuation on a district, sub-watershed or watershed scale is where the MWMO primarily invests its capital improvement funding.

Objectives:

- Encourage the use of new and innovative water management systems for energy, water supply, and stormwater and waste water treatment and reuse
- Evaluate the effectiveness of new technologies
- Provide technical and funding assistance for projects, programs, and policy development in the Watershed that encourage conserving water resources
- Provide leadership surface and groundwater conservation and reuse whenever opportunities arise

- Pilot innovative and visible demonstrations to showcase techniques for local conditions
- Leverage funding from other sources to purchase property that supports watershed planning goals
- Provide financial assistance to member organizations for responding quickly to emergencies that impact water resources
- Collaborate with emergency response officials in training and implementation of emergency response practices

Communications and Outreach

Purpose: Provide information, training and educational opportunities, and services and products to promote responsible stewardship of water and natural resources for and by the watershed community. The MWMO watershed community can better support MWMO activities and develop their own initiatives, if they have access to information, training, education, and financial support for water and natural resource projects and activities responding to local threats to water resources identified by the community.

Objectives:

- Learn from and work with other groups and efforts
- Provide services and products to inform and educate the watershed community using a variety of methods and media
- Create and support opportunities for public participation and involvement
- Collaborate with other professionals and networks to leverage funding and increase the reach and effectiveness of watershed education
- Inform and educate land use decision makers about the relationship between land use and natural resource protection/conservation
- Provide training and certificate programs for the evaluation, development, and use of new technologies and management practices

Water Resources Monitoring

Purpose: Provide a scientific basis for identifying and tracking water quality and quantity issues, and to provide information to aid in the selection projects and evaluating the success of those projects. Water quality

monitoring provides scientific data to ascertain where and how storm water management practices can be implemented to effectively achieve TMDLs, state standards, and MWMO purposes and standards.

Objectives:

- Monitor biological, chemical, and physical parameters of surface and groundwater resources in the Watershed
- Monitor water quality within the Watershed
- Develop a record of baseline data to characterize water quality and identify pollutants that exceed water quality standards
- Assess pollutants listed on the Minnesota Impaired Waters list for the TMDL process
- Collect rate and volume data for the Mississippi River and key subwatersheds
- Monitor performance of stormwater management practices

Planning

Purpose: Provide direction to the MWMO's activities. Clarify and integrate the MWMO's goals, responsibilities, and future courses of action. Coordinate implementation of MWMO Standards and goals by member organizations. Maintain involvement with Mississippi River regional working groups.

Objectives

- Keep the MWMO's Watershed Management Plan (WMP) current to address new circumstances and changing priorities
- Bring together information (i.e. watershed assessments and data, public comment, staff and Board reviews) to identify MWMO planning priorities
- Develop consensus among stakeholders for managing resources in the Watershed
- Coordinate budget establishment process and financial evaluation of MWMO projects and activity areas
- Work with member organizations on the implementation of ordinances, standards, plans, and enforcement

Watershed Assessment

Purpose: Develop a scientific base of knowledge that characterizes physical, chemical, cultural, historic, biological, social, economic, organizational, and political resources of the MWMO to guide planning and management decisions in the Watershed.

Objectives:

- Provide information needed to set and refine design and performance standards for the Watershed
- Conduct basic research to further knowledge on general water resource issues and emerging issues within and beyond the Watershed's boundaries
- Conduct assessments within the Watershed to define the ecological, physical, biological, cultural, social, economic, organizational, and political characteristics that comprise the MWMO
- Conduct project-based diagnostic and feasibility studies

Conclusion

Soil and water resource protection and management laws have provided a solid, adaptive structure to address soil and water resource in the State of Minnesota. These laws continue to evolve as Minnesotans seek to better manage the resources in response to climate variation and to become more sustainable and resilient in our practices. There are some critical lessons that have been learned over the last fifteen years of developing and implementing the watershed management plan.

First, it is important the organizations have clear purpose and mission, so the board, staff, and people impacted by the organization's work have a clear understanding of the mission and the strategies towards prioritized, targeted, and measurable implementation results. Second, it is an imperative to be as inclusive as possible when identifying and developing issue statements and solutions to the priority problems identified through the watershed assessments and people's narratives regarding their experiences of living in the watershed. Third, watershed implementation requires good communication and coordination across all levels of government to most effectively and efficiently manage water resources. None of agencies alone are positioned to do all that is needed to protect, manage, and restore water resources.

Finally, local implementation is more successful when there is education and information provided to those impacted by the solutions. This outreach effort needs to occur before, during, and after best management practices are applied. People need to understand why they are being asked to spend their money or alter a traditional practice or agree to less usage of water in order to enhance the water system for all in the watershed.

3

Design and Implementation of Water Resources Monitoring Program for the State of Mizoram-Pilot Project

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Abstract

Watershed management is critical for sustainable food and water throughout the world. However, hydrological data is needed to perform analysis and provide information to decision makers. University of Minnesota in St. Paul, Minnesota, United States and the Mizoram University, Aizawl, India have been working together under a memorandum of agreements for the last five years. Mississippi Watershed Management Organization (MWMO) in Minneapolis, Minnesota, USA has been collaborating with University of Minnesota and the Mizoram University scientists and faculty members, for the past three years. MWMO has hosted two faculty members from Mizoram University and provided on-site field training on water resources monitoring. This paper describes the design and implementation of water resources monitoring program for the state

of Mizoram as a pilot project. A field manual to implement the water resources monitoring program is also prepared as part of this pilot project.

Keywords: Sustainable Food and Water, hydrological data, Water Resources Monitoring, University of Minnesota, Mizoram University, Mississippi Watershed Management Organization.

Introduction

Mr. Chongthu Chawnghnuna, from the Public Health Engineering Department of the State of Mizoram, visited University of Minnesota (UMN), St. Paul, Minnesota in 2011 as a full-bright scholar to learn more about watershed management to address water issues in state of Mizoram, India. Since then a multidisciplinary team of scientists from University of Minnesota through its memorandum of understanding with the Mizoram University (MU) has been working together to collaborate on various projects. Mr. Chawnghnuna and the government of Mizoram invited a team of four UMN scientists to visit Mizoram in January 2013 to help develop a program to address water and land use management issues in Mizoram. Team held a jointly sponsored international symposium on land use in the Eastern Himalayas in March 2014 in Aizawl, Mizoram.

Dr. Joe Magner and two master degree students from University of Minnesota travelled to Mizoram in early part of 2015 to assess the water resources monitoring needs. A team of Mizoram University scientists traveled to University of Minnesota in May and June 2015 for a joint symposium and to further strengthen UMN and MU cooperation and learning. University of Minnesota collaborated with Mississippi Watershed Management Organization (MWMO), a local watershed management organization in metropolitan Minneapolis, Minnesota, to provide watershed management and water resources monitoring training to Mizoram University scientists. Dr. K. C. Lalmalsawmzauva from the Department of Geography and Resource Management, Mizoram University, Aizawl, India stayed two extra weeks in June 2015 to learn more about watershed management and water resources monitoring at MWMO. Dr. Udai B. Singh, Water Resources Director at MWMO visited Mizoram University in December 2015 to collaborate with Mizoram University scientists to assess the need for field training and provide training on stream flow measurement using Flow Tracker. Two students from the University to Minnesota also travelled in January 2016 to conduct field work in Mizoram.

Dr. Renthlei Zonunsanga from University Grants Commission-Human Resources Development Center, Mizoram University, Aizawl, India visited University of Minnesota and Mississippi Watershed Management

Organization from July 2016 to March 2017 as a visiting faculty to learn and collaborate on water and soil resources management and water resource monitoring.

A joint collaboration was developed between UMN and MU, and managed through the Center for Integrated Natural Resources and Agricultural Management (CINRAM) at the University of Minnesota, St. Paul, Minnesota. The team of scientists at UMN includes hydrologists, natural resource economists, social scientists and outreach specialists. UMN has an important partnership with MWMO.

Ministry of Water Resources, Central Government of India in partnership with Minor Irrigation department of the state of Mizoram has launched a National Hydrology Project (NHP) in fiscal year 2016-17. The objective of the NHP is to improve the extent, quality, and accessibility of water resources information and to strengthen the capacity of selected water resources management institutions in India.

Team of Dr. Udai B. Singh from MWMO, Dr. Joe Magner from UMN and Dr. KC Lalmalsawmzauva and Dr. R. Zonunsanga from Mizoram University have been working on designing and developing a hydrological and water resources monitoring program for the state of Mizoram.

This paper provides an overview of the design and implementation of meteorological and hydrological monitoring program for the state of Mizoram. Main objective of this paper is to design a pilot project to implement water resources monitoring in Mizoram.

Elements of Pilot Project for Water Resources Monitoring Data Collection for State of Mizoram

Establishment of Hydrologic Science Center at Mizoram University

It is suggested and recommended to establish a Hydrologic Science Center (HSC) at the Mizoram University. The center could be a joint collaboration between departments of Geography, Human Resources, and Civil Engineering from the Mizoram University and the Minor Irrigation and Soil and Water Conservation Departments from the State of Mizoram. The international collaboration between Mizoram University, University of Minnesota, and Mississippi Watershed Management Organization could continue through the on-going Memorandum of Agreement between Mizoram University and University of Minnesota.

In addition to hydrological monitoring network design and hydro-meteorological and hydrological data processing, the HSC can also develop

in class and field training programs to provide training on development of stage-discharge (rating) curve, rainfall-runoff correlation, gauge-discharge modelling, predictions in un-gauged basins, applications of remote sensing & Geographic Information Systems in water resources management.

The HSC can function as valuable resources for future institutional capacity building to provide training for future professionals in the field of hydro-meteorology and hydrology for State of Mizoram and other North-Eastern states of India. The HSC will provide reliable hydrological data for the state of Mizoram. Interdisciplinary approach can create an opportunity for the Mizoram University and state government departments to come together and collaborate on projects for the betterment of the state of Mizoram and its people which is not common in India. This joint venture could strengthen the bond between state government departments and the Mizoram University for the welfare of the people of Mizoram. Looking at global warming and its associated problems, HSC can play an important in collecting and organizing reliable data.

Weather Station and Manual Rain Gage Station at Mizoram University to collect Meteorological Data

As part of pilot project, a weather station should be installed at the Mizoram University campus as a central weather data collection station to collect continuous data on precipitation, air temperature, humidity, barometric pressure, solar radiation, wind speed and wind direction. Figure 1 shows an example of weather station. Complete details to design and



Figure 1. An example of Automated Weather Station at the Roof Top of MWMO Stormwater Park and Learning Center building, Minneapolis, Minnesota, USA.

install a weather station are provided in a Hydrological and Water Resources Monitoring Data Collection and Training Manual for State of Mizoram that is being prepared separately for the Mizoram University and Minor Irrigation Department of state of Mizoram.

A manual rain gauge station can also be installed at the Mizoram University campus to record daily precipitation data manually on standard data sheets.

Manual and Automatic Rain Gauge Stations at Mizoram University Campus

In addition to manual and automated rain gauge station at the Mizoram University campus, manual and automatic rain gauge stations can also be established at various locations throughout the state of Mizoram as suggested in the National Hydrological Project proposal by Minor Irrigation department. Figure 2 and Figure 3 show the manual rain gauge and an automated rain gauge stations respectively. Manual rain gauge data can be collected by various well trained citizen scientists or government officials at the manual rain gauge locations. Automatic rain gauge has a small data logger that collect the long-term data and that data can be downloaded once every three or four month's intervals using the data transfer shuttle from the manufacturer.



Figure 2. A manual rain gauge station at the MWMO Stormwater Park and Learning Center, Minneapolis, Minnesota.

River Gauge Stations at Various Locations

Staff gauges can be installed at various feasible locations throughout the river networks of state of Mizoram to accurately record the water level on daily, weekly, or bi-weekly basis to collect long term river level data throughout the year. The river level data can then be used to develop stage discharge relationships for each river system with the help of acoustic Doppler current profiler equipment by collecting flow data at various river stages. Figure 4 shows a River Level Staff Gauge. Staff gauges needs to be surveyed to a reference point with pre-determined bench mark survey to transfer the data to a standardized system based on the elevation above mean sea level.



Figure 3. An automated rain gauge station on the Roof of Thomas Edison High School Gymnasium building, Minneapolis, Minnesota.



Figure 4: River Staff Gauge to Manually Monitor River Levels.

Reservoir Level Monitoring Station

Staff gauges can also be installed and utilized to monitor water level in the Serlui B Dam hydropower generation reservoir. Having long-term daily reservoir level data will help in determining the optimum operation of the hydropower electric generation system. An in-situ pressure

transducer can also be installed in a stilling well to continuously monitor the reservoir level. This pressure transducer can store data for a longer period.

Water Quality Sampling Station at Hydropower Generation Reservoir

Biweekly or monthly water quality sample can be collected at the end of the river that joins the Serlui Dam reservoir to determine total suspended solids concentrations and total phosphorus and total nitrogen concentrations. TSS data will assist in assessing the long-term viability of the Serlui B Dam reservoir for hydropower electric generation. Long term record of Total Phosphorus and total Nitrogen concentrations data will provide the potential growth of aquatic vegetation in the Dam reservoir.

Stream and River Flow Measuring Stations

Stream flow measurements can be made using a Flow Tracker to measure the flow rate in wadable streams in the Mizoram river networks system to develop stage-discharge relations for various locations in the river systems. Figure 5 shows a use of flow tracker for flow measurements.



Figure 5. Stream flow measurement using a Flow Tracker in Shingle Creek, Minneapolis, Minnesota.

Conclusions

Hydrological and water resources monitoring data is essential and very much needed to perform analysis and provide information for watershed management for sustainable food and water throughout the world.

University of Minnesota in St. Paul, Minnesota, United States and the Mizoram University, Aizawl, India have been working together under a memorandum of agreements for the last five years to collaborate on various projects. Mississippi Watershed Management Organization (MWMO) in Minneapolis, Minnesota, USA has been collaborating with University of Minnesota and the Mizoram University scientists and faculty members, for the past three years. MWMO has hosted two faculty members from Mizoram University and provided on-site field training on water resources monitoring. A description of design and implementation of pilot project for hydrologic and water resources monitoring data is provided in the paper. It has been suggested and recommended to establish a Hydrological Science Center at the Mizoram University to collaborate with other state government departments to collect the hydrologic data and provide training. Description of installation of weather station, manual and automated rain gauge stations, river level measurements, and stream flow measurement using Flow Tracker to develop State-Discharge relationship is also provided. A field manual to implement the water resources monitoring program is also prepared as part of this pilot project.

Reference

Singh U.B. and J. Magner. 2017 Hydrologic and Water Resources Monitoring Data Collection and Training Manual. Mississippi Watershed Management Organization and University of Minnesota, Minnesota, USA.

4

Rational Resource Management and the Role of Traditional Knowledge Among the Santhal and the Bhumij Tribes of Binpur II Block, Paschim Medinipur, West Bengal

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Abstract

This research tries to examine the man-environment relationship as evolved through practice of traditional knowledge over space. Rational utilization of natural resources specially land, water and forest, their management and conservation techniques adopted by the Santhal and the Bhumij communities of Binpur II block, Paschim Medinipur district, West Bengal, are identified through empirical survey. The study attempts to explore the faces of modification of hostile physical environment to productive cultural environment with the application of traditional knowledge. Ethno-methodological techniques have been adopted for showing biographies of land use / land cover, resource harvesting, sacred sites, *toponym* of land categories, folk songs, folk stories and information related to resource conservation etc. Ecological transects were carried out to take actual information of landuse practice and management techniques adopted to conserve natural resources. GIS software are used to prepare land cover map, Digital Elevation Models and Normalized Difference Water Index (NDWI) map are prepared with help of Landsat TM. All these scientific tools are used for scientific analysis of the land in the study area. The result is

compared with the existing land use practices as guided by traditional techniques. Moreover an inventory of traditional conservation methods is made which are imbedded in their life practices to use, manage and conserve natural resource base.

Keywords: Natural resource, Santhal and Bhumij, Inventory, Traditional knowledge (TK), Resource conservation

Introduction

Traditional knowledge is a distinct trend in utilization of natural resource base in a sustainable manner. The tribal people living in a traditional societies share a clear understanding about nature and they form an unorganized body of knowledge regarding sustainable use of environmental resources. Those have taken shape by the way of their long term interaction with the environment and accumulation of tested experience transferred across generations. Careful observations have revealed that such traditional knowledge find their expressions in their cultural practice, social norms, ethic beliefs, community behaviour and livelihood practice, which ultimately becomes a knowledge–practice–belief–value complex. This complex plays pro-environmental role for conservation of natural resource directly or indirectly. The present work is a humble representation of such traditional understanding validated with modern scientific method of understanding natural resource base. The forested western part of Paschim Medinipur district of West Bengal is dominated by tribal community of diverse ethnic groups like Santhal, Sabar and Bhumij. The study concentrates on two villages of Binpur-II block of and tries to explore people's perception on the natural resources, patterns arises from resource extraction and traditional cultural practices in conserving environment. It is also tried to make an inventory of traditional ecological knowledge as exists among these communities and assess their significance. Dhobakacha and Mahulboni village, Binpur-II block, P.S-Belpahari, Sub-Division -Jhargram, and Dist-Paschim Medinipur, comes under the '*Jungalmahal districts*' (Malley, 1911). These two villages are among the most backward villages of Paschim Medinipur. Most of the people of this both villages are tribes.

The area is characterized by undulating steep slope, hilly and rocky surface having low fertile soil, water crisis and forest covered area. So the physical environmental characteristics of the study area are not favourable for agriculture the main base of any rural settlement of India and hence the villagers have to face hardship for leading normal life. Hence the people have to adopt with the unfavourable environmental condition.

Objectives

The objective of this study is to find out the existing environmental resource base and livelihood pattern. How the people with lack of education, health, food and drinking water facilities as well as economic opportunities adjust with this condition. How they develop some alternative resource for their livelihood and manage and conserve environmental resource in a sustainable manner.

- 2.1. The Traditional techniques they adopt for rational utilization of resource.
- 2.2. Conservation methods imbedded in their culture for sustainable utilization of resource.
- 2.3 Make an inventory of the pro-environmental eco-centric culture practiced in the study area.

Literature Review

The study of traditional knowledge considered species identification, ecological process, and relationship with environment and livelihood practices. It is noted that traditional knowledge is practiced at several levels of life cycle as a *knowledge–practice–belief–value complex*. These values are rooted in them and closely related to the “sense of place” (Berkes, 2008). Landscape around us bears detailed ecological knowledge. It is a repository of the memory of past events, and thus a vast mnemonic representation of social relationships and of society” (Berkes, 2008).

Traditional knowledge (TK) and Indigenous Knowledge (IK) are locally invented knowledge used for many purpose and have a unique spiritual and cultural identity. Contemporary ecological education should therefore draw insights from this system of education” (Battiste 2002 cited from Maweu, 2011).

Traditional knowledge talks about the protection of environment through the utilization of land, water, soil and forest in a rational manner. Indigenous knowledge includes relationships with environment of ethnosience including agriculture (Warren et al. 1995; Armitage, 2003), ethnobotany (Schultes and Reis, 1995; Cunningham, 2001; Laird, 2002), ethnozoology (Clement, 1995; Sillitoe, 2002; Anderson and Tzuc, 2005), ethnopharmacology (Marles et al., 2000), irrigation systems (Mabry, 1996), soil and water conservation (Reij et al., 1996), soils or ethnopedology (Pawluk et al., 1992), ethnoveterinary medicine (Mathias-Mundy and McCorkle 1995; SRISTI, 2007), human food and healing (Pieroni and Price,

2006), weaving (M'Closkey, 2002) and ethnoastronomy (Ceci, 1978) throughout the world people practiced.

In West Java, Indonesia, *Kebun-talun* is a cropping system refers to rotation between mixed garden and tree plantation. It offers overall productivity and served different function by sequentially stage, *Kebun* or planting of a mixture of annual crops mainly for selling and different traditional techniques for agriculture and landuse management. *Kebun campuran* a transition stage in which annuals is mixed with half-grown perennials. Finally, after harvesting of annuals, it is kept abandoned for two or three years and become dominated by perennials *Talun* stage (Berkes, 2008). The farmers of San Benito community in Guatemala modify the forest environment by planting Cardamom (*Elletaria cardamomum*) under tall trees so that plants can get shadow. Cardamon is a cash crop which produced exclusively for market. The characteristic vegetation that dominates the arboreal status includes palm trees such as the bayal (*Desmoncus orthacanthos*), which is used for the making of thatch and basketry (Maass, 2008). Farmer of Roq-há community in Guatemala use to grow velvet bean (*Mucuna pruriens*) in agricultural land as green manure at fallow period. They use it as soil nutrient instead of using chemical fertilizer at the time of cultivation and use the leaves of madre cacao (*Gliricidia sepium*) to prepare an organic fungicide. The leaves of the b'ach'e (*Eupatorium semialatum*) were used by some farmers to fertilize the garden crops (Maass, 2008).

Tribes of Java use their land in a preferable manner. They plant vegetables for their own consumption in *Pekarangan* (home garden) and small excess for marketing. This strategy helps to balance their economic status. In *Pekarangan*, multi species plantation around a house includes food crops, medicinal plants, bushes, fruit trees and weeds etc are planted (Berkes 2008). Another type of landuse has been identified as "potrero" where land is pasture after cropping a certain time of the year. Some trees usually left like Plam, Manaco (*Orbignya cohune*) to provide shadow to the livestock or forage brizanta (*Brachiaria* sp.) as feed for the animals. The Zuni, a tribe of Pueblo, USA, used some methods for careful placement of field on alluvial fans, management of gully formation and supply of soil moister, nutrient etc. A common technique used by traditional peoples from Mesoamerica to the Sahel includes the use of weirs, dams or terrace walls to slow runoff and foster the deposition of upland sediments. In this way, eroded slopes are rehabilitated as topsoil builds up behind structures (Pawluk et al., 1992 sited from Berkes, 2008).

Tribes in India too manage land by applying traditional knowledge. Munda people of Tripura, cultivate paddy instead of tea in the flat land (*Lunga*) situated between two hillocks, where tea plantation cannot be done (Singh, 1994). In Orissa, tribal communities have two folds cultivation, cultivation for self-consumption and commercial cultivation. They used to grow vegetables and fruit (mango, jackfruit, banana, papaya, and cashew nut) inside the forest in common lands and prefers to grow rice in more fertile ancestral lands. Millets are grown more on ‘*Padar*’ (Unbunded high land) lands. Vegetables are cultivated on unbunded or bunded high lands (*Aat* or *Mal*) (KCSD, 2007). The traditional occupation Santhal tribe of West Bengal was hunting but now they practice agriculture. They used to apply traditional knowledge for rational landuse practice. Most of the tribal populations of West Bengal are concentrated on Paschim Medinipur, Purulia districts. Tribal livelihood depends on forest for their basic needs, entertainment and culture. A natural mixed forest provides raw materials like bamboo, twigs, woods, leaves for constructing their houses and also provides some foods such as mango (*Mangifera indica*), jackfruits (*Artocarpus heterophyllus*), Mahua (*Madhuca longifolia*), wood-apple (*Aegle marmelos*) etc. Forest is the main object of their entertainments like dancing, singing. They have place for worship of God often situated in the forest. They, are the son of nature, live a simple way of life and utilize forest in a sustainable way. Around 90% of tribal people in India were depending on land directly or indirectly for their survival (Verma, 1995). Environment gives opportunities how they use the land for sustenance. Tribe’s primary traditional occupation was hunting and gathering, but now it is getting changed as the forests are disappeared and wildlife has diminished. They brought up in nature’s lap and lives close proximity with rich biodiversity of landscape. They formulated a sustainable livelihood by incorporating indigenous knowledge passed through generations (Singh, 1994). Santhals of Purulia district, use to practice paddy in the ‘*baid*’ or low land vegetation in ‘*tora*’ or upland areas where water availability is lesser (Dolui et al., 2014). These traditional knowledge imbibed in their culture and practiced in different festivals too. Festivals like *Dasara*, (held during rainy season) *Janthar*, (held after harvesting) *Baha*, (a spring festival) and the biggest and important festival *Sohrae* held during last day the Bengal month *Pous* (December-January) states about their environment friendly traditional cultural practice (Singh, 1994).

Study Sites and Methods

Dhobakacha and Mahulboni are two Santhal dominated villages situated at southern part of Binpur-II block in Paschim Medinipur district.

Both the villages are surrounded by dissected hills as part of Dalma range of Chhotonagpur plateau. Dhobakacha is extended from 22°38'50"N-22°37'50"N to 86°40'30"E-86°39'20"E and Mahulboni is extended from 22°39'00"N-22°38'00"N to 86°43'00"E-86°41'00"E. Total area of Dhobakacha and Mahulboni are 1.692 and 1.345 sq km respectively (Census Report, 2011).

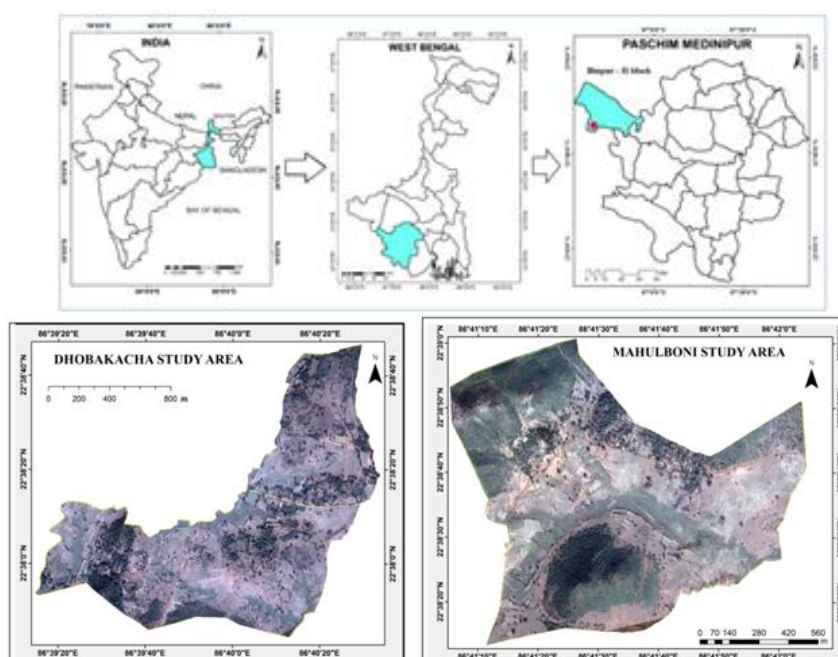


Fig 1: Study area

Selection of the study area is based on two pre decided criteria of tribal concentration and natural resource base. These two criteria are significant to establish man-nature relationship and the way people practice traditional knowledge to use and conserve the natural resources. Santhal and Bhumij community has a traditional ecological education transmitted orally from generation to generation focused on preserving the sacredness of life and whatever enhanced it. Primary data are collected through ethno-methodological techniques during field survey. Census hand book and cadastral map of villages are used as secondary data source along with published and unpublished works.

For data collection, personal interview were taken through pre-structured questionnaire with standard techniques of voice recording. Data collected through random sampling method and an intensive investigation

of the particular area of interest. Different survey instruments and GPS were used to collect spatial data. Both qualitative and quantitative data are used by applying inductive approach methods to analyze the field data.

Precise record about landuse landcover, resource harvesting, place name, sacred sites, roads, local name of lands, position of check dams, stories and legends associated with individual traditional people are taken and incorporated for making map biography (Freeman, 1976; Riewe, 1992; Tobias, 2000 cited from Berkes, 2008). These individual maps are aggregated together to form a landuse map of Dhobakacha and Mahulboni village community. For resource use area mapping, important resources such as water, soil, rocks and minerals, natural forest etc were mapped through a questionnaire-based study (Berkes et al., 1995 cited from Berkes, 2008) in special context of Dhobakacha and Mahulboni village community. ArcGis 10.1 is used to prepare land cover map with the help of field information and Digital Elevation Models (DEM) with the help of Google Earth elevation. Normalized Difference Water Index (NDWI) map has prepared by Erdas Imagine 13 with the help of Landsat TM satellite image. Field information has summarized into cartographic records on the basis of geographic zones in Dhobakacha and Mahulboni village to show all the resources and land features which are important to local Santhal and Bhumij community (González et al., 1995; Chapin and Threlkeld, 2001).

Discussion

Decadal Growth Rate of Dhobakacha and Mahulboni Villages

Binpur-II block is situated in the north western part of Paschim Medinipur district. Before 1980 the areas of Binpur-I and Binpur-II are under Binpur block. According to census (1971) total population of Binpur block were 1, 93,000. Fig. 2 shows the decadal growth rate of population in various census years of Binpur-II block. Decadal growth rate is calculated on the basis of 1981 census population when Binpur-I and Binpur-II is already divided. Decadal growth rate of Binpur-II block gradually increase from 1981 to 2011.

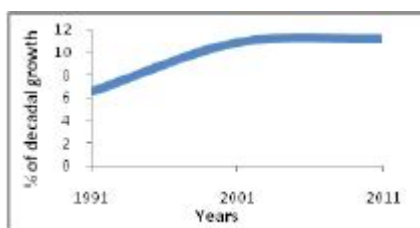


Fig. 2: Decadal growth rate of Binpur-II block

Occupational Structure

Economy of the both tribal villages depends on natural resource base. Inhabitants of these villages depend on primary activity such as

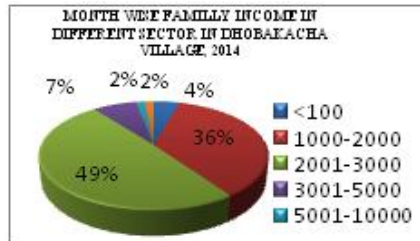


Fig. 3: Family income in Dhobakacha village



Fig. 4: Family income in Mahulboni village

agriculture and forest resource collection. It is difficult to find any service holder, because most of the people of both the villages are engaged in agricultural activity as a labour. Economy mainly depends on subsistence activities. Hence, family income is not so high. As per information, the monthly family income ranges between Rs. 2000 - 3000 even monthly incomes of few families are ranges between Rs. 1000 - 2000. Family with high income is very rare to find in the both villages. Only one family of Dhobakacha and 20 families of Mahulboni earn Rs.10000/month.

Agriculture, landuse and management:

To set an idea on the landuse pattern of these two villages, we have prepared a detailed landuse map through empirical data input. Dhobakacha is characterized by dissected hill and premature soil. Upland areas are covered with rocky soil dominated by weathered quartz. The foothills in the relatively lowland have water availability and fertile soil. Slope plays a great role in their agricultural pattern as well as their settlement and livelihood. Area of Dhobakacha village is about 1.692 sq km. Availability of water to plays a key role for selection of crop type and

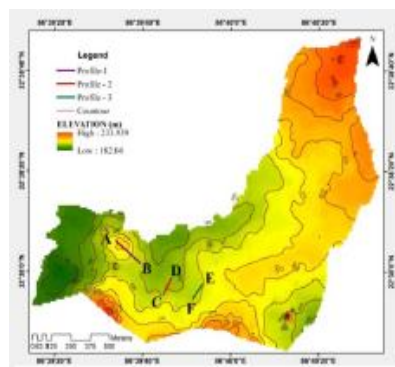


Fig. 5: Land use map of Dhobakacha village

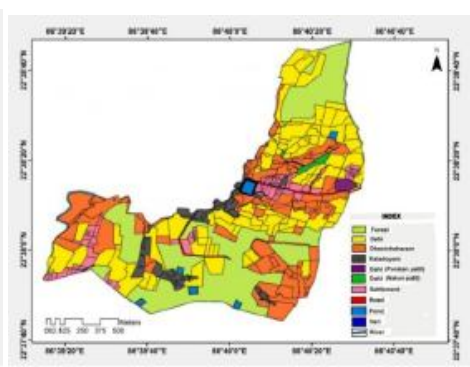


Fig. 6: DEM map of Dhobakacha village

cropping sites. From the landuse map (Fig. 3) it reveals that, most of the sloppy area, hilltop and upland (*Dahi*) are occupied by forest, pasture land and fellow land. Villagers classify total land into three types firstly, *Dahi*, the sloppy land (5° - 10°) have no cultivation potentiality. Babui grass (*Eulaliopsis binata*) plantation is practiced in *Dahi* waste land (Fig. 10). Babui grass is very important raw material for making Babui rope. About 40% people are engaged in this activity and its popularity is gradually increased due more profitable activity than agriculture. Babui grass roots protect top soil from erosion and reduce nutrient erosion. Secondly, in *Dhani Chaharam* (slope $<5^{\circ}$) which is the basin area between two and more hills where underground water are accumulated (Fig. 10). But in rainy season, they usually use traditional check dam system to retain water for dry season. It is the main objective regarding construction of check dam but there is also another key role to recharge water by infiltration. Due to steep slope the rate of surface runoff is high. So, they manage two severe problems of agricultural water and domestic fresh water supply

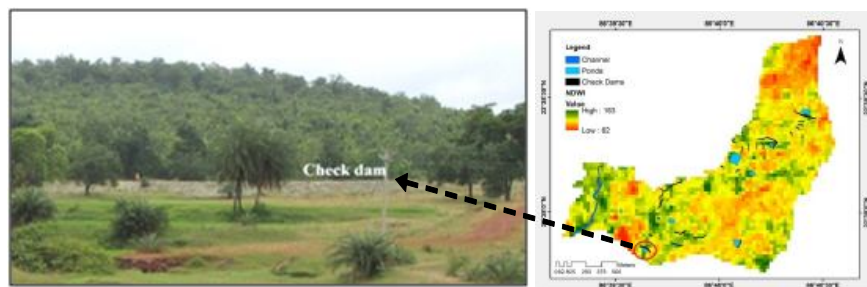


Fig. 7: Check dam position and NDWI map of Dhobakacha village

through a minor solution by constructing check dam (*Veri*) using locally available materials like rocks, lateritic soil, log, straw etc (Fig. 7). Settlements and roads are developed where water supply is sufficient and relatively plain lands. Every house has its own vegetation garden for daily needs (Fig 8). They use organic manure (cow dung) to fertilize vegetables growing land. Livestock activity in every house gives economic stability.

They used to go forest every day for collection of woods, sal-leaf, and fruits. They cultivate paddy one time in a year on *Dhani Chaharam* land. The method 'tillage and keeping the land fallow' preserved fertility of lands. The third and last type of land is *Kaladoem* which is very fertile land due to presence of moisture throughout of the year (Fig 9). This low sloped land is used to produce paddy, maize and vegetables because the soil more fertile for its clay and loamy nature but the area of this *Kaladoem* land is very much less.

Landuse and landcover zones at Dhobakacha village

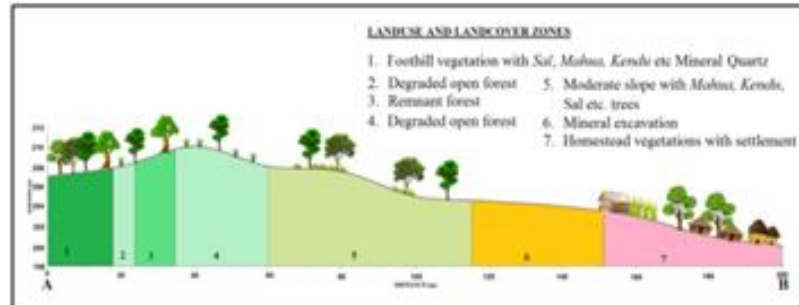


Fig 8: Longitudinal profile-1 along AB line

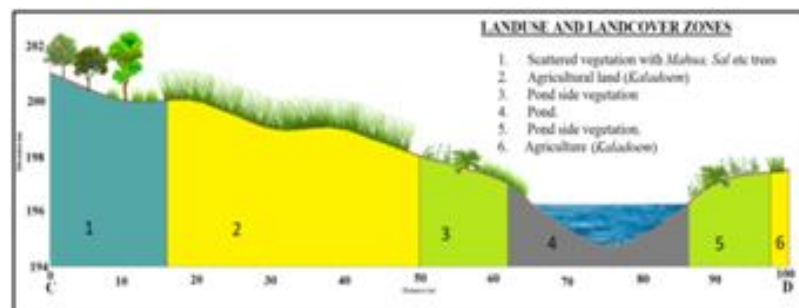


Fig 9: Longitudinal profile-2 along CD line

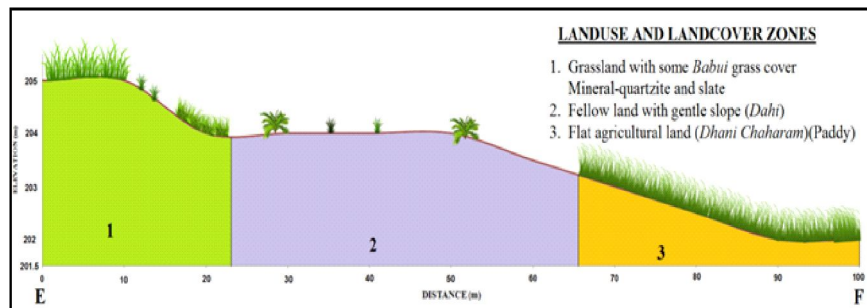


Fig. 10: Longitudinal profile-3 along EF line

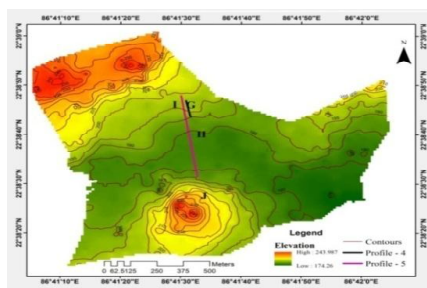


Fig. 11: Landuse map of Mahulboni village

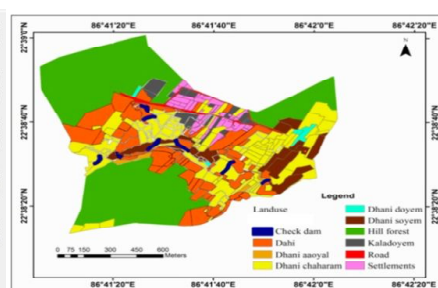
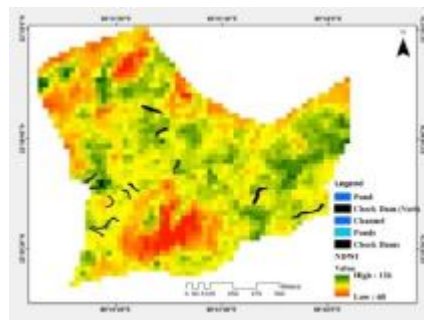


Fig. 12: DEM map of Mahulboni village

Village Mahulboni is surrounded by hillocks and the area is undulated (Fig. 11). Area of Mahulboni village is about 1.345 sq km. Shale, slate, quartz, quartzite etc are important minerals present in the soil. Highlands and hillocks are fully covered by natural forest (toponym *Beer*) with Sal, Kendu, Mahua, Simul (Dry tropical forest) species. Highest and lowest elevation is 240 m and 170 m respectively. Water scarcity is the initial problem to set up a settlement in an isolated area. Therefore, settlement, road and agricultural activity developed in valley areas because of availability of water. But now villagers overcome with digging well, pond, constructing check dam (*Veri*) store surface runoff water.

Traditional knowledge of Santhal describes *Dahi* land as sloppy (5° - 12°) fellow land and it is used for growing seasonal vegetables (Fig.



13). *Kaladoem* is fertile land with 6° - 8° slope and characterised by agricultural land for using in rainy season. *Dhani chaharam* with 1° - 6° slope and are very fertile for paddy, maize and vegetables (Fig. 14). This land has further divided into three types, like *Dhani doyem*, *Dhani aayol*, *Dhani soyem*. *Dhani doyem* is relatively high land than *Dhani aayol*

and *Dhani soyem*. During rainy season farmers cultivate paddy here. *Dhani aayol* lands are situated near check dams which retain soil moisture for nearly 5 months to its neighbouring place. Check dams (*Veri*) are constructed by locally available materials like log, rocks, mud etc. It can identify that *Dhani soyem* (most fertile land) are located just after check dams (Fig. 13, 15)

Landuse and landcover zones at Mohulbani village

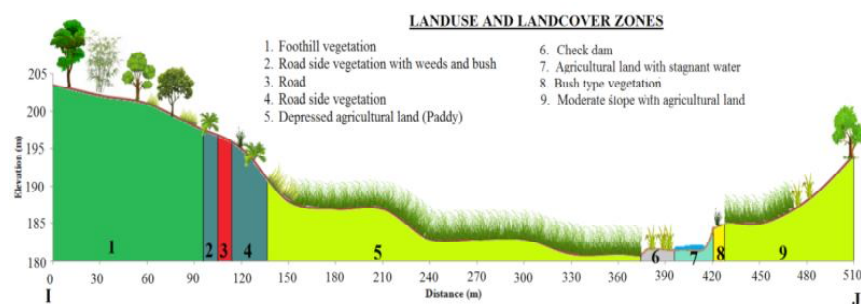


Fig. 14: Longitudinal profile-4 along GH line

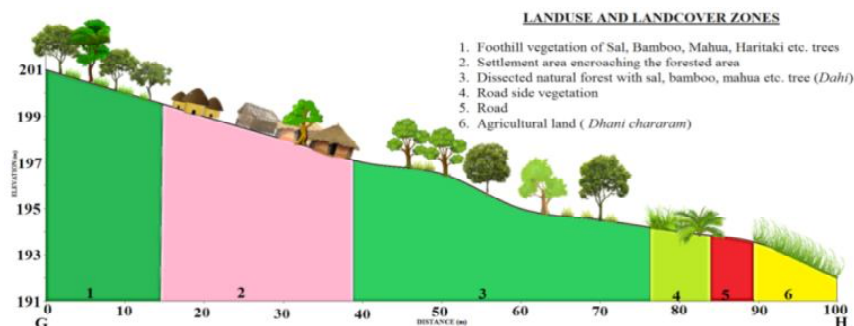


Fig. 15: Longitudinal profile-5 along IJ line

Cultural practice and resource conservation:

During field survey, detailed information was collected on the cultural practices of these two communities through interviews. It may be a valuable inventory for nature conservation. The songs which they sung during various festivals throughout the year are used for this purpose. These songs perpetuate through generation orally and there is no authentic documentation. So, we have tried to document some of the songs and these can be used as a repository of traditional culture for conservation environmental resource (Table no.1).

Table 1: Songs of Santhal

Occasion	Songs	Meaning	Environment conservation messages
"BAHA" festivals	I am an orphan lady, Going outside of the house, My human body is full of dust. Mustard and <i>sesamum</i> oil, Holy waterfalls will care of it.	An orphan lady who have no one to care. When she goes out of her house, become dusty. But she knows that mustard oil and water of waterfall will refresh her.	In this song they formed a sensitive touch towards earthly objects. Environment always nourish us so we should keep use in a sustainable way.
"SOHRAE" festivals	Parakeets are crying at " <i>Sinch</i> " Forest Day and night., They have neither grain nor emedy, Tame Parakeet flying away, Being very unhappy.	Parakeets are crying in the forest day and night for lack of food. So, tame parakeet flying away to forest being unhappy.	Through this song the sympathy of forest bird come into account. Forest is being changed. The birds are endangers due to lack of food and

			suitable environment. So, we have to take care of them.
“SOHRAE” festivals	O Vulture you travel country to country, Do not sit on road side Peepul tree. That tree is our mother, She is also your creator.	Singer tells a Vulture not to sit on road side <i>Peepul</i> tree. Because God abode there.	This song brings a message that trees are our mother. It's our responsibility to conserve them and to protect them from evil power.
“SOHRAE” festivals	In front of our house ... Who pluck china-rose? Who tear that? I will complain to Jagmajhi. I shall establish a court in my house, For judgment. Gather all villagers	They usually plant china rose in front of their house. They think that some flower trees are very much fond to God. This song expressed a deep feelings towards plants	Some useful trees have to give special care.
“SOHRAE” festivals	Earth is created... If I become a bird or insect, I will travel here and there... Everywhere in the earth...	Here this song presents imagination beyond reality. Theological thoughts are the main guideline of their life. Like insect and bird they also try to free their mind from earthly sufferings.	Earth is created by God. Like us birds and insects have got life from God. The opportunity should be same for all of us.
(Burdahi dang) Common Song is sung by aged lady in any festivals.	Our younger son grazing buffalos, On lower field, Upper field is full of <i>Kaskom</i> grain. Please eat it before leave.	Usually younger family member act as cow boy. They grow various grain on upper field and they do not let go any guest in starve.	Here we find a geographical concept about how to use a land. The foothill is a perfect place for grazing domestic animals because of availability of water and grass. And relatively high land i.e. “Dahi” is used for specific agriculture.
Burdahi dang	One root has broken	A <i>Peepul</i> tree's	Every man of a

	of big Peepul tree One branch has broken of small Peepul tree Pradhan's wife notices that. Jog boatman's wife will stand it up.	roots have broken. Always they are in touch of every trees, whether she is Pradhan's wife or a boatman's wife. This song tagged their environment concerned mentality.	society, no matter about his/her position in the society, should raise hand to take care of existing trees.
Burdahi dang	Open pasture, White pond and black water, White crow, cuckoo do not bath here, In summer time, My lover will bath here.	In summer month the pasture land gets to dry and convert to a bare land. Pond's water is evaporating and colour of water is black.	This song reflects the pathetic situation of summer. Ponds need proper management for water at summer time.
Burdahi dang	We leave meals, But can't leave to use, Water of Subarnarekha river. Small fishes of Subarnarekha river, Talk in day time, smile in night.	Subarnarekha river is their fish catching field. They use water for their household purpose. Fishes of Subarnarekha river beckon them.	Natural flow of water (surface water) should be utilized instead of ground water for household purpose.
Chuityea "Naming ceremony"	Whose courtyard, <i>Neem</i> tree swinging, Someone's' courtyard, <i>Neem</i> is swinging. Who brought it up? Father plant it and mother take care of it.	<i>Neem</i> is very essential tree in Santhal's daily life. They have got tradition to use <i>Neem</i> tree from their ancestors.	Here the song indicates significance of medicinal plant. Like <i>Tulsi</i> (<i>Oclmum tenuiflorum</i>), <i>Neem</i> (<i>Azadirachta indica</i>), <i>Sarpagandha</i> (<i>Sterculia foetida</i>) have various power for curing diseases. We should keep alive our Ayurveda tradition.

Source: Murmu, 1991

Results

After analyzing the field data we found some important points about Santhal, Sabar and Bhumij, tribes of Dhobakacha and Mahulboni village.

1. Tribal habitat of both the villages depends on agriculture and forest resources.
2. Their traditional agricultural system is based on their own traditional ecological knowledge. They used to cultivate in valley areas in between two hillocks where ground water potentiality is high.
3. Valley area is covered by loamy and fertile soil and is used for mainly paddy cultivation.
4. Both Dhobakacha and Mahulboni village depends on monsoon rainfall for cultivation and they developed check dams which is locally known as “*Veri*” using water potential zones on the lower valley for further cultivation in dry season.
5. They sell Babui grass (raw and processed) and forest products in the local market for earning money.
6. Their seasonal songs and dance expresses the actual meaning of sustainable use of natural resource.

Conclusion

Land is the main resource base for the Santhal and Bhumij tribes of Binpur II block. Agriculture is the main source of economic earnings. The land in this area is not fertile and comes under agricultural drought zones of West Bengal. But these communities have developed sustainable management measures through the application of indigenous knowledge passed through generations. They have applied the knowledge not only for the agricultural site selection but also for proper crop species selection. GIS techniques have been applied for scientific analysis of landuse. Landuse land cover map, Digital Elevation Map, Normalized Differential Water Index map, landscape profiles and ecological transects have been match up to the existing landuse practices. It shows that with the help of simple traditional techniques they modified unfertile physical land to productive lands. Selection of Babui grass for commercial use is a rational decision taken by the community as an alternative source of income as well as to manage soil erosion in the sloppy unfertile land (*Dahi*) which is not favourable for paddy cultivation. Construction of check dam (*Veri*) to check excessive gully erosion and retain surface runoff in the foot hills is another simple yet useful method for agriculture in this dry area. To preserve the fertility and moisture content in the soil they use the method of ‘tillage and keeping the land fallow’. Mulching is a common practice in every

household. This organic manure is used in homestead gardens for vegetable farming. This traditional environmental friendly practices absorbed in their lifelong practices in form of sacred grooves, folk songs, believe, customs and rituals.

Acknowledgment

The authors are thankful to the villagers of Both Dhobakacha and Mahulboni village especially to Rasana Sing, Kapoormani Mandi and Bablu Buskey for their cooperation and sharing of information during field survey. Authors are also thankful to the students of Geography and Environment Management of Vidyasagar University for their cooperation to fulfil the work.

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5

Site Suitability Analysis for Identifying Potential Water Harvesting Sites in Lachigad Watershed, Uttarakhand

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Abstract

The problem of water scarcity is most prominent in many region in Uttarakhand. Due to Water problems many villagers specially the women often walk more than 2 Km through strenuous mountainous terrain to reach the nearest source of water. Therefore , the water scarcity compel the youngsters to migrate to other places or to NCR regions in search for job opportunities as agriculture activities could not be carry out. Lachi Gad watershed is situated in Pauri Garhwal District of Uttarakhand. The total population is approximately 1600 mostly farmers, women's and ailing elders. The present study aim's to identify suitable potential sites for rain water harvesting structures in Lachigad Watershed, Uttarakhand using Geoinformatics techniques. Therefore, to identify the suitable sites for water harvesting structures like Percolation tanks, Check dams, contour trances etc , we have taken different layer such as landuse/Landcover (LULC) , slope information, soil characteristic and drainage characteristics etc . GeoEye imagery of 2016 is use for Landuse/Landcover (LULC) analysis. GIS techniques is use for generating Buffer zone map and to calculate the weighted value in different classes using weighted overlay analysis. Lachi Gad watershed has been defines into three classes i.e. Most Suitable,

Moderate and Low. The analysis indicate that there are many sites in Lachi Gad watershed , that can be properly managed for water recharge and conservation which can be beneficial for drinking , domestic use and agricultural activities for the villages.

Keywords : Water Scarcity, Villages , Potential , Lachi Gad, Watershed and Geoinformatics techniques .

Introduction

In spite of the abundant rainfall receive every year, water is still the main problem in the Himalaya region. Rainfall pattern and distribution is not uniform both in terms of time and amount. Hence , it is important to manage the runoff water by selecting the suitable site for rain water harvesting (Vorhauer and Hamlett , 1996; Mbilinyi et al., 2005). Rainwater harvesting is the method for collecting and storing of runoff water for proper utilization such as for domestic uses, industry , livestock and agriculture (Mzirai and Tumbo, 2010; Hatibu and Mahoo, 1999). The growing pressure on water resources for domestic uses , agriculture activities has augment to over use of existing sources of water. Hence , depleting the water table and drying up the streams and springs which is the lifeline of the people. It is necessary for water runoff harvesting by selecting sustainable site for maintaining the environments in sustainable way (Ziadat et al., 2006). There are many types of water harvesting techniques such as collection and storage of runoff water (from roofs and land areas) , moisture conservation (soil and water conservation), concentration of runoff to crops in the field etc (Falkenmark and Rockstroöm, 2004) but as the study is based in mountain region , the main focus is on surface runoff such as sheet, rill, gully and stream flow (Rockstroöm, 2000). Type of conservation techniques selected for runoff water conservation are digging of pit (which will confine water in fields) , farm dams or reservoirs, groundwater recharge systems, check dams, tanks and bunds etc (Durga Rao et al., 2001).

The potential of runoff water harvesting and forest conservation has been initiated and implemented by the locals, social workers and an environmentalist under the leadership of Mr. Sacchidanand Bharti an Environmentalist cum Social Workers cum Teachers and Dr. Suresh Kumar Bandooni , co-author of this research paper with active support from **DLVS (Dudhotoli Lok Vikas Sansthan)** an NGO and Mahila Mangal Dals (**Woman Wellfare Organisations**).



Construction of percolation tank at lower slope for water recharging

Using of innovation technologies such as GIS and Remote Sensing to locate and identify suitable site for identifying potential water harvesting is necessary for cost effective and time saving (Padmavathy et al., 1993; Coskun and Musaoglu, 2004). In this Study , we have focus on identifying potential water harvesting sites in Lachi Gad watershed in Pauri Garhwal , Uttarakhand by using Geoinformatics Techniques. Due to high runoff potential and poor infiltration water scarcity in this area start from December to June almost every year. So, the site suitability is determined by considering various parameters such as slope , soil , rainfall , drainage , landuse/Landcover.

Study Area

Lachi Gad watershed is a part of Eastern Nayar river catchment in central eastern part of Garhwal Himalaya. Within Garhwal Himalaya it comes in Pauri Garhwal district between 29° 52' 23" to 29° 54' 28"N latitude and 79° 1' 48" to 79° 4' 43"E longitude in the state of Uttarakhand, India and encompasses a total area of around 13.81 sq.km. It comes under Bironkhal block and Thailisain tehsil with the elevation from mean sea level ranges between 1100 and 2300 mts. The total population is approximately 1600 mostly farmer. The climate is warm and temperate with cold winters, warm and crisp springs, cool summers and a strong monsoon.

The average temperature of the watershed is 20°C approximately. The summer temperature ranges from 15°C to 26°C while during the winter temperature ranges between 10°C and 15°C. Many times winters temperature decreases below freezing point and snowfall is frequent. The average annual rainfall of Bironkhal station is 175 cm and about 150 cm to 200 cm of rainfall during the monsoon season. During the winters, snowfall may occur as low as 1400 mts. The winter rainfall and snowfall ranges between 15-25 cms. The main types of landuse are forest, agriculture,

pasture, barren and waste land.

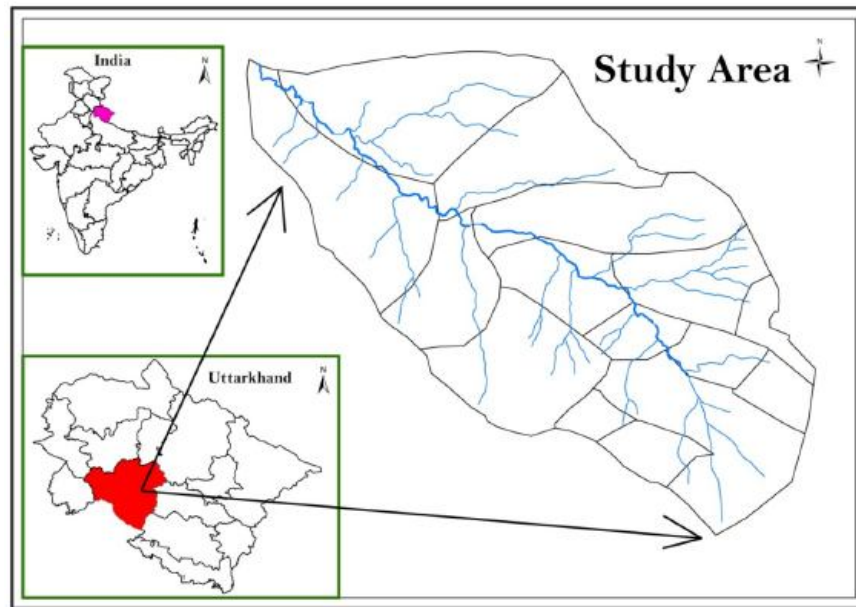


Fig.1. Study area

Methodology

Water harvesting site suitability model is developed using model builder in ArcGIS tools. To develop the model many spatial analysis tools were used i.e. DEM, Weighted overlay analysis. The input parameters are Slope, Drainage Network, Landuse/Landcover, Soil Texture etc. GeoEye satellite imagery for 2016 is used to generate Landuse/Landcover map, Srtm data of 90 m resolution is used for generating DEM and Slope percentage and Drainage Network is generated by using SOI Toposheet. As model builder works in the raster environment with grid format layers. Therefore, vector themes were converted into grid. Different weighted values were assigned to different thematic layers based on field survey and available literature review. Thereafter, pixel values of each layer were reclassified from 1 to 5. The most suitable parameters were classified as 5, while the least suitable were classified as 1.

Objectives

- To study landuse/Landcover and important spatial analysis to calculate site suitability.
- To selection of suitable sites for water storage in hilly terrain

Hypothesis

1. The cultivated area are not suitable for water harvesting sites
2. Moderately slope and forest area are best site for water harvesting pits.

Results and Discussion

The criteria used for analysing suitable water harvesting site are slope, vegetation cover, Drainage network , Soil texture , Distance from homesteads and Crop fields . These parameters were integrated using Arc-GIS and Erdas Imagine software (ESRI, 2001; Gangodagamage and Clarke, 2001) to suitable site for water harvesting. A variety of Spatial Analyst tools such as weightage overlay analysis , DEM , calculating slope and distance , reclassifying values, and the raster calculator were utilised to solve various spatial problems.

Soil

Soil type becomes one of the important parameter for selecting the best possible potential site for water harvesting. The permeability of the soil should be less as water should not percolate through soil mass. Loamy and sandy soils are not preferable for the site selection. The soil group of the study area was derived from prevailing M.Phil Thesis of Dr.S.K.Bandooni (1988) soil maps. The soils in the study area (Fig.2) can be grouped under five soil group (Table 1).

Table 1: Soil group in Lachi Gad Watershed

Soil Group	Area	Percentage
Grey Soil	4.97	35.9
Red Brown Soil	3.79	27.4
Red Dominant Soil	0.93	6.73
Red Soil	3.74	27.08
Sandy Soil	0.38	2.75
Total	13.81	100

Source : M. Phil Thesis of Dr. S.K. Bandooni (1988)

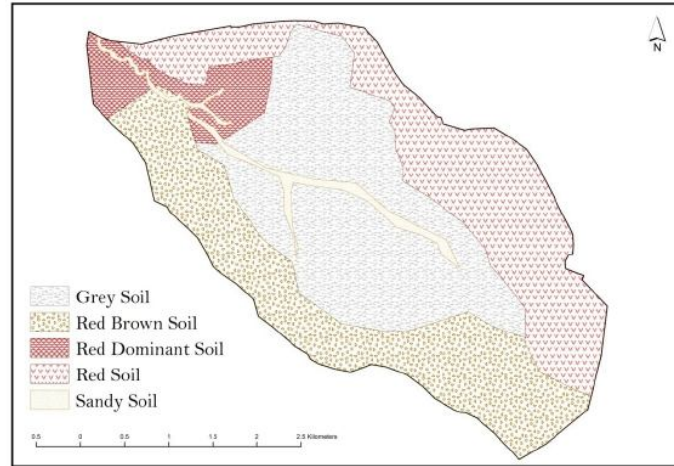


Fig.2 : Soils Texture

Source : M.Phil Thesis of Dr.S.K.Bandooni (1988)

Drainage Network

The drainage network is generated using SOI toposheet No.53 O/ 1 and subsequently updated using satellite imagery . Lachi Gad watershed is a part of Eastern Nayar river catchment in central eastern part of Garhwal Himalaya. Eastern Nayar is a tributary of Ganga and emerges from Dudhatoli ranges. Eastern Nayar meets Western Nayar at Satpuli and joins Ganga River. The confluence point of these two rivers is Vyasghat in Pauri. It is further arrange into different stream order and were ranked by following the procedure of Horton (1945). This layer is significant from the point of view of site selection specifications.

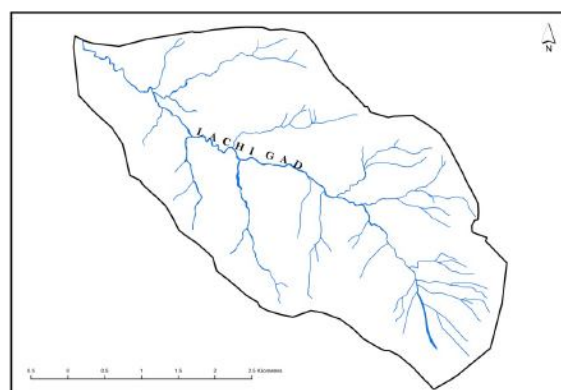


Fig.3: Drainage Network, Lachi Gad Watershed

Source : SOI Toposheet

Table 2: Stream orders.

Stream Order	Suitability	Characteristic
I	3	Steep Slope and Dense forest.
II	2	Moderate slope
III	1	Gentle slope and more water is available and it is mostly agriculture land.

Landuse/Landcover

Land use pattern in a region at any particular time is determined by the physical, economic and institutional framework taken together. In other words, the existing land-use pattern in different regions has been evolved as a result of the action and interaction of various factors, such as the physical characteristics of land, the institutional framework, the structure of other resources available, and the location of the region in relation to other aspects of economic development e.g. those relating to transport as well as to industry and trade. The present pattern can, therefore, be considered in some sort of static harmony and adjustment with the other main characteristics of the economy of the region. A close study of the present landuse pattern and the trends during recent years will help to suggest the scope for planned shifts in the pattern.

Table 3: Landuse/Landcover,2016

Classes	Area (Sq.Km)	Percentage
Settlement	0.29	2.09
Agriculture	5.71	41.34
Fellow Land	0.72	5.21
Forest	5.02	36.35
Scrub Forest	1.9	13.75
Barren Land	0.17	1.23
Waterbody	0.17	1.23
Total	13.81	100

Source : Compiled by the Author

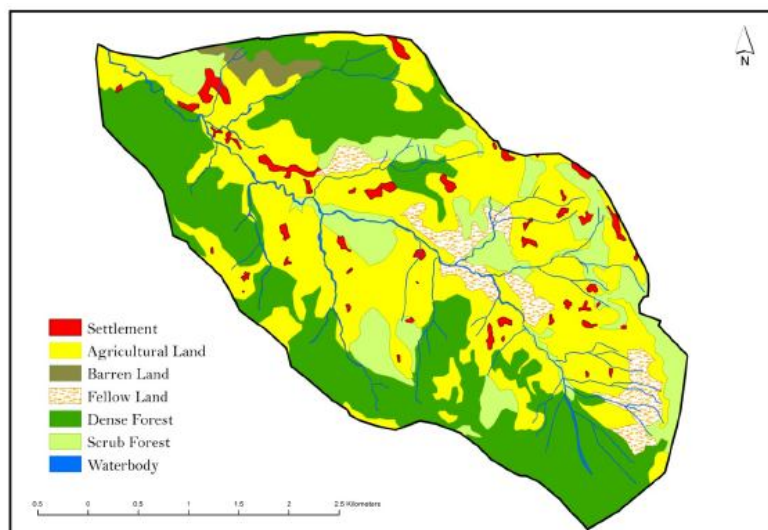


Fig.4 : Landuse/Landcover, 2016.

Source : Compiled by the Author

It is evident from Table 3 and Fig.4 that agriculture and forest have largely modified village landscape with about 41.34 % and 50.1 % (Dense forest 36.35 % and Scrub forest 13.75 %) of the total study area. Extensive goat , cattle farming , crop cultivation and horticulture characterise the area. It is a rainfed cultivation . The area under fellow land is 5.21 %. It has been observed that fellow land has increased in recent year as people in the area have no interest left in cultivation due to the shortest of water and destroyed of crops by wild animals. Hence , most of the youth who could do agriculture have migrated out in search of better opportunities . Settlement cover an area of 2.09 % follow by barren land of 1.23 %. The area under waterbody account 1.23 %.

Table 4: Suitability ranking for Landuse/Landcover

S.No	Landuse type	Category	Suitability
1	Intensively cultivated	Very high	1
2	Moderately cultivated	High	1
3	Forest, exposed surface	Medium	5
4	Mountain	Low	5
5	Water body, Settlement	Very Low	Restricted

Source : Author

Slope

The major parameters that affects the runoff , recharge and movement of surface water in any region is the topography of the area. The important terrain parameters for the selection of suitable site for water harvesting are slope and altitude. DEM and Slope map are derived from SRTM data of 90 m resolution taken from open source data. The DEM is used for the generation of slope which classifies the entire study area in different categories of slope ranges (Table 5).

Table 5: Slope Category

Sl.No.	Slope Category	Slope %	Water harvesting site suitability
1	Nearly Flat	< 5	3
2	Gentle slope	3-10	4
3	Moderate Slope	15-30	6
4	Steep Slope	15-33	5
5	Very Steep Slope	35-30	2
6	Extremely Steep Slope	>50	1

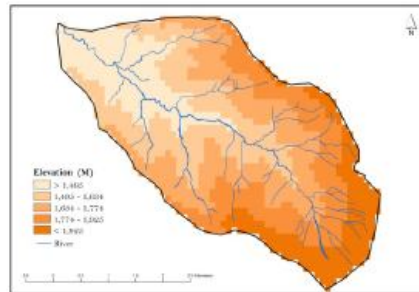


Fig. 5: Elevation

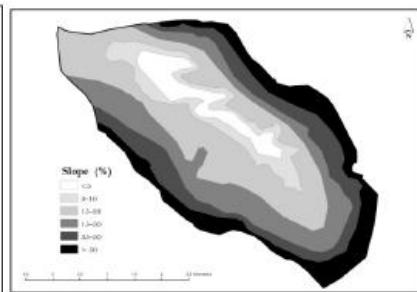


Fig. 6: Slope

Source : Compiled by Author

Distance from Homesteads and Crop Fields

Table 6: Suitability rankings associated with each distance interval class for homesteads and Cultivated land, high rankings characterise areas with a high suitability

Interval class (straight line distance)	< 250 m	250-500m	500 -750m	750-1000m	>1000m
Homestead & crop suitability ranking	1	2	3	5	4

Source : Compiled by Author

Suitability rankings associated with Euclidean distance interval class for homesteads and cultivated land are classified into five categories. Depending on the criteria, suitable rank is allocated for homestead and cultivated land to analyse the suitability. The higher rank indicates the area with high suitability for water harvesting. It is therefore, with increasing distance from homestead and cultivated land, there is increase in suitability.

Results and Discussion

Site Identification

By integrating all the thematic layers and giving suitable weightage values to each layer, a composite map of potential site suitability for water harvesting is generated using ArcGIS Model builder (Fig.7). This suitable site is divided into different categories (Fig.8) such as most suitable, moderate and low or unstable for locating suitable site for digging pits, percolation pond, check dam and sub surface dyke. To understand the accuracy of estimation, suitable sites were identified in the field as per the IMSD (1995) and FAO (1977) guidelines and the water experts team.

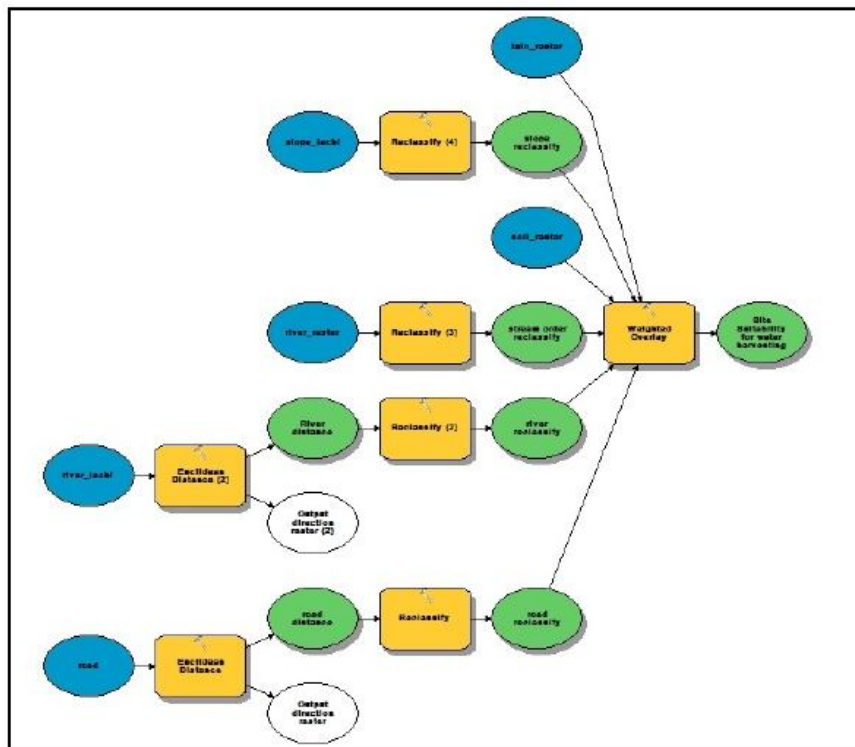


Fig.7 : Schematic of the Site Suitability Model Builder

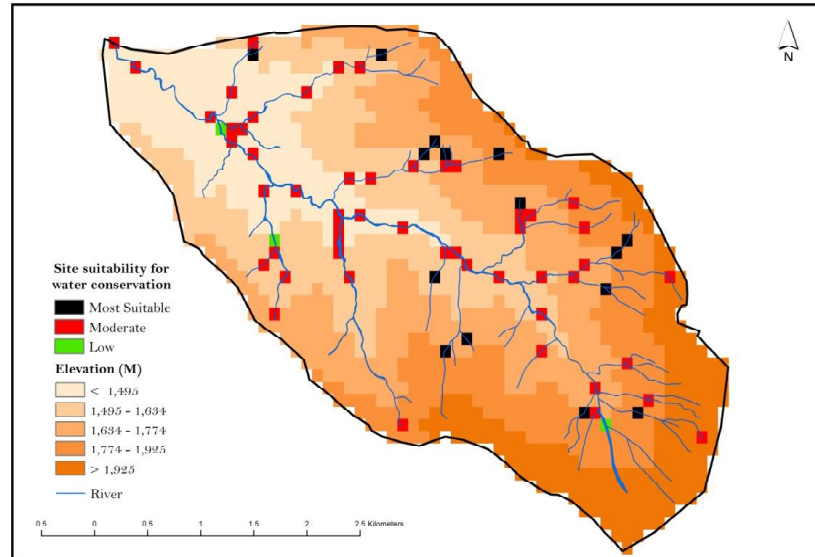


Fig. 8: Site suitability for potential water harvesting

Source : Compiled by the Author

Every year there is scarcity of water resources during the winter season in Lachi Gad Watershed , Garhwal Himalaya due to the high runoff in raining season. Fig.8. shows the suitable area for potential water harvesting site. The area with black color on the map, shows the most suitable site for potential water harvesting in the study area as there is presents of high elevation with Steep to Moderate slope of 15 – 30 % and 15 -33 % of slope. The runoff is very high with dense forest cover and the water come from the hill top to surface area, the land is free to construct any conservation features. Hence , it is suitable site for locating any water harvesting techniques such as check dam , digging of pit and plantation of sub- Tropical fruits like apple and walnut. Whereas the red color area shows the moderate suitable site for potential water harvesting as the slope is gentle and nearly flat having a slope percentage of 3-10 and <5. The area is cover with scrub forest and agriculture with less runoff in comparison to the black color area on the map . This zone is suitable for locating percolation tank or pond for storing water. Finally the green color Zone shows area with low potential site for water harvesting due to the very steep and extremely steep slope with a slope percentage of 35 -30 and > 50.

Conclusion

Water harvesting is one of the important water conservation techniques to meet the demands of the people. The selection of suitable sites for water harvesting is important and challenging. Therefore, the present study focussed on developing a GIS base methodology for identifying potential site for suitable water harvesting in Lachigad Watershed, Uttarakhand. Different analysis tool such as Digital Elevation Model (DEM) for slope analysis, Weighted overlay analysis, reclassification were used for identifying the location of water harvesting interventions. Land use maps for the year of 2016 are prepared using GeoEye data. Digital elevation model (DEM) derived from Shuttle Radar Topographic Mission (SRTM) is used to derive the slope map using ERDAS imagine. The soil group map is generated with the aid of M.Phil thesis of Dr. Suresh Kumar Bandooni (1988). The drainage network are generated from the SOI topographic sheets and subsequently updated with the aid of Satellite imagery. The GIS based site suitability model described in this present study is effective in terms of identifying and ranking potential water harvesting sites in the mountain region of Lachi Gad watershed. The suitable sites obtained from the present study is good agreement with the water and Himalayan ecosystem expert Dr. Suresh Kumar Bandooni who is also a co-author of this research paper. This study will help the planners to identify the source areas that generate high amount of runoff in the upstream area and harvested water can be used for cultivating crops area. Water scarcity will continue, if runoff water is not utilise in an sustainable manner and the region will continue facing water problem and would have to depend on rainfed agriculture. Thus, water harvesting is a appropriate option to accumulate surface runoff for later utilisation, especially during winter season when there is limited water availability.

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6

Protection of Ox-bow Lake with Sustainable Management –A Case Study of Khalsi Lake, Nadia

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Abstract

Sustainable management is a modern process for the environmental development. The goal of the management is to restore the ability of natural systems to generate the natural resources and ecosystems on which the socio- cultural set up is dependent. Sustainable management takes the concept from sustainability and synthesizes them with the concept of management. Sustainability has three branches: the environment, the needs of present and future generations, and the economy. Using these branches, it creates the ability of a system to thrive by maintaining economic viability and also nourishing the needs of the present and future generations by limiting resource depletion. This study is based on the protection of Ox-bow Lake with sustainable management. There are four ox-bow lakes of River Jamuna, tributary of Ichamati in Nadia district of West Bengal and these lakes are situated far from the river in recent times. Due to human intervention all lakes are going to be died. These lakes should be protected by sustainable management that will be eco-friendly and future generation can be helpful from the development.

This study will highlight sustainable management of one lake amongst the four which is Khalsi(ox bow lake) situated in Nadia district. Planning to protect the lake, obstacles on the way of protection and sustainable development will be discussed in this paper.

Introduction

Ox-bow Lake (5.31 Km long), a huge water area is used for fishing by Barrackpur Fishery Department. In this way the water body is being used intensively but the resource can be used extensively with proper planning, steps and management.

Khalsi is an Ox-bow Lake of Jamuna River. Jamuna River is a tributary of the Ichamati River. It flows through the Indian state of West Bengal and is one of the major rivers of the North 24 Parganas district. Till the 17th century, the Jamuna originated as a distributary of the Hooghly River separating from it near Tribeni, along with the Saraswati River, hence giving the town its name. Unlike the Saraswati that flowed southwest from Tribeni, the Jamuna used to flow eastwards, along the northern borders of the present day town of Kalyani and the region around the Indian Institute of Science Education and Research, Kolkata, in the Nadia district, then enter the North 24 Parganas district and finally merge with the Ichamati River. The lake Khalsi is connected with the river by 1.22km long Chanel.

Objectives

Main objective of this study is to give a suitable planning for sustainable management of the selected lake. Main objective of the study is to make a plan for sustainable management based on the lake by which not only recent generation but also future generation also will be helpful.

Study Area: Ox-bow lake Khalsi (22° 58' N to 23° N and 88°38'24'' E to 88°39'36'' E) in Nadia district of West Bengal had been studied.

Condition in Monsoon of the study area: In the season of monsoon the lake gets full of water in some years due to heavy rainfall and the lake becomes the cause of flood over the inlet area in the month of September and October.

Condition in dry season: In dry season a huge part of the lake becomes very dry (March to May) and volume of water decrease in a high rate. At that time dry parts of the lake used to cultivate paddy.

Changing condition of the lake: The area of the lake has not changed yet but the depth and the volume of water changed enough. The lake stayed full of water in dry season also even 30 years ago but now the condition of water level in dry season is very poor. Even the depth is also decreasing now a day due to the wash away of soil from inlet area of the lakes.

Four barriers made by the people across the lake which are

constructed by mud and local vegetation but these barriers are disappeared in wet season due to water flow.

Methods and materials: Methodology has been done out in three stages:-

Pre-Field Survey: Consultation of books and journals, collection of secondary data from Government and Non Government Organizations.

Field survey: Field survey for the collection of primary data from the people of inlet area of the Ox-bow Lake.

Post Field Survey: diagrammatic representation.

Result and Discussion

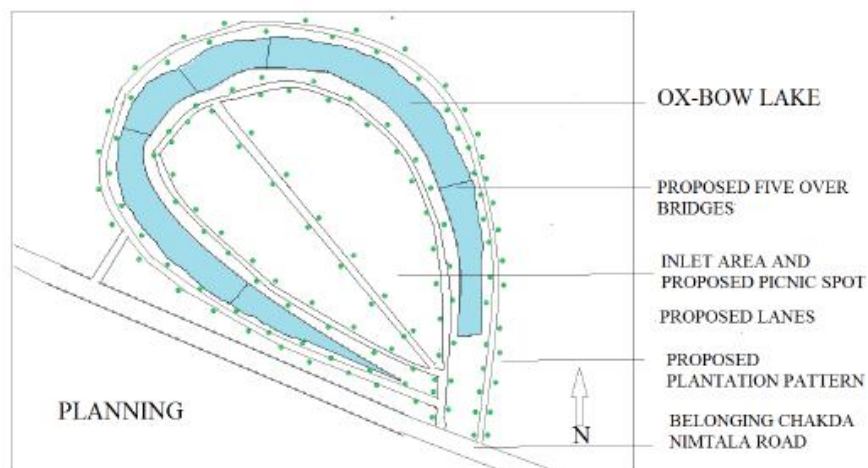
Planning: A scientific planning has to take for sustainable management and for that under saying steps can be taken-

- a. Have to make the surrounding area high. Otherwise in wet season huge amount of water will destroy all the constructions.
- b. A road surrounding the lake has to construct which will be connected with the main road. The road should be concretized thus it will be last for a long time. Another concretized road has to be made surrounding the inlet area.
- c. There will be five bridges over the lake and some extended parts (with shed) of the bridges have to construct which will be used for the sitting seat of fish catchers.
- d. Two parallel rows of different trees have to plant surrounding both roads. At first first -growing trees on western row should be planted in initial stage. After one or two years eastern rows trees should be planted. By this trees of both rows will get sufficient sunlight. Trees will control the soil erosion thus the shape and depth of the lake will not be changed. Coconut trees may be planted in the inlet area.
- e. Two or three care taker has to appoint to maintain the planning area.
- f. Initial steps should be taken by the Government through the local administration and Government and may provide one time financial contribution for the sustainable management through the planning.
- g. Inlet area mainly used for cultivation. Though already there live some families but expansion of settlement is not expected because

the inlet area may be used as picnic spot. A huge area with green cultivated land, long and short trees surrounding a long ring shaped lake with calm water; fish catching facility will obviously attract the people.

- h. Through this management the water body will be reserved and future generation also will be helpful from this management.
- i. After completing the whole work the area can be rejuvenated by the earnings from the area. From pisciculture a huge amount will be collected, from entrance ticket to the picnic spot also money will be collected. After some years wood from the growing trees and coconut can be collected to sale. But after cutting tree new trees have to plant.

Planning for Sustainable Management



Obstacles

- a. Government and as well as people are not taking the sustainability of any development or management as an important issue and as a result it will be difficult to get local Administrations support for the planning.
- b. If Government takes any positive initial step there will also be many problems as (i) Here is a huge chance of low quality of construction, (ii) After completing all construction day by day all built things will going to be lost due to maintenance problem, (iii) It will be tough to stop the extension of settlement, (iv) The area is

located in an interior part of Nadia District and it's a negative point for the study area as a picnic spot. (v) Selection of trees and choosing the right place for them is difficult.

Conclusion

In initial stage there will be lot obstacles in this purpose but if Government takes positive stage it's not too difficult to manage or develop not only the study area but also similar areas sustainably. For this our Government as well as people has to bear positive thinking about conserving our environment by sustainable management. Indian Government is organizing many seminars workshops on environmental protection collaborating with many Educational Institution which are very important but if these programs organized in open stages it will be more resultant as many people will get the opportunity to go through the program directly.

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7

Sustainable Resource Management in North East India: A Socio-Economic and Political Perspective

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Abstract

Sustainable development is a holistic concept embracing economic, social and environmental aspects of human activity. Therefore to ensure sustained economic growth, building a balanced and coherent nexus between development, social equity and environmental sustainability is the urgency of this time. However, roadblocks are present in achieving and implementing the sustainable development goals. There are several political socio-economic and financial barriers in this respect. While unscrupulous growth and development are the priorities of a consumerist society rather than people's rights and welfare and environmental concerns, there inevitably exist social inequity and environmental injustice.

Introduction

Against this backdrop, the North East India (NEI) is the case in point. The region consisting of the eight states of Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Sikkim, has several distinct advantages as it is endowed with rich untapped natural resources especially forest and water and it is the most bio culturally diverse regions of India. Additionally, its proximity to the adjacent countries like Myanmar and Bangladesh has increased its strategic significance. Specially it is considered as the "Eastern Gateway" of India's Look East Policy and the

entry point of Southeast Asian market. The altitudinal pattern of the region varies from place to place. The plains mainly comprise of Brahmaputra and Barak valleys. The adjoining areas of Barak rivers are active flood plains with marshy lands subjected to extreme annual submersion. The Manipur basin has an area of 1,853 km². The Tripura plains have an area of 3500 m² and has land features of erosive nature. The region has about 60 per cent area under forest with Arunachal Pradesh having about 80 per cent of its area under different kinds of forest, while Assam has the minimum percentage of forest area (30 per cent). Such varied physiological features and altitudinal differences gives rise to varied types of climate ranging from near tropical to temperate and alpine (Das, et.al, 2009). The region is home to over one hundred tribal communities and a large percentage of them is dependent on traditional natural resource based livelihoods. Along with this, the strategic location of the region at the confluence of South, Southeast and East Asia has rendered it a significant entry point between the peoples of the region. Such diversity of communities often generates unique socio-cultural, agro-ecological and land-holding systems in the region. Not only that, it is a part of the Indo-Myanmar biodiversity hotspot, one of 25 such hotspots in the world (Myers et al., 2000) and its physiography has generated a profusion of habitats, which harbour diverse biota with a high level of endemism.

Despite being an eco friendly region, different indicators have shown a grim picture. Due to its geo ecological fragility, transborder river basin, low riparian position as well as the seismicity of Eastern Himalayan periphery where it is situated, it is very prone to water and climate induced disasters. The region is highly dependent on natural resources but in the present time there are instances of huge degradation and depletion of the natural resources as population growth and unscrupulous development activities have created inroads in the natural environments and too much dependence on unsustainable shifting cultivation has put pressure on its fragile eco system. It is the fact that the region falls under high rainfall zone with subtropical type of climate, but in recent years it has witnessed severe changing precipitation induced droughts and unprecedented floods due to climate change induced rapid glacial melting in the Himalayan region. Such drought or floods- both extremes pose a threat to the economy, livelihoods and social fabric of the region. When such changes in climate act as a catalyst generating paucity of significantly necessary resources like croplands, forests and water supply, the societal structure may become stressed exacerbating the inherent politico economic instabilities of this land locked region.

So the study by employing descriptive analytical and content analysis concentrates on the following issues:

- The reasons behind the fact that despite having huge natural resources that offer the greatest potential for growth and development, the NER has been alienated from the economic resurgence witnessed in much of India;
- The significance of the crucial nexus between developmental aspirations and environmental sustainability in the North Eastern region;
- What are the recurring barriers that are prohibiting this region from the attainment of sustainability goals;
- The possible sustainable resource management and development options that balance conservation of resources, development and community involvement in the process.

The Degradation of Natural Resources in North East India due to Climate Variability

The natural resources of the North East are degraded due to several reasons. Climate variability and environmental change are among the most common reasons. Deforestation, unsustainable shifting cultivation practices, fragmentation and degradation of lands have huge negative impact on the biodiversity as well as forest biomass production here. The region's natural resources are also under enormous pressure due to increase in human and livestock population, dam building, industrial activities, coal mining operations and other development works.

Threats to Food Resources

This is quite well known that the agro based economy of India is severely impacted by rapid climate change, resulting in acute food scarcity. This is true for the North Eastern region as well where over 60 per cent of the crop area is under rainfed agriculture, and it is highly vulnerable to climate variability. The pattern of agricultural growth of the region has remained uneven across regions and crops. It is found in various studies that the high relative variability and inter-annual variability of rainfall have created increased occurrence of droughts and floods in the recent times, leading to uncertainty in yield and increased agricultural vulnerability.

Unprecedented drought like situation affected very adversely the whole Northeastern Region in general and Assam in particular during 2006.

Specifically several districts of Assam were badly affected due to drought like situations consecutively for two years in 2005 and 2006. In the intense drought-like conditions that prevailed in as many as 15 districts of Assam during the summer monsoon months of the year 2006 owing mainly to below normal (nearly 40 per cent) rainfall in the region, more than 75 per cent of the 26 million people associated with livelihoods related to agriculture in these districts were affected and the state suffered a loss of more than 100 crores due to crop failure and other peripheral affects. Other states of the region also received rainfall 30 – 40 per cent below their normal rainfall except Mizoram (Das, P .J., 2009). It is found that the state of Meghalaya also suffers from drought like situations and floods which inundate vast plain areas affecting crop yield. Actually, the precipitation patterns have changed largely over the last twenty years, making extreme rainfalls and floods more likely. Raising and reaping of crops are affected for this reason which threatens the livelihoods of 80 per cent of Meghalaya's population engaged in the agriculture sector (Raju, 2012). However, while agriculture is severely affected by adverse climate cataclysm, the former is also responsible for polluting the environment in the region. Rice is grown throughout the year in the North East in different agro ecosystems. Flooded rice soils provide an optimum environment for methane production and emission and are concerned to be a major anthropogenic source of biogenic methane. Nitrous Oxide is another greenhouse gas emitted from different agricultural crops (Baruah, 2008).

Water Scarcity: Due to the hilly terrain, cultivation of crops along the slopes and overgrazing by livestock, the soil resources of the region are subjected to erosion and loss. Besides, it can also be observed that majority of the districts which rank as very highly vulnerable with respect to floods also ranked very highly vulnerable with respect to drought. This indicates that the increased intensity of rainfall in a short duration will lead to reduced soil moisture retention (Ravindranath, et.al, 2011). Thus, climate change in the region not only affects crop yield and generates food scarcity, many districts face severe water scarcity during the summer months. Even Cherrapunjee, the high rainfall area is suffering from acute water scarcity. Due to global warming the areas are getting less rain while the soil is not able to hold water that does arrive. As a result of this, along with the adverse effects on the livelihoods of hill farmers who depend on subsoil water, the shortages of drinking water particularly during winter months are also endemic. It is also quite astonishing that although the North Eastern region has abundant water resources as one third of India's runoff flows from the North East through the Brahmaputra and Barak rivers and these

rivers constitute India's National Waterway 2 (NW-2) and their basins contain seasonally flooded wetlands that sustain a broad range of biodiversity, still it faces water scarcity.

With glacial contribution decreasing over the years, the future lean season flow may decrease and water stress may increase in the Brahmaputra basin where large populations depend on agriculture for livelihoods. Actually, the two basins constitute the lifeline of the region, providing great opportunities but posing numerous challenges. Glacial retreat in the Himalayas may lead to serious alterations in the hydrological regime of the Brahmaputra river system as the mainstream of the Brahmaputra and some of its tributaries like the Subansiri and the Jia-Bharali are partly fed by snow-melt run-off. Projected increase in rainfall and accelerated summer flows may give rise to more intense flooding and flood hazards, but consequent retreat of glaciers may reduce flows in the long run (Das, P.J., 2009). The monsoon was particularly intense in 2012. And the severity of flooding could increase in the next few years under the effects of global warming and because of the construction of new infrastructures near the Brahmaputra, which put the lives of millions at risk. It is also clear that the abundant surface water resource imposes severe distress and costs on the region through frequent flooding and erosive processes and that this needs to be managed to improve economic development. The region also has a substantial unutilized groundwater resource (World Bank, 2007).

Deforestation: The forests of North Eastern India are rich in biodiversity and much of the dense forests of Assam, Nagaland and Arunachal Pradesh are part of the Himalayan biodiversity hotspot. The watersheds of the region are critical catchments that regulate hydrological flows to some of the world's most densely populated agricultural lands and cities, including nearly 250 million people in Bangladesh and Eastern India. However, deforestation and flood are also causing serious problem to the environment in the region. As the landscape of the uplands of the North East is denuded of forest cover, much of the unique flora and fauna have started disappearing which in fact affects the ecological fabric of the region as a whole.

Unsustainable Resource Use and Management

Climate change is not the sole driver of increased food insecurity, water scarcity and deforestation in the NEI. The agro-ecosystem of the NEI that was once considered ecologically and economically sustainable, is gradually becoming unsustainable due to escalating anthropogenic and other pressures. Lack of proper knowledge about resource use and

management has exacerbated the situation. For instance distorted pattern of shifting cultivation poses potential threat to the rich biodiversity of NE India, particularly to the unique faunal diversity. Shifting agriculture is mostly found in tropical forests of NE India and changes in tropical habitats due to human-induced land-use practices are a major concern considering that the biodiversity-rich tropical rainforests are undergoing conversion to secondary habitats at a rapid rate (Dollo, et.al., 2007). However the economic prosperity and development of the inhabitants of NEI are contingent upon sustainable shifting agricultural practices and resource management. It requires a concerted eco-technology backstopping (eco-technology development/modification, demonstration/ dissemination, adoption/adaption and capacity building/ capacity enhancement) to be sustainable, as access to technology in the region is grossly inadequate, given the constraints of terrain and limitations of prospective line departments. What is grossly needed is low-cost eco-technologies accessible to the practitioners to address this agro-ecosystem and make it more productive but the region does not witness such efforts (Samal, et.al., 2016).

Despite the existence of several forest laws and regulation the forest of Northeast is decaying. Often shifting cultivation has been blamed for forest destruction. But the fact is that shifting cultivation aims to create forest instead destroying it as without forests the next jhum cannot be cultivated. Actually human interferences in the natural landscape have immense negative impacts. Indiscriminate extraction of fuel wood, shortening of jhum cycle, conversion of natural forests into plantations for horticultural crops, mining, overgrazing, and forest fire are the major causes of deforestation in northeast India. In some North Eastern states, such as Nagaland and Meghalaya, over 90 per cent of the forests are under direct control by traditional village institutions, communities, and private individuals, a sharp contrast from other parts of India where state forest departments retain legal and territorial control of the vast majority of forest areas for decade (Fernandes, 2010).

Table: Proportion of all Forest Land under Community Control

State	Percentage of Total Forested Area	Percentage of Total Community Control
Arunachal Pradesh	82	62
Assam	30	33
Manipur	78	68
Meghalaya	70	90

Mizoram	87	33
Nagaland	85	91
Tripura	55	41

Source: Forest Sector Review of Northeast India, Background Paper No. 12 , Community Forestry

International, Santa Barbara, CA, USA, March, 2006,p.9 .

While the forest dependent communities of the North East may have considerable legal authority over the natural resources of the region, based on legislation passed during the British Colonial era, as well as under the Indian Constitution and laws approved in the 1950s in particular, at present, indigenous community-based systems of forest conservation are threatened by the absence of formal mapping, boundary registration and titling. The privatization of once “communally” held forests and watersheds typically leads to their deforestation and conversion to agriculture (Poffenberger, 2006). Due to climate induced and manmade deforestation not only is valuable biodiversity being lost, but so too are the benefits of forest functions such as purification of water, regulation of the water flow, and the stabilization of soil erosion, in addition to climate change benefits.

The Dilemma of Developmental Aspirations and Environmental Sustainability

There exist a crucial nexus between development and environmental sustainability. The NEI is also facing this dilemma. The hilly landscape of Northeast India is suffering from massive distortion of the ecology due to the open cast mining as well as the construction of large dams as part of hydropower projects. The degradation of environment associated with open cast mining observed in Upper Assam (at Tiklok and the other one is at Lebo- Tirap). In the open mining for extraction of coal, the industry is, at first removing the top soil, valuable trees, vegetation etc. and the top soil cutting from the upper layer of the hillock above the coal seam are dumped in nearby areas. By doing so, a barren artificial hillock consisting of the rocks and debris is created in the place of the natural green hillocks. It is observed that the industry continued its operation without considering the question of environmental preservation. Two major sector industries are extracting crude oil in the State. Their main operation is drilling and production. Most of the drilling sites are located in the paddy fields, low lying areas, forest areas, and in some case these are on the back or near the water courses, due to which nearby areas are badly affected damaging agricultural fields, crops, vegetation, drinking water

source(Pandey, et.al., 2013). Fertilizers, paper and cement industries are also liable for degradation of environment in this region but their detrimental effects are mostly localized.

This region has been identified as the future powerhouse of the country and as a result the region is witnessing rapid increase in the proposals for construction of hydropower dams. So, often dams are made out to be the panacea for all the problems of the northeast as it is claimed that by exploiting the country's largest perennial water system the dam building helps in producing cheap, plentiful power for the nation, economic benefits through power export, employment generation, flood control and little direct 'displacement' of local communities. Such push for large hydroprojects was initially driven by the central government. Later there emerged lot of private players, initiating the signing of multiple Memoranda of Understanding (MoU). Soon the region was flooded by such 'MoU virus'. But, "Owing to the extremely active geodynamic condition of the terrain, even the slightest tampering with the ecological-geological balance can initiate environmental changes, likely to assume alarming proportions eventually. There is an imperative need for extraordinary care when it comes to modifying topography by excavation, placing loads of water and sediments in river impoundments, changing groundwater circulation through road cutting, removing protective forest cover, etc(Valdiya, 2003, p.72)".

Actually when large dams block the flow of a river, they also trap sediments and nutrients vital for fertilising downstream plains. They alter the natural flow regimes which drive the ecological processes in the downstream areas. Quite literally they disrupt the connections between the upstream and the downstream, between a river and its floodplain. So with the North East identified as India's future powerhouse and atleast 168 large hydroelectric projects set to critically alter the riverscape, large dams are emerging as a major issue of conflict in the region. This is evident in the following instances. In the 1970s, the Gumti dam in Tripura submerged large tracts of arable land in the Raima Valley and displaced the local tribal population, leading to unrest. Projects such as the Loktak hydroelectric project commissioned in the 1980s have impacted the wetland ecology of the Loktak lake in Manipur, seriously affecting the habitat of the endangered Sangai deer and the livelihoods of local people. The project proponents did not take into account the effects on the lake ecosystem, the people and wildlife whose lives are connected with the lake in their cost-benefit analysis(Wangkheirakpam, 2003). The impending loss of home, land and livelihood has led to many years of opposition to the Pagladiya project

in Assam and the Tipaimukh project in Manipur on the Barak river too. It was estimated that the latter would permanently submerge an area of 275.50 sq. km. in the state of Manipur. A large number of people, mostly belonging to the Zeliangrong and Hmar tribes, would be displaced permanently and deprived of the right to their environment and to their age-old traditional occupation (Singh, 2003). This controversial hydroelectric project will also destroy forests and green covers of the region. An estimate shows it will destruct 82.47 lakh trees. "The project requires more than one fifth of the total 118.184 hectares of forest land diverted for execution of 497 hydel projects in the entire country after the Forest Conservation Act 1980 came into force (Sethi, 2013)." The project has been locked in controversy for years with Bangladesh voicing concern about the Barak river project. The construction has been questioned due to several critical grounds which include geological and seismic factors, environmental impacts, downstream impacts which extends up to Bangladesh, conservation of socio-cultural heritage, impacts on health and hydro dynamics of the dam itself.

While the building of hydro power projects in various states of the region affects the environment of the Northeast in particular and thereby the lives, livelihoods and economy of them, demands are also raised to stop dam construction in the upper reaches of Brahmaputra and its tributaries by China as the North East is going to suffer the most. Chinese policy in damming middle reaches of Brahmaputra to harness hydro-power and divert water to mainland China may cause drought in the North-Eastern part of India and Bangladesh. Again if China discharges more waters during monsoon season it could create massive floods in the area. China's plan to build the dams over the Brahmaputra river and diverting water into its arid provinces has been opposed by state governments of Northeast India (Deccan Herald, 2013).

The Roadblocks and Barriers : Socio-Economic and Political Perspective

Though in the North Eastern region, much arable lands rich in natural resources are found in vast tracts on both sides of the Brahmaputra river valley, it remains one of the most underdeveloped regions in India. While climate variability and human interferences in the natural landscape have contributed to the destruction of natural resources in the NEI, there exist other issues that hinder the sustainable use of resources. The high incidence of poverty, low land productivity, economic under development, poor infrastructure and connectivity both within the region and with rest of the country, and its inherent socio-economic instabilities

and law and order problems have further worsened the situation. So the region is facing both environmental insecurity and challenges pertaining to unsustainable economic growth and development.

Unlike most of India's rapidly growing states where the agricultural sector is in relative decline, with growth in the service and manufacturing sectors accelerating, agriculture remains the backbone of the economy and is dominated in the hill states by jhumming. As a result, climate induced declining agricultural yield directly affects the region's economy. The continuous population surge and their sole dependence on limited resources have escalated the depletion of natural resources like forests and lands that culminates in environmental degradation along with growing marginalization of farmers. The incidence of rural poverty has taken the problem one step forward. The exposure and sensitivity to a drought or a flood of the rural poor farmers of the NEI is very high. They are also constrained by low literacy levels or lack of proper infrastructure to be able to access the government support programs or employment opportunities present in cities. The 11th five year plan (2007) suggests that despite huge investments (\$1.5 billion), the infrastructure development in the North-East region has remained non-uniform or incomplete in phases due to poor planning, absence of co-ordination, poor management of projects and lack of accountability. There is considerable lack of income for the states, due to the low industrial and economic activity and credit non-availability for individuals due to low penetration of financial institutions. All these factors lead to a lag of development in most of the North-East when compared to the other regions of India (Nair, et.al., 2013).

Recently the government has taken several steps to counter the multiple vulnerabilities that the region is witnessing. Efforts to improve the management of natural resource base for the protection and restoration of the environment; to exploit the hydro-potential for power generation and to overcome the infrastructural bottlenecks, have been made time to time to induce sustainable and equitable growth and development of the region. But still the region faces backwardness. There are problems at three levels. First, the states of NER are largely dependent on central government aid. The Ministry of Development of North Eastern Region (MDoNER) is charged with the planning, execution and monitoring of development projects and schemes in the NER. Its vision is to accelerate the pace of socio-economic development of the region so that it may enjoy growth parity with the rest of the country. But the availability of central fund is not equally allocated. The politicians, their patrons, builders and other groups reap the benefit of such funds depriving the masses. So

development in the actual sense remains a far cry. Secondly, the region lacks inclusive growth and meaningful development. Actually in the NER, development projects are rarely assessed in terms of their far reaching environmental and socio economic implications. It is true that development needs increased energy services and hydel projects are required for that. But given the mushrooming of so many large dams in the region at the expense of environment, a question often comes into prominence that whether these dams' juggernaut really generates development. The possible answer may be that the people of this region requires 'meaningful development' instead of 'destructive development'. Thirdly, the traditional knowledge base for the conservation of resources are not properly utilized and community involvement and participation of local people and their indigenous institutions in this process are less recognized.

The Possible Way Forward

Given the the absence of sustainable development initiatives viable for the hilly regions there exist efforts like The North Eastern Region Community Resource Management Project (NERCORMP) which is a rural development project working in three states of Northeast India with the overall objective of improving the livelihood of vulnerable groups in a sustainable manner through improved management of resources.. The project is a joint effort between North Eastern Council (NEC), Union Ministry of Development of North Eastern Region (DoNER) and IFAD. NERCORMP delicately balances the intricate relationship among livelihood creations in forest areas, environment stability, rural development, poverty alleviation, and food security. The community driven development agenda seeks to generate various livelihood. One of the focus areas of the project has been reduction of harmful effects of shifting cultivation and it talks about conversion of Jhum land into terraces and community forest reserves, promotion of cash crops and perennial horticulture crops in jhum areas, and promotion of agro-forestry in those areas. It introduced the community to technologically, socially and environmentally viable agriculture tools and techniques, while promoting strategic prioritisation for food security. The project underscored the importance of women as the repository of locally rooted knowledge system and adopted measures to ensure effective participation of women in the development projects designed for the community (Baruah and Hazarika, 2011). Though the NERCORMP is succesful even in the insurgency prone areas, there are difficulties in converging the project activities with other governmental programmes. The absence of efficient local level organisations for supporting effective community mobilisation is another

hurdle for the project's successful implementation. If the government can check such problems, such projects can be an effective tool for both resource management and economic resurgence of the region.

The Clean Development Mechanism (CDM), a Kyoto Mechanism, which aims to give developing countries the option for more sustainable development by permitting industrialized countries to finance greenhouse gas reduction projects in developing countries and receive credit for doing so, could provide an opportunity to secure funds to restore the region's degraded forests and establish new areas of forest cover. However, to qualify for CDM assistance certain conditions need to be satisfied. The projects involving rehabilitation of forestlands that were degraded to less than 10 percent forest cover after 1990 do not qualify for funding, nor do projects that involve avoidance of deforestation. In addition, areas that have had less than 10 percent forest cover, but were officially defined as forests since 1990, are not eligible either. For a country as large and ecologically diverse as India the biologically appropriate definition of forests should vary by eco regions. For the NorthEast, CDM funding potential can be maximized if the definition allows for high crown density and height. Appropriate areas can be readily identified through comparative assessments of forest cover changes using the widely available aerial maps of the region. However, in the absence of an agreed definition it is impossible to quantify the financial opportunities that could emerge from the CDM. Further assessments must await government decisions (World Bank, 2007).

As the climate sensitive agricultural practice is the main source of income here, some alternate sources of income such as livestock production needs to be distributed evenly across the states, so that the farmers do have livelihood sources if there is a climate related disaster. Not only that, in order to avoid the ill practice of distorted shifting cultivation, technologies are needed that are suitable for local conditions and can implement the principles of external input for sustainable agriculture. It must be based on locally available resources, low cost and on community engagement so that it can generate employments.

Along with such solutions we must remember that unsustainable pattern of development basically affects both the environment and the economy of the region. While facing such problems what is needed is the proper environmental management and planning that includes successful utilization of the environmental resources. The 6th schedule and other constitutional provisions relevant for the region although provides the

indigenous community with varied degrees of autonomy and self management, in practice there seems to be little opportunity for them for participation in decision concerning large development plan of the government that includes multiple large hydel projects exploiting region's perennial water systems. But before executing such plans their social and environmental impacts as well as the feasibility should be properly scrutinised. In this regard neutral environmental clearance procedures are required in order to evaluate the viability of the projects on environmental and social grounds. A key feature of the current environmental clearance process is the Environmental Impact Assessment report, which is a critical document aiding decision-making. The geocological tenuity of the region demands a proper environmental decision-making process as virtually more or less each project is treated as a fait accompli both by the expert committees appraising these projects and the concerned regulatory authorities.

By way of the conclusion it can be inferred that reckless consumption precedes conservation of resources in a consumerist society. The end result of which is scarcity of resources and environmental catastrophes. NEI is not an exception in this regard. The lopsided development policies as initiated by the government that allow private enterprises to exploit natural resources unsustainably has exacerbated the problem in the North East. The poor marginalized multitude and tribal groups are the worst sufferer for this as they are living at the edge and their traditional habitats have been destroyed by rapid urbanization and conversion of forestlands for growing more food, industrial activities like dam building to generate hydro energy, mining and so forth in the name of the so called 'development'. So environmental degradation both natural and man-induced coupled with population growth, inequity in distribution of resources as well as economic marginalization of some classes, market intervention etc. has generated a grim social landscape in the region where it is difficult to devise strategies necessary for balancing economic growth, social justice and ecological sustainability and bridge the gap between development aspiration of a country and its significant stakes in the process of environmental protection. So for the resource rich North Eastern region, sustainability is the key to find avenues of prosperity. Development initiated by an all powerful state must take into account the environmental concerns and the need of the custodian of nature first. Local Community involvement, application of locally available resource based low cost technologies and the positive role of the civil society are highly requisite for that. In order to be sustainable the development discourse for North East India therefore

must be people centric otherwise it would be impossible to keep the wheels of the economic growth acceleration moving as witnessed in much of India.

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8

Sustainable Management of Sundarbans as Green Heritage: Essential for Climate Future

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Abstract

This Paper assessed the impacts of climate change on the first climate hotspot of South Asia, Sundarbans region, an inhabited ecological region which is geopolitically divided between India and Bangladesh. This study examines the information collected during visits to Islands of Gosaba, Bali, Bak Khali and Sagar of Indian Sundarbans Delta. We interviewed local population and officials in these areas to understand how climate change is changing socio-economic and cultural landscapes of Sundarbans Island after being hit by the severe cyclonic storm Aila in 2009. This cyclonic storm was one of the worst natural disasters to affect over the Bay of Bengal and caused extensive damage in India. The storm was responsible for at least hundred deaths across India and more than million people were left homeless and displaced. The result of the study shows that there is necessity of legal, regional and development programmes for the protection and conservation of ecological region of Sundarbans. Mangroves Forests of Sundarbans served as protective shield to coastal communities and the loss of these mangroves forests due to climate change will manifold the risks to livelihood of local populations and biodiversity from storm surge, sea level rise and flooding.

Keywords- Sundarbans, climate change, sea level, mangroves, migrations, displacements.

Introduction

The Sunderbans is an ecosystem, the world heritage and the biggest mangrove tiger habitat comprising 104 islands that covers an area of 3,500 sq km. The Sunderbans is the world's largest mangrove forest and but also one of the most endangered eco-systems in the world. Approximately 60 percent of Sunderbans lies in Bangladesh and 40 percent in India. Overwhelmed problem between India and Bangladesh over the last four decades is due to this [Climate] Border i.e. Sunderbans. Resolving these borders and boundaries would greatly help them not only to improve their relationship but also preserve this global ecosystem or global common. The Sunderbans could become the epicenter for one of the biggest challenges to face human existence in the coming decades i.e. the problem of climate change refugees and new border reinforcement practices will be clearly evident in the coming years. The Sunderbans, hosting one of the largest continuous mangrove forests in the world, and shared between India and Bangladesh, are being increasingly reported, especially in media, as the '*First Climate Hotspots*' in South Asia. This inhabited ecological region is geopolitically partitioned between India and Bangladesh and subjected to two different regulatory regimes. Designated by the UNESCO as a world heritage site, the Indian Sunderbans Delta (ISD), the western part of the delta of the Ganga-Brahmaputra-Meghna (GBM) basin is spread over about 9630 square kilometers and is home to inhabit by over four and a half million, largely rural, people. The larger (eastern) part of the Sunderbans delta is in Bangladesh. As many as 54 deltaic islands (occupying a little over half of the area) are populated and the remaining space is covered by the mangrove vegetation. There is a long history of extreme weather events, such as severe storms or cyclones, occurring at frequent intervals.

Methodology

Sunderbans comprise of 19 blocks spread over two districts of North and South 24 Parganas. These blocks were clustered into 4 geographical zones that constitute the four entry points to the Sunderbans. For this study two zones was selected that is Kakdwip zone covering 4 blocks namely Sagar, Namkhana, Kakdwip and Pathar Pratima and second is Canning zone covering 3 blocks namely Canning I, Basanti and Gosaba. The criteria for selecting these areas due to highly vulnerable to climate change, people are usually deprived and exposed and due to coastal area. An informal discussion was used to collect information at the field level. Observation and Focus Group Discussion was held with the village people,

including the poorest and marginalized communities. We have interviewed local population and officials to know how climate change is impacting the Island. I have reviewed and analyzed secondary data, information and literature that is available in Journals, Books, Newspaper Articles, including information on official websites of several Governmental agencies, scientific data and reports.

From Sea Level Rise to Climate Displacements

Sundarbans like other coasts witness wave motions, micro and macro-tidal cycles and long shore currents that influences its physical changes; the environmental quandaries caused by climate change creates a hostile atmosphere both in the side of Indian Sundarbans and Bangladesh, and even conflicts between the two countries. Being at the ground zero; climate change results in multiple challenges from loss of livelihood means, water conflicts, refugee problem, economic-ecology fracas that spawns a diplomatic thorn between the two countries (Ganguly, 2016). An eminent scholar and leading expert on the Sunderbans, Sugata Hazra discovered quite some time back that islands were vanishing much before terms such as global warming and climate change became fashionable. In his view: “For the people of the Sunderbans, adaptation is critical for survival. For, even if we don’t produce any carbon for the next 100 years, temperature and sea level will continue to rise, inundating the islands and forcing the islanders to migrate. The question is, will we continue to disown them and look the other way? Or will we demand that they get their rightful dues” (quoted in Subhro Niyogi, 2009).

According to a recent WWF Report (Danda et al 2011: 3), in the context of unfolding climate change and “in view of the grave situation facing the ISD [Indian Sundarbans and the fact that without much needed change, this environmentally and economically important area is rapidly heading towards an uncertain future.” It is a well known fact that as early as 2006, nearly two-thirds of Ghoramara Island in the Sundarbans had been permanently inundated due to sea level rise. And both Lohachara Island, once inhabited by ten thousand people, and Supribhanga island (both located southwest of Ghoramara), had also submerged. Those displaced from the Lohachara Island fled sought to refuge in an island called Sagar, which is said to be equally vulnerable to rising sea levels. According to one estimate, some “70,000 people out of the 4.1 million living in the Indian part of the Sundarbans islands would be rendered homeless by 2020” (Panda 2010: 76).

As cited in many climate change documents a 1 m rise in sea level would inundate 18% of Bangladesh's total land, directly threatening 11% of the country population with inundations. The Khulna region that lies along the country south-western coastline in Bangladesh is the most exposed to sea level rise (DRCSC, 2010). Cyclone Sidr and Aila that ensued in Bangladesh and India brought with it trajectory of worries that left deep scars among the populations. On 14 November, 2007, Tropical Cyclone Sidr also known as very Severe Cyclonic Storm, moved towards the Bay of Bengal and across the south-western coast combined with rain and high waves that destroyed the large part of the mangrove forest. In Bangladesh around 5,000 people were dead as it was a very strong cyclone that hit Bay of Bengal and Bangladesh after 1991 where over 143,000 Bangladeshis were affected that year. Researchers predict the onslaught of such cyclone like the Sidr on Sundarbans mangrove forest will take at least 40 years for the people to recover from its impact. It has been scientifically proved that villages which are bordered by mangroves are at low risk to be affected by tidal waves and floods, WWF (2010). After two years again in May 2009, another devastating cyclone Aila hit India and Bangladesh resulting in devastation and damages to livelihoods and property. The ecologically vulnerable zone of the Sundarbans Delta in West Bengal received a hit sweeping away river embankments and bringing in large scale soil erosion, and eroding paddy fields in the mangrove delta. Post-Aila, thousands of farmers at Gosaba block, South 24 parganas in West Bengal, India still face extreme hardships as most of them are dependent on agriculture and soil deposits on agriculture fields which has made farming impossible for almost a year. The displacement and hardship has also led to trafficking of young women, according to findings by Press Trust of India (The Hindu, 2011). The human death toll during Aila 2009 was around approximately in hundreds people and few left with 50,000 huts being partially or fully damaged. The WWF (2011) study reported a land loss of 97.16 sq km from some of the most vulnerable southern islands of the Sundarbans. In the south western part of the Sundarbans, and islands with dense mangrove substantial erosion took place. Some of the most vulnerable islands identified are Dakshin Surendranagar, Sagar, Namkhana, Moushuni, Ghoramara, Dhanchi, Dalhousie, Bulchery, Bhangaduni and Jambudwip.

A preliminary survey made in Sundarbans over the last 30 years point out that close to 7000 people have been displaced from original habitat, being converted to environmental refugee, and will witness an increase in the coming years. Centre for Science and Environment (CSE), one of India's leading environment pressure groups, in partnership with

the Kolkata-based South Asian Forum for Environment (SAFE), has raised an alarm on the continuous loss of habitat from climate change but also a complete lack of climate-sensitive development planning. Inadequate development planning is forcing people in this fragile region to migrate to other parts of India in search of livelihoods, while the number of climate refugees in the area swells and vast swathes of agricultural land is either devoured by the encroaching sea or rendered unfit for cultivation (DRCSC, 2010 and 2012-13).

It has been pointed out in a UNESCO (2007) report that, a sea level rise of 45 cm will result in destruction of more than 75 percent of the Sundarbans mangroves. Already in 2009, there were an estimated 8,000 climate refugees in the Indian Sundarbans. As Study carried out by WWF (2010) found that in 2001-2002 out of the existing 100 islands on the Indian side, 12 were susceptible to excessive erosion and would lose 15 percent of their landmass by 2015. Already in the last 30 years, erosion of the Indian Sundarbans island system has resulted in reduction of 100 km of land (Hazra, 2001-2002). According to the WWF (2010) stated that in the past five years in the Sundarbans, two-thirds of the Ghoramara islands were submerged while the Sagar islands have lost around 7,500 acres of land. As many as; it has seen, seven villages have disappeared under the relentless tides. Over the past two decades, four islands (Bedford, Lohachara, Kabasgadi and Suparibhanga) have been permanently flooded and 6,000 families have been made homeless. Many of these poor people now live, many living in the slums of Dhaka. And the Sagar Island already houses 20,000 refugees. Dhar (2009) has noted that Cyclone Aila left over 2.3 million people displaced and nearly 8,000 missing between India and Bangladesh. The Sundarbans itself was inundated with over 20 ft of water and an estimated 400,000 people there were badly hit by flooding.

Within the last 40 years, island Ghoramara has been hit by the rising sea level. According to the scientists of the School of Oceanographic Studies of the Jadavpur University, despite 2.1 percent annual growth rate in the administrative area of the Island the population of Ghoramara is decreasing. "The population of Ghoramara has decreased from 5,236 in the 2001 census to 5,193 in 2011, which may be attributed to migration, in spite of existing growth rate within the same administrative area". Research led by Tuhin Ghosh has pointed out that though actual record of migration is not available, "a majority of residents of Ghoramara (almost three-fourth) say that about 4,000 people from the island have migrated out.". Five villages of the Island such as Khasimara, Khasimara char, Lakshmi Narayanpur, Bagpara and Baishnabpara have already submerged. Factors

like severe erosion, embankment failure, cyclone and storm surge are leading to habitat loss, resulting in migration of people from the Island. Environmental degradation leads to loss of livelihood. Climate change further accentuates economic insecurity. As a result migration is taken as an adaptive measure as the islanders don't have any alternate skills" (The Hindu, 14 November 2014).

In 2008, Abul Maal Abdul Muhit, Bangladesh's Finance Minister made a statement to the effect stated that international migration is one of the country's major adaptation strategies followed by Bangladesh. At the 14th United Nation's Climate Change Convention held their 14th summit in December 2008 (COP-14) in the Polish city of Poznan, then Bangladesh demanded that the opportunity of international migration for climate change victims should be included in the new global climate deal under discussion (Roy, 2009). As for the Sundarbans, the then India's Minister of Environment of India, Jairam Ramesh (2010) suggested that India and Bangladesh should join hands to protect the Sundarbans from environmental degradation. In October 2010, a draft protocol to be signed by both nations was approved by the Bangladesh cabinet at a meeting chaired by Prime Minister Sheikh Hasina (Cited in Shloka Nath 2011) a point to which we shall return shortly in the section to follow.

Mangroves use and Degeneration in the Delta

Mangroves refer to a tidally influenced wetland ecosystem within tropical and subtropical latitudes, also found in areas without a tidal regime. It features marine tidal forests that include trees, shrubs, palms, epiphyte and ferns. The Sundarbans mangroves occupy about 62% of the southwest corner of Bangladesh; to the south the forest meets the Bay of Bengal; to the east it is bordered by the Baleswar River, to the west by the Sundarbans National park of India and to the north there is a sharp interface with intensively cultivated land. The mangrove wetlands functions as nursery grounds for a wide variety of aquatic species and a sanctuary of living marine resources. Shared between India and Bangladesh; the mangroves anchors important brackish water finfish and shell fish that forms vital source of food and income for the population (Raha et. al, 2014).

The mangrove forest consists of about 200 islands, separated by 400 interconnected tidal rivers, creeks and canals. Among the 'intangibile' benefits, mangroves protect the coast against wave and wind erosion; moderating the effects of coastal storms and cyclones; nutrient sink-effect and reduction in excessive amounts of pollutants, and entrapment of upland runoff sediments saving shore reefs and reducing water turbidity (Ganguly,

2016).

Change in Agriculture Locale and Deforestation

The agricultural locale had shrunk between 2002 and 2009 from 2,149.615 square kilometers to 1,691.246 square kilometers suggested by Government of West Bengal in 2009. The area suffers from a low intensity of cropping because mono cropping of rice is practiced seasonally, and horticultural crops are rarely grown. Further, only 12% of the cropped area in the Sundarbans is irrigated through rainfed ponds, tanks and canals; majority of the agricultural land is rainfed (ibid). It has been observed by local inhabitants of the island that rainfall has become erratic and its intensity has increased causing further damage to the agricultural yield. According to West Bengal State Action Plan on Climate Change between 1777 and 1971, continuous deforestation and land reclamation activities have been carried out in the Sundarbans region. It has been observed that 5% of forest cover was lost between 1989 and 2009. This deforestation has increased man-animal conflict, local extirpation of several species and added to the biological loss of the region. Further, clearing of forests have not facilitated self-sustaining agriculture on the flood plain, as it tends to be submerged under saline water during high tides.

Changing Material geography of Indian Sundarbans Delta

According to the IPCC (2015) report, South Asia and Island countries have the least capacity to adapt and will be the most adversely affected by climate change and associated sea level rise. The Indian Sundarbans Delta is bounded by the Ichamati- Raimangal River in the east, by the Hugli River in the west, by the Bay of Bengal in the South, and the Dampier-Hodges line drawn in 1829-1830 in the North (Danda et al, 2011). A little over half of this area has human settlements on 54 deltaic islands the remaining portion is under mangrove vegetation. According to many reports in Indian Sundarbans there is high frequency of extreme weather events such as severe storms and cyclones. The main activity of Indian Sundarbans Delta is heavy dependence of natural resources for biomass, aquatic resources, rain-fed paddy agriculture, handmade products, and tourism.

Sagar Island is culturally considered to be the end of the river Ganga and the Island is known to the Hindu Pilgrims as “Ganga Sagar”. Gosaba Island is the main entry point to the Sundarbans Tiger Reserve adjoins the Gosaba CD block and therefore income from tourism is the highest here compared to other blocks adjoining forest in the Indian

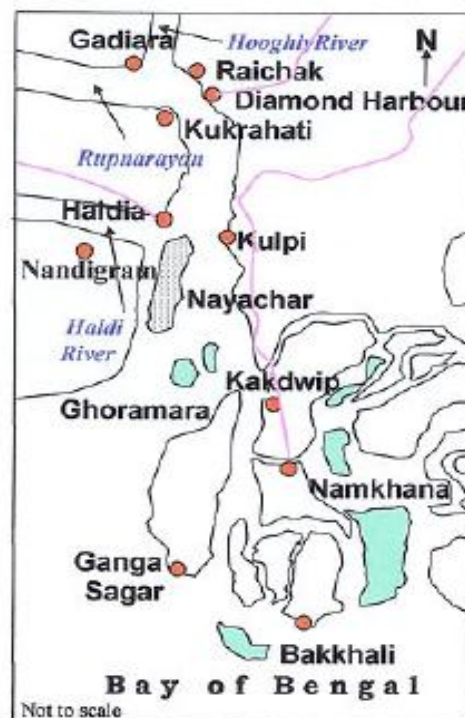
Sundarbans Delta. It enjoys greater advantages in terms of opportunities and access to services such as grid electricity. The population in Indian Sunderbans Region is mainly due to immigration and movement from neighbouring regions and both push and pull factors are responsible for the movement of people in the region. First generation comes from Nepal and Bangladesh who arrived at the heart of region during the colonial administration. One group comes from Chotanagpur plateau of tribal people who were brought to clean forest and administrative work. This group were remained on the boundaries of society. According to Danda et, al 2011 in the Indian Sundarbans Delta caste and religious identities are not found to be determining factors to access to opportunities possibly for two reasons- Firstly, due to land reforms and land distribution policy undertaken by the state government. Secondly, rapid physical changes along the edges of the Islands. It is common to find caste fisherman to be marginal farmers and caste farmers to be fisherman (ibid).

There are two departments in Sundarbans that are Sundarbans Affairs Department and the Forest Department. The Sundarbans Development Board was created in 1973 in order to address the socio-economic backwardness of the region. West Bengal State Action Plan on Climate Change (2010) stated that ‘Small ponds in rural areas especially in Sundarbans regions will be re-excavated, reclaimed and renovated. About 500 hectares water with a unit cost of Rs. 1 lakhs per hectare will be brought under this scheme by the year 2020’. There will be Promotion of Solar Light: Tapping non-conventional energy resources by way of erection of solar light is very important in respect of adaptive measures for climate change (Danda et.al, 2011). In West Bengal 12th Five Year Plan (2012-2017) there is a special provision for the development of Sunderbans.

Sagar Island Demography

Ganga-Sagar is a place situated in the Sagar- Island which is again located in the extreme south of Sundarbans of the South 24 Parganas in the Diamond Harbour Sub-division. Sagar Island is one such famous pilgrim centre where people criss-cross of the country being attracted and come to earn virtues of pure life. The island is surrounded by the Bartola or Muriganga River in the north and east, Hooghly River is flowing in the west and in the South by Bay of Bengal. In Bengal it is known as Sagar Dwip and it is the largest island in the Bay of Bengal which encircles the island at its southern side. In the Sagar Island there are at least 44 villages of which Ganga Sagar is the largest one (Majumdar, 1971; Saha, 1999). Despite of taking bath to the holy water of Ganga, there are several spots

of attraction as Sagar Light house, Solar plant, Wind mill, Deer park etc. and also. Gangasagar Island is different from the Paikhali, Gosaba. It's been five years to solar project near Gyan bazaar in BakKhalī, seaside resort in South 24 Parganas district of West Bengal and wind projects are also there (Shekar Roy, 2013). Most of the land is being unproductive after the Aila.



Source: Wikipedia https://en.wikipedia.org/wiki/Sagar_Island

Climate and People- Witness Stories

People of Sundarbans have been observing changes due to hazards and change in weather pattern and learning their lessons from climate change and adapting and mitigating themselves by different ways. So in this section we have adopted method of data collection based on unstructured questions in which there is no set structure of interview and interviewees answers in their own words regarding the changes that inhabitants of Sundarbans are witnessing like change in rainfall pattern, changes in fishing patterns, rise in sea level, frequency and intensity of extreme climatic events, and heightened land erosion. Since 2009 Aila was the most recent and severe disaster that continent had witnessed and

the maximum impact is on their lives and livelihood.

Mr. Burman Resident of Pakhirala, Gosaba, said that three floods we have witnessed so far first in 1981 and then 1990 and then 2009, Alia the biggest devastating flood, we moved towards hotels and schools and stayed there for almost more than a month and we received food packets from helicopters. We are still facing the impacts of Alia on our lives. There is lack of development in the region due to which people have to migrate for the jobs. Tourism remains for two-three months. After that people have to struggle very hard for their survival. Gosaba was being settled by Britishers in 1930 with geo-economics perspective because of forest, picnic, tiger project was also being created. British bought these island people for work purposes. He further stated that “Bangladeshi immigrants and climate change are the biggest threat”. Limited resources of Sunderbans migrants have to share it with other people. Fresh water is also the biggest hindrance.

Mrinal Raptan, Guide Forest Department from Pakhirala, Indian Sunderbans said these days’ people of Sunderbans are moving to Chennai, Andaman Nicobar Island. Lives in these islands are on risk because there are so much of dependences on the forest. You cannot risk your life every time. He was of the view that neither WWF nor any other organization is doing useful work in this regard. He was of the view that there is falling in the practices of catching fish which is somehow related to over exploitation of fishery resources over the past decade. We are also witnessing changes in navigational depth and water current. Due to change in water temperature there is fall in the catching of fish. Another vital issue is the threat to safety and security. Fisher folk, in the Sunderbans, do not receive the benefit of an early warning system like weather patterns from All India Radio or any other source in the country. Unavailability of timely information on weather forecasting endangers fisher folk while they are in the sea for fishing. Fisher folk often face pirate attacks on the high seas.

Susan Mandal, a Farmer of Bali Island, said that due to Alia production of ‘Dhab’ (coconut), banana has been affected. The Sunderbans is my home. I have lived here from last 70 years. I am 72 and things have gone bad to worse. During Aila 2009 my single hectare of land disappeared in front of my eyes. I start fearing one day our whole village will get disappeared. Sea water of Aila in 2009 destroyed crops and those impacts are still visible. Our cow, goats get washed away during storms. The traditional honey collectors go into the deep forests from every year to collect honey. People in the Sunderbans face the risk of losing their life to attack from tigers and crocodiles and bites by poisonous snakes.

Mohini Mandal, a Shopkeeper from Bali Island lost her shop and house during Aila Flood and stated further that life has changed afterwards. Mohini is now a resident of Bali Island. Her original home was on Lohachara Island which disappeared in 1996. In the past two decades, four islands including Lochara, Suparibanga, Kabasgadi, Bedford have been permanently flooded and many people were displaced and homeless. Many communities were displaced. Lohachara Island was divided into 5 administrative zones and the total population was almost 7 thousand. There we did not have any source of drinking water. The tube well was eroded by the river after that local official did not start new one. We have to go to another island for fetching water. Access to safe drinking water is a major problem for the inhabitants.

Interview of Swami Jitavnanda, Bharat Seva Sangh, Ganga Sagar said that illegal migrants coming into Bengal firstly from Nepal, Banga Bastighat and Basanti and sometimes from Maynmar too. On Jammudeep Island central government established control through military as Bangladeshi migrants enter so much from there. From Sagar Island people are moving to Andaman for work. Aila victims are given help every month of rice and money....20,000 people died. No information was available before 'Aila' came that is why it is being called Aila after its arrival. It arises without any information. Everyday Bangladeshi migrants came to Sunderbans and almost 20 percent of people come from there. Geopolitical border security of India is being threatened from three sides' Panjab, Rajasthan and West Bengal. There is also commercialization of borders or geo-economics of borders. Muslim migrants comes from Bangladesh. He is trying to securitize while stating that " Rehne ke liye nahi Ate Barbad karne ke liye" Muslim migrants came here just for destroying the security not for living. There is relatively little reliable knowledge on the status of the tiger population according to a swami who has been staying for last 20 years could never ever get a chance to see a single tiger. Socio-economic-cultural profile is not uniform throughout the inhabited part of the Indian Sundarbans delta. This differentiation is due to geographical characteristics, population composition and their background, access to different sets of resources and subsequent occupational specialization and the non-uniform pace of socio-economic transformation through the region.

Interview from Naga Sadhu Sri Shambu Panch Das, said that Global Warming has become a reality. I have been living in Sagar Island from many years, and have witnessed changes in its demography. Bangladeshi population are also present here. Alia came for 30 days water remains there. Government did not give much help. After Alia many left the island

and move to milakhali and Kolkata due to flood they move and they never returned

Interview from Sheikh Samad Ali, a member of Panchayat said that after Aila Rice production has been affected, the quality of food was not that of high-quality after the flood. Earlier production was higher. People who were being displaced from Aila are getting 16 kilogram rice at the rate of Rs.2 from the government. NGO's too are supporting. From MLA quota, Rs 70,000 were given to build houses for the people. Today, the challenges posed by political, economic and social factors greatly affect the quality of life of the people, especially the poor, living in this area. These are issues that need to be addressed along with the ecological factors that affect this region.

Interview of Gangadhar Tamang, whose parents migrated from Nepal to ganga sagar island an electrician from Ganga Island said that taran tarun sangh club NGO being given help to people. Five kilometer land loss due to Aila. The greatest impact of Aila is being felt in the Bakkhali. He stated that development of the region started late after 2009. "Those who lost land are still on the land and those who got land from the government are not fertile land. Due to fear people never come back. People from Sagar Island were moving to Kerala, Gujarat, Chennai for work and many other regions of the country. There is no change in the weather pattern. But the production of 'Pan', 'Mirchi', 'Rice', 'Water Melon', 'Mango', are being affected. Lokh Nath Mission (NGO) too is working for the development of the region. After alia development started in the Ganga Island.

Radhakant Roy, a Resident of Bakkhali said that 30 acres land submerged. There are many places where there is no production around 100 acres of land. Government provided help to few not to all people. He further stated that there is no change in the climate. We don't have any hope from the government for any kind of help. Around 1000 cottages were lost in the Boat khali Island after Aila. 200-300 families moved towards other regions near Kolkata. Continuous shrinkage of employment opportunities compels the poor villagers to migrate to nearby cities and towns and to other parts of India.

Interview of Muhammad Sheikh from occupation, he is a rickshaw puller. He said that government stopped the work of 'Band' embankment in between on the Island of Boat Khali. He was of the view there is no migration which is taking place from the Bangladesh. He said his own home was being damaged in the Aila cyclone 2009. Subsequent flooding

devastates many households by taking lives, washing away cattle, damaging standing crops and ultimately rendering agricultural land unproductive or underproductive. The Irrigation Department of the State Government either repairs or builds these embankments afresh. The soil used for building embankments are excavated from nearby land which aggravates the situation as further tidal action weakens the base of the new embankment, which subsequently collapses.

These stories deserved to be verified, their truth tested against scientific studies. Is there indeed incredible that is changing about Sundarbans? After interacting with people, our research suggested that geo-economics and geopolitical factor plays prominent role in triggering human migration but now anthropogenic geo-climatic factors are also playing crucial role in this aspect. 'What makes you displaced and refugee is what you have gone through it's not about displacement or crossing the boundaries and borders. The story of homeless and displaced is the story of the world that is still truculent for the geography. After talking to inhabitants, it was observed that there was not despair from disasters affects but there is still a hope of believer gnosis which truly reflects their story of courage, integrity, gratification and adventure.

Anurag Danda, WWF-Sunderbans coordinator has pointed out that since India is perceived as a huge landmass by the rest of the world, the country's 700 islands including the Sunderbans, Andaman & Nicobar, and Lakshwadeep are often sidelined. He has further stated argued that the voices of the people of the Sunderbans needs to be taken to the global stage. In his view, "Danda emphasized that it is vital for India to remind developed countries of the adaptation fund that they had committed to developing nations since." It is the poor people who have to make the biggest transitions. How can India manage the increasing number of climate refugees if developed countries don't help out?" (cited in Subhro Niyogi, 2009).

IX Climate Policy of India and Bangladesh

A Indo-Bangladesh Sundarbans Eco-System Forum, which is currently in the planning stages, is to be made functional. The forum, which will include non-governmental organisations and civil society of both the countries and would aim at, plans to coordinating efforts in afforestation, management of mangroves and conservation of the tiger. First of its kind in India, this is an innovative idea in using bilateral environmental problems to foster broader regional cooperation between India and Bangladesh. As pointed out above, the Sundarbans, where continued destruction due to

rising sea levels and natural disasters has already produced thousands of 'climate refugees', is at the centre stage of battle against climate change. As pointed out by Shloka Nath (2011), "There is hope. For all its predicaments, the Sundarbans is a place where adapting to climate change actually seems possible, thanks largely to the one commodity that both India and Bangladesh have in abundance: human resilience. This must not be wasted. The economic and environmental element must be enjoined for maximum impact."(ibid)

India has initiated national level policies such as the 'Disaster Management Act' in 2005 to deal with climate change disasters. The Cabinet Committee on Management of Natural calamities and the National Disaster Response force were constituted in the same year. These task forces, however, have had limited effect in curtailing the devastating effects of climate disasters. The 2008 Kosi floods showed this in many ways. Most notably, the National Action Plan for Climate Change makes no mention of any plan to save the biodiversity of the Sundarbans (IANS, 2009).

Effective and durable solutions to the resolve the problems mentioned above are a new understanding that will encompass the economic and the environmental considerations. It will mandate effective cross border management in both countries at two levels: state and local. For example, India and Bangladesh could initiate begin a joint relocation and emergency evacuation programme for climate disasters such as cyclones or flooding. This will go a long way in preventing communities from being displaced. Working together under a bilateral agreement, India and Bangladesh can potentially manage the crises of 'climate refugees' through the use of micro-credit programs like micro-loans for livelihoods and micro-insurance for environmental disaster cover. Cooperation over Sundarbans would certainly benefit from promoting overall cooperation between India and Bangladesh. Sharing of the waters in the Ganges–Brahmaputra basin is a historic opportunity for both countries to create not only a bilateral, but also a regional policy, under the auspices of a body such as the South Asian Association for Regional Cooperation (SAARC). Working together for Environmental Impact Assessment (EIA) for the entire Ganges-Brahmaputra Delta will also be a good starting point.

In an exclusive interview with Gateway House in September 2010, the then Environmental Minister of Jairam Ramesh said:, "Environmental diplomacy and environmental cooperation can often be triggers for enhancing broader regional cooperation. It helps to build trust, gets your people working with each other, learning from each other, and breaks down

barriers. I hope to see more of this going forward.” (Cited in Shloka Nath 2011:10).

The joint management of the Sundarbans by India and Bangladesh remains a challenge in bilateral relations between the two countries and calls for a new, innovative thinking on the conventional vocabulary of International Relations and Geopolitics. The key concepts of the Westphalian state-systems, especially ‘sovereignty’ and ‘security’ need to be heavily tempered by the notion of ‘sustainability’ and ‘environmental/ climate’ justice.

The Memorandum of Understanding signed between India and Bangladesh over the Sundarbans (see Ministry of External Affairs September 06, 2011) recognizes at the outset that “the Sundarban of India and Bangladesh represent a single ecosystem divided between the two countries” (ibid). The MOU also acknowledges that the wildlife sanctuaries of the Sundarban located in both countries is recognized as UNESCO World Heritage Site and in Bangladesh as Ramsar site as well”. Furthermore “Both Parties recognize the need to monitor and conserve the Sundarban, which is home to rich biodiversity consisting of large variety of rare species of flora and fauna, and acts as a vital protective barrier protecting the mainland from flooding, tidal waves and cyclones. It is heartening to note that “Both Parties, with a view to exploiting the potential of the Sundarbans for development and alleviation of poverty, agree to undertake, but not limited to, the following endeavors”:

1. Consider and adopt appropriate joint management and joint monitoring of resources;
2. Explore the possibility of implementing conservation and protection efforts, encourage mangrove regeneration, habitat restoration and rehabilitation programs, which would eventually increase the potential for carbon sequestration;
3. Develop a long term strategy for creating ecotourism opportunities for both countries, which will create synergy and generate greater revenue.

While in agreement that the “Sundarban ecosystem is greatly influenced by human use and the human beings living around the Sunderban”, the MOU says that the Parties will (a) “map and delineate these human settlements on respective sides so that a better understanding emerges of the relationship between human settlements and the ecosystems”; (b). “further develop a management plan that utilizes this

information to address issues of livelihood, deprivation by flooding and other climate related disasters, man-animal conflict, pollution, resource depletion, etc.” and (c) through the management plan, also identify opportunities for livelihood generation that do not adversely affect the Sundarban ecosystem.” As far as the challenge of climate change is concerned, “Both Parties will carry out research to develop a common and shared understanding of the impacts of climate change along with adaptation strategies that can be implemented.” And in order to realize the objectives enshrined in the MOU, “A Working Group will be set up to define activities, responsibilities, time, and resources involved, according to the activities established as per this Memorandum” (ibid).

No doubt the long MOU between India and Bangladesh is the much needed right step in the right direction. It’s timely and effectively implementation will depend not only on the political will of the two countries but also the introduction of a new ethical-normative framework that would not only ‘save’ the ecological properties of the Sundarbans but also the lives and livelihoods of millions of by and large poor people. The discussion that follows, we believe, has some valuable insights to offer for those in both academia and policy making circles interested in ecologically sustainable, socially just and culturally appropriate ‘development’ of the Sundarbans.

At an event organized on the Sundarbans at the sidelines of CoP21 meeting in Paris on December 9, 2015, The Environment Ministers of both India and Bangladesh former Prakash Javedkar and Mr Anwar Hossain Manju, have explicitly stressed the need for joint action to protect the Sundarbans, world’s largest mangrove forest. Both the governments have passed several policies in respect of protection of the Sundarbans. Now a point to which we shall be discussing in the section to follow:

To adapt to climate change India formulated the National Action Plan on Climate Change (NAPCC) and launched it in June 2008. Out of the eight missions, most important were the creation of climate friendly sustainable habitats, water mission for integrated water resources management; promoting sustainable agriculture, enhancing ecosystem services of forests, developing strategic knowledge base to address the concerns of climate change among others. States under the gloom of climate change needed, to develop their prioritized action plan vis a vis their respective climate change concerns under the overarching objectives and missions of the National Action Plan on Climate Change. The NAPCC provided more opportunity for identifying the risks and opportunities of

climate change, mainstreaming the climate change concerns by introducing low climate resilient developmental activities in the state and generates pipeline investment ready initiatives that can be directly adopted. Given the adverse climate situation, the national climate action plan appears as a major step, but it is also becomes essential to implement it with a sense of urgency (NAPCC, 2008). The Government of West Bengal considering that climate change can prove to be a threat as well as opportunity for the state identified key sectors and regions that are likely to be most vulnerable. The State Action Plan has identified following sectors - water, agriculture, horticulture, fisheries, animal husbandry, forestry, energy efficiency, non-conventional energy sources, and marked Sundarbans, Darjeeling Himalayas, habitat, institute for climate Change studies.

India is also a signatory to a number of multilateral environmental agreements and conventions (MOEF, 2012), including the UN Framework Convention on Climate Change (UNFCCC) in 1993, the Kyoto Protocol in 2002 and the Convention on Biological Diversity (CBD) in 1994. India is also a Party to related conventions, namely the Convention on International Trade in Endangered Species of Wild Flora and Fauna, the Ramsar Convention on Wetlands of International Importance, and the Convention on Migratory Species. Sundarban Affairs Department was created in 1994 to give an impetus to the development efforts in Sundarban region and Sundarban Development Board was created in 1973, was placed under the said Department. Sundarban Affairs Department implements developmental activities through Sundarban Development Board regarding formulation of integrated programme for effective utilization of the resources placed at its disposal, co-ordination of plans and revision of policies.

The National Adaptation programme of Action (NAPA) prepared by the Ministry of Environment and Forest (MOEF), Government of the People's Republic of Bangladesh comes as a response to the decision of the Seventh Session of the Conference of the Parties (COP 7) of the United Nations Framework Convention on Climate Change (UNFCCC). It seeks to address the challenges laid down by climate change in the vulnerable areas in the country (NAPA, 2005). After the new democratic government came into power Bangladesh Government revised Bangladesh Climate Change Strategy and Action Plan (BCCSAP) of 2008, and building on it and expanding on the National Adaptation Programme of Action (NAPA) it brought into effect the new BCCSAP 2009 where the climate change constraints and opportunities are being integrated into the over-all plan and programmes involving all sectors and processes for economic

development (MoEF, Bangladesh, 2009). The National Environmental Management Action Plan (NEMAP) 1995 includes in its recommendation that actions on land resources must integrate indigenous land out practices, to increase efficiency of the production system and its application.

Conclusions

Boia (2005) insightfully argues that the battles over climate change occur as much in the cultural and individual imagination as in the atmospheric spaces in which physical climates are formed. This was clearly visible in the Sundarbans which has become one of the climate change experimental laboratory. Before going to the region, I have heard so many voices and narratives from media, IPCC reports, think tank and academics that climate change is impacting in the Indian Sunder bans region and changing socio-economic and cultural landscapes of Sundarbans at accelerating rate but on other hand while meeting with official people and inhabitants of several island my study concluded that climate is not the only cause for changing their landscape's ecology but lack of economic development; education and inappropriate governance system are also the foremost cause behind their backwardness. Management of Sundarbans within the context of the challenges faced due to climate change should be the prime focus of the Government's policy that requires successful adaptation governance in Sundarban that will depend on how aware the population is about the changes in the natural systems, interpret their implications and make informed choices about the solutions provided by the Government.

Some Scholars like Kanksha Mahadevia and Mayank Vikas(2012) insightfully suggested that the Government of West Bengal should demarcate specific areas of the Sundarbans that are particularly susceptible to cyclonic storms and particularly relevant for those people who live in the critically vulnerable areas of islands and will be required to invest in creation of infrastructural facilities, providing employment opportunities at the short term, will help the Sundarbans be a more accessible area for dissemination of knowledge not only this the State Government must put in place effective early warning systems.

Planetary management in form of water management is the most attractive feature of the inhabitants of the region. The beauty of their life is being reflected from their bare needs and best utilization of resources. It's high time that climatic moral and adaptation education needs to be expanded in Sundarbans delta in order to solve the uncertainty of climatic future otherwise new counter movements and new hierarchies of power

changing the discourse of apprehension about climatic futures. Franzen (2015) insightfully argues that we are living in a Anthropocene, a world who created us and whose climatic future is again depends upon our creation. In 2009, Environment Minister of West Bengal, Sainen Sarkar has urged the then Union minister for Environment and Forest, Mr. Jairam Ramesh, to highlight the plight of the islanders at the Copenhagen Summit on climate change. Sainen Sarkar emphasized that “For the people of the Sunderbans, climate change is not a subject of debate but a reality they are battling daily?” (Subhro Niyogi, 2009).

“We need leadership for change. Sitting on the bench waiting for someone else to make the first move doesn’t work. Heads of state need to start thinking globally; businesses and consumers need to stop behaving as if we live in a limitless world”.- Marco Lambertini, Director General, WWF International.

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9

Identifying the Causes of Water Scarcity and Sustainable Water Conservation for Improving Livelihood in Bankura District, West Bengal: A Geographical Perspective

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Abstract

Water scarcity is one of the important concerns of present day geographers as water is the central subject of all kinds of developmental activities. Water is kinds essential for all socio-economic development and for maintaining a healthy ecosystem in the world. At present reduction of water scarcity is prime goal of many countries and Government. Bankura is one of the most backward district of West Bengal in terms of economic and human development. Water scarcity is a regular threat for the people of Bankura district which has great negative impacts on development of Bankura. Therefore Taldangra, Raipur, Ranibandh, Khatra and Onda are the five CD Blocks of Bankura district have been selected where problems of water scarcity are very much predominant and people suffer this problem throughout the year. Therefore, in this research paper, an attempt has been made to point out the root cause of water scarcity in these blocks and suggest some remedial measures especially the sustainable water conservation for further planning through which the problem may overcome and make Bankura district more water sustain and efficient.

Keywords: *Goal, Water Scarcity, Threat, Sustainable Water Conservation, Remedial Measures*

Introduction

Water scarcity involves water shortage, water stress or deficits, and water crisis. The relatively new concept of water stress is difficulty in obtaining sources of fresh water for use during a period of time; it may result in further depletion and deterioration of available water resources. Water shortages may be caused by climate change, such as altered weather-patterns (including droughts or floods), increased pollution, and increased human demand and overuse of water. The term water crisis labels a situation where the available potable, unpolluted water within a region is less than that region's demand. Two converging phenomena drive water scarcity: growing freshwater use and depletion of usable freshwater resources. 70% of the earth surface is covered with water, which amounts to 1400 million cubic kilometres (m km³). However, 97.5% of this water being sea water, it is salty. Fresh water availability is only 35 m km³. Out of the total fresh water, 68.7% is frozen in ice caps, 30% is stored underground and only 0.3% water is available on the surface of the earth. Out of the surface water, 87% is stored in lakes, 11% in swamp and 2% in rivers. Scarcity has various causes most of which are capable of being remedied or alleviated. A society facing water scarcity usually has options. However, scarcity often has its roots in water shortage and it is in the arid and semi- arid regions affected by droughts and wide climate variability, combined with population growth and economic development, that the problems of water scarcity are most acute (UN-WATER, 2006).

Objective of the Study

The major objectives of the present study include

1. To identify the global and regional water scarcity scenario
2. To identify the causes of water scarcity in Bankura district
3. To analysis impact of water scarcity on environment as well as surrounding nature
4. To incorporate some remedial measures through which problem of water scarcity is recover.

Source of Data Base:

This research work is based on both primary and secondary data, collected from different sources.

Secondary Database: Secondary data was collected from various sources which include various websites of internet sources, articles, andreplica. A

structured questionnaire was prepared to collect the data from the local people as well as B.D.O , S.D.O and other office of Bankura district 5 community development block (Taldangra, Onda, Khatra, Ranibandh, Raipur).

Primary Database: Primary data have been collected from the local people of Bankura district's 5 community block (Taldangra, Onda, Khatra, Ranibandh, Raipur) area based on perception study with the help of structured questionnaire. Therefore 75 sample have selected from each C.D block of Bankura district and total sample size was (75 samples * 5 C.D block) 375 and systematic random sampling was done to point out and removal process of water scarcity of this district.

Methodology

To satisfy the aforesaid objectives the following methodology has been followed in the present study.

The methodology adopted can be divided into the following parts:

Pre-Field: In this phase, general literature survey was carried out and collection of maps and secondary data for related to water scarcity in Bankura district from various Government and non-Government Source. A structured questionnaire was prepared to collect the data from the respondents, as well as different office of Bankura district.

Field: As the study area is the zone of water scarcity, it becomes a difficult task to conduct the primary survey. To cope with this problem stratified sampling was done on random basis. To know about the water scarcity and its associated problems ,at first it has been selected 5 community block of Bankura district and then start surveying in different part ,village of this block. Relevant photographs have been taken during the field survey to illustrate the scenario more specifically. Some officers, experts, planner and executive in different organization were personally met and interviewed.

Post Field: This stage involves computation of master data table from the questionnaire, statistical application, cartographic representation, drawing maps using GIS techniques, analysis of data and information obtained in order to understand the present status of water condition, and its related problem as well as health and environmental problems. QGIS, 21st Century GIS, professionals, Map info, Corel draw, Adobe Photoshop software have been used for digitization and drawing of maps.

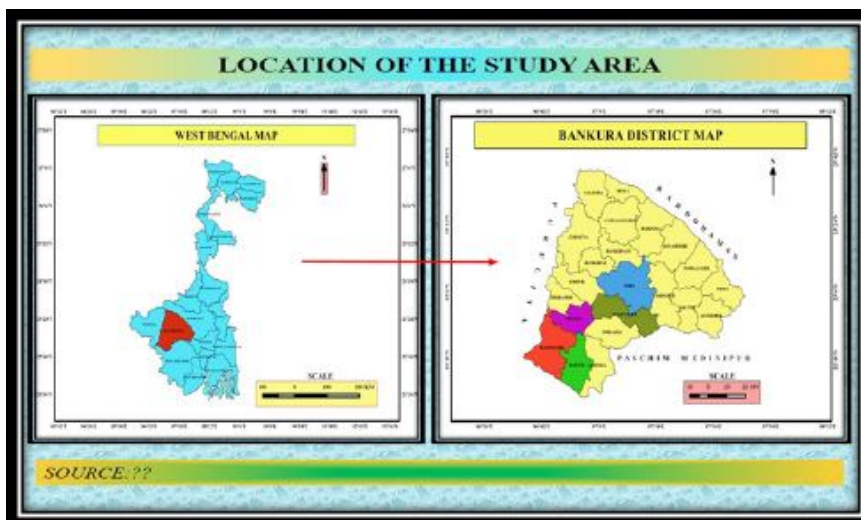
Location of the Study Area :-

The study area of this research work is confined within the limit of Bankura district, West Bengal and the perception survey area is 5 community block of Bankura district that are –

- I. Onda,
- II. Khatra,
- III. Ranibandh,
- IV. Raipur,
- V. Taldangra.

Bankura district is an administrative unit in the Indian state of West Bengal. It is part of Medinipur division one of the five administrative divisions of West Bengal. Bankura is surrounded by Bardhaman district in the north, Purulia district in the west and (Map No:1) Paschim Medinipur district in the south and some part of Hooghly district in the east. Damodar River flows in the northern part of **Source** Bankura district and separates it with the major part of Burdwan district. The district head quarter is located in Bankura town. Bankura district is a part of Medinipur division. It is situated between $22^{\circ} 38'$ and $23^{\circ} 38'$ north latitude and between $86^{\circ} 36'$ and $87^{\circ} 46'$ east longitude. It has an area of 6,882 square kilometres

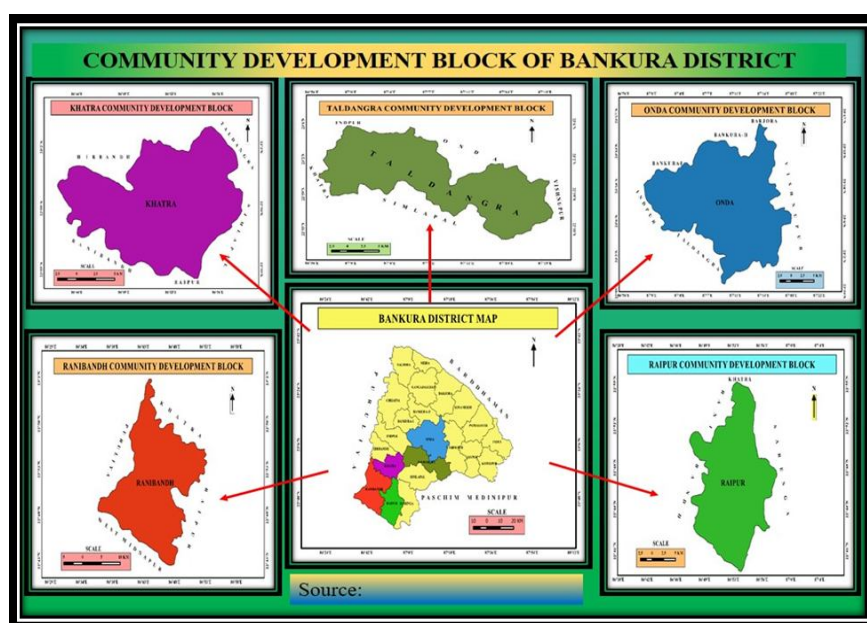
Map No:1



Source: District Development Report, 2011

(2,657 sq mi). On the north and north-east the district is bounded by Bardhaman district, from which it is separated mostly by the Damodar River. On the south-east it is bounded by Hooghly district, on the south by Paschim Medinipur district and on the west by Purulia district. To (Map No:2) the west the surface gradually rises, giving way to undulating country, interspersed with rocky hillocks. Much of the country is covered with jungles.

Map No: 2



Source: District Development Report, 2011

Ground Water Condition: The primary source of ground-water is rainfall, a part of which is lost as evaporation and transpiration and another part moves as surface run-off and remaining part percolates into the ground from direct rainfall or by lateral infiltration from surface water-bodies to form saturated ground-water zone.

Discharge of groundwater takes place by sub-surface inflow to contiguous areas and by seepage to steam channel beside extraction of water by ground-water structures, viz., dug well, tube well etc. Ground-water in the district occurs both under water table condition (Map: 3) and confined condition. Ground-water in the near surface aquifers occur under water-table condition and in deep aquifers, under confined or sub artesian

Map No: 3

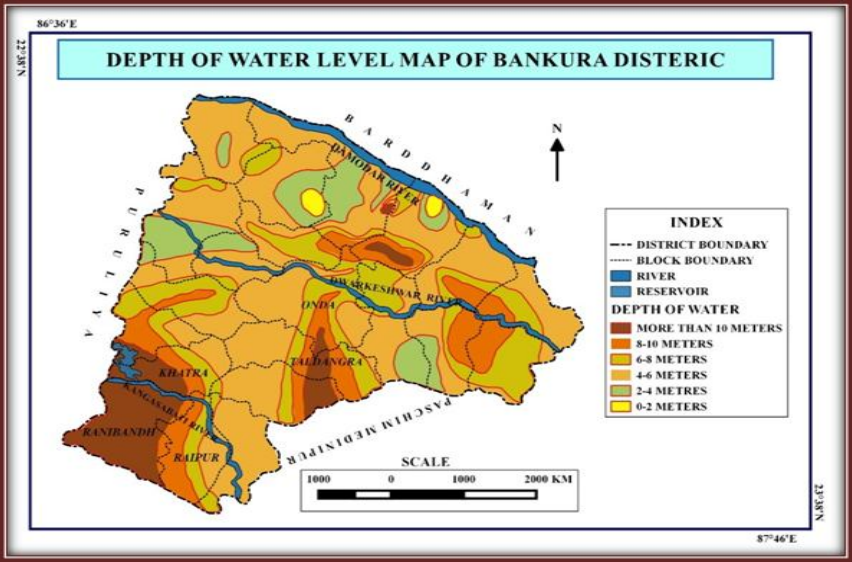
Source: NATMO

condition in favourable terrain. The blocks of Bankura-I, Chhatna, Saltora, Gangajalghati, Ranibandh, Khatra, Hirbandh And Indpur fall under this sector. In the middle sector covered by laterite and older alluvium, ground-water occurs in the moderately thick to thin aquifer under unconfined to semi-confined condition. In this region, the ground-water is mainly abstracted through open dugwell with limited number of low-duty tubewells. Heterogeneous character of the water-bearing formation with complex aquifer geometry prevails in the area and is feasible for open dugwells of 10 mts. to 15 mts. depth having 3 mts. diamts. The sites are location-specific and hill slopes are to be avoided. Low-duty tubewells are also feasible in favourable area. The yield of such low-duty tubewells (75 mts. to 100 mts. depth) varies from 20 to 25 cubic metre/hour.

Depth of Water Level

In the year 2001-2002 it has been observed that during the pre-monsoon period there was a great variation in water-level in different part of the district. In a very small part of Patrasayer and Simlapal blocks the waterlevel was (Map: 4) below 3 mts. BGL. In some of the spots autflow faintly existed. In a large part of Sonamukhi, Patrasayer, Indus, Barjora, Mejia, Simlapal, Taldangra and a small part of Raipur, water-level was between three to six mts. BGL. The south-western part of Ranibandh and Raipur, western part of Chhatna and Khatra, eastern part of Joypur, Bishnupur and western part of Indus and Kotulpur and in some patches of Taldangra, Onda and Barjora, the water level was above 10 mts. BGL. In rest of the District, water-level was between 6 mts. and 10 mts. BGL.

Map No: 4



Source: NATMO

Perception Study on Water Scarcity in Selected Five Community Development Block in Bankura District

Any research work is based on perception survey, this research paper is not an exception one, so structured questionnaire has been prepared to point out the overall observation of water scarcity problem in selected CD block in Bankura district.

The graph (Fig:1) showing the main source of water are available in selected blocks in Bankura district. In these blocks the main source of

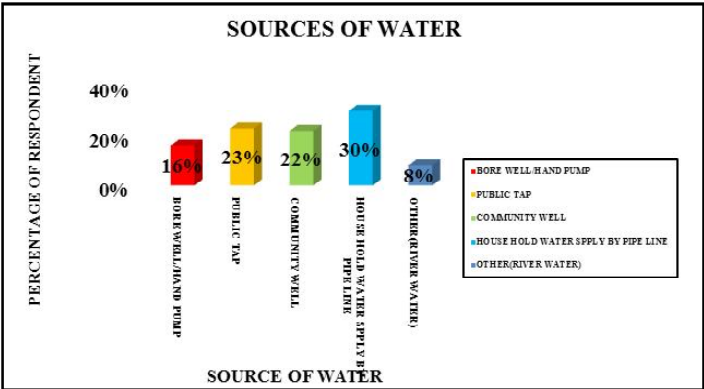


Fig: 1

Source: Primary Data,2017

water are bore well /hand pump, public tap, community well household water supply by pipe line, and river water, pond water. Maximum 30% people says that here main source of water are available in respondent's neighbourhood that is household water supply in pipe line. 23% respondents told that the Source of water is community well and 8% respondents says their source of water is river water. However the source of drinking water that uses in these block's people. Almost 45% respondents use community well for drinking water. 23% respondents (Fig: 2) says their source of drinking water is public tap, 15% peoples use drinking water that source is household water supply by pipe line. 13% household use bore well and hand pump water and in some of case when water problem is the respondent (Fig:3) covering distance to collect drinking water from the source. In these blocks maximum people going near about 1 kilometre for collect drinking water from the source and 33% respondent covering distance upto 0.5 km. for collect drinking water from the source .And 14% respondents they maximum cover distance that is more than 1.6 kilometre to collect drinking water.

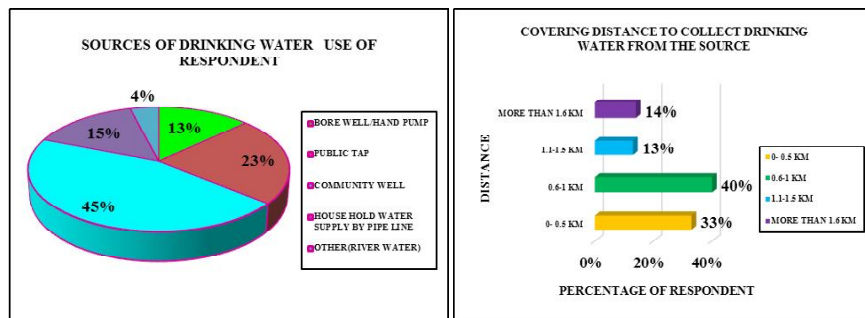


Fig: 2 & 3

Source: Primary Data, 2017

Therefore approximately total time to cover (Fig: 4) the distance from drinking water sources in these blocks. Here 43% respondent says 10 minutes time gets when they are going to bring drinking water. 37% respondent told 10 minutes to 20 minutes time gets to cover the distance from drinking water sources. 13% peoples response 20-30 minutes and 7% respondent says that they spent more than 30 minutes when they are cover the distance from the drinking water sources. Moreover (Fig: 5) carrying of water from the source by the respondent in these blocks. In this block maximum 54% adult female carrying water from the source and 22% adult male are carrying water for household. Some of case children are carrying water from source, Here 11% male and 13% female children are carrying water. However the fact (Fig:6) represent the frequency of water supply by pipe line and Tanker in selected C.D blocks. 6% respondent says that

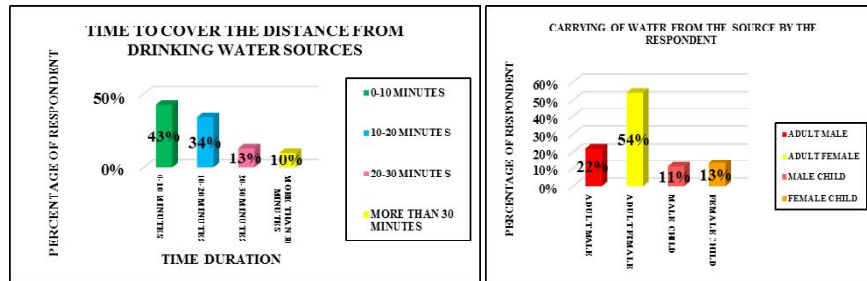


Fig: 4& 5

Source: Primary Data,2017

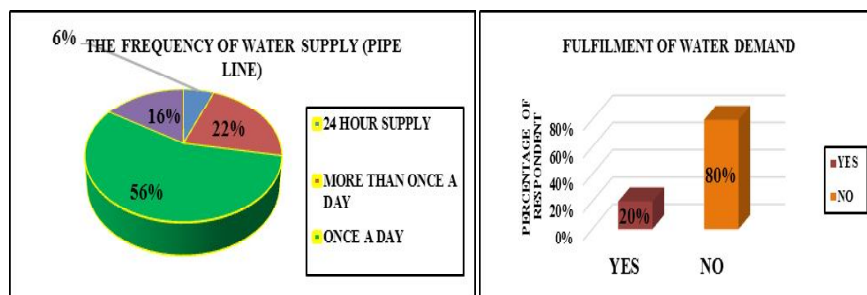


Fig: 6& 7

Source: Primary Data,2017

the frequency of water supply is 24 hours.22% respondent told there water supply frequency is more than once day. Maximum people of this area replied the frequency of water supply is once a day but 16% people told the frequency is once in two day during summer time. The figure (Fig: 7) showing fulfilment of water demand .In selected blocks Government provide water supply by pipe line or tanker to fulfill water demand during scarcity and any time.but there maximum 80% respondent says they are not satisfied because they are not fulfill their water demand.But in urban area's people almost 20% they told they are satisfied with the fulfilment of demand of water supply.Therefore the fact (Fig:8) represent the

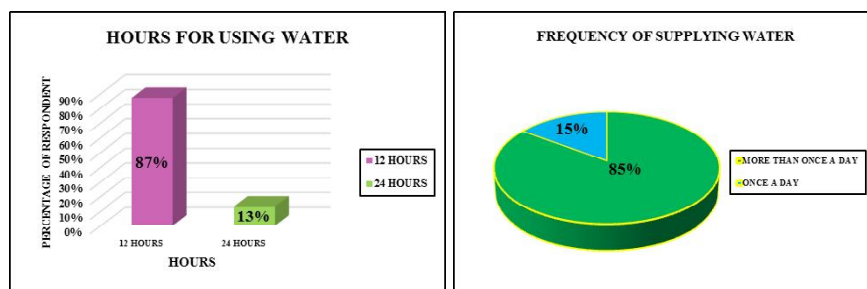


Fig: 8 & 9

Source: Primary Data, 2017

frequency of water supply that respondent like to get water by pipe line or tanker. In selected blocks almost 85% respondents prefer the frequency of water supply is more than once a day and 15% people say they want the supply of water once time in a day but it will be sufficient amount of water. Therefore This diagram (Fig: 9) represent on the days that respondent get water that amount of water how many hours they usually use .In selected blocks maximum people ,almost 87% people told they use water less than 12 hours.And few number of people response they use 24 hours water that supply by pipe line. Therefore the diagram (Fig: 10) showing predominant month of water scarcity in selected blocks. From the diagram it can be seen that in the month of March, April and May maximum people facing water scarcity because this summer time water availability is being less amount so they suffer very problem. But some area of this block people says that they suffer water problem throughout the all month. Almost 27% respondent told they face water scarcity throughout the all month but in summer season they face very much water scarcity. Perception survey reveals the fact that the physical properties of drinking water in selected blocks where 40% of the (Fig: 11) people says there drinking water have

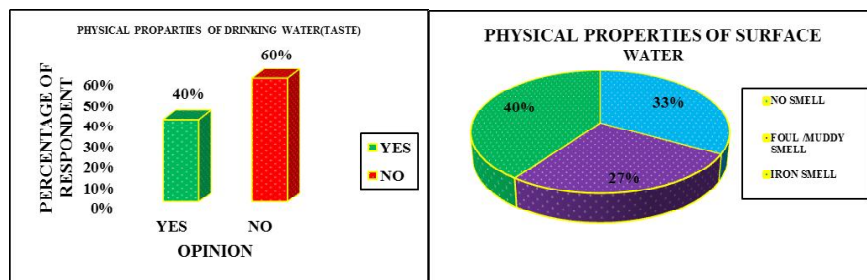


Fig: 10& 11

Source: Primary Data, 2017

iron smell and 27% respondent told there water have muddy types smell but 33% people response their water have no smell that they use and some

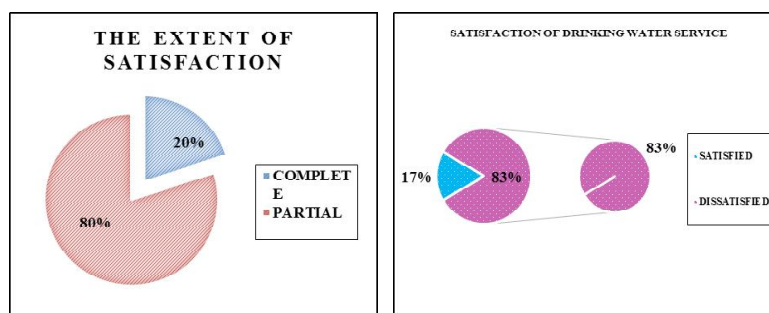


Fig: 12& 13

Source: Primary Data, 2017

of time they purify water then use so they have not gets any smell. The fact represents that the physical properties of drinking water especially taste in selected blocks. Here (Fig: 12). Almost 60% respondents of this block says there drinking water have not taste normally and 40% respondents told the drinking water have test naturally that they use. This diagram (Fig:13) showing the satisfaction of drinking water service that provide the water supply authority of different block. There few number of block people that almost 17% respondent says they are satisfied drinking water service but maximum people that is 83%, they told they are not satisfied of drinking water service because the authority of water supply department have not taken any action or not satisfied their demand. The fact (Fig: 14) represent the extent of satisfaction of the respondent. 20% respondent of selected blocks people says they are completely satisfied of the authority's water related service. 80% respondent told they are satisfied but that is partial.

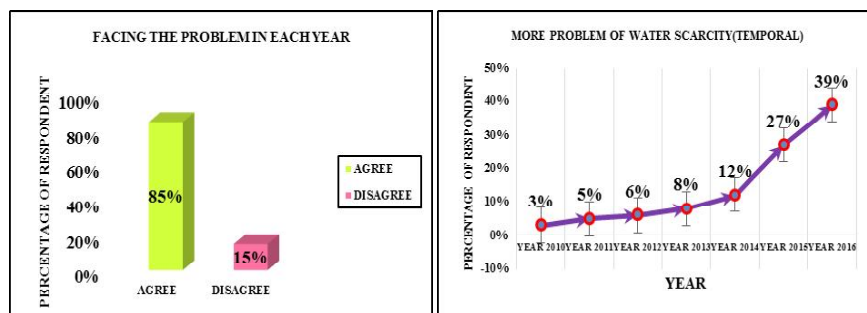


Fig: 14& 15

Source: Primary Data, 2017

The survey represents the fact (Fig: 15) more problem of water scarcity in previous year. Maximum respondent (39%) of selected blocks people says year of 2016 they face more problem due to water scarcity and this year is water scarcity is being increase than the past year. However From the diagram (Fig: 16) it noticed that the water scarcity is gradually increase from the year of 2013 and up to recent year. This diagram represents an overview about water scarcity. Maximum people (85%) of selected blocks they says every year they face problem due to water scarcity but 15% respondent they answer disagree. The survey represent the causes of water scarcity in selected blocks of Bankura distric (Fig: 17) where people mention some causes of water scarcity that are prolong absent rainy days, drought, more irrigation, less amount of ground water, less supply of dam water. However 55% respondents said the main causes of water scarcity of this area that is prolong absent rainy days, 22% respondents answer the cause is less amount of ground water. 6% respondents reply more irrigation

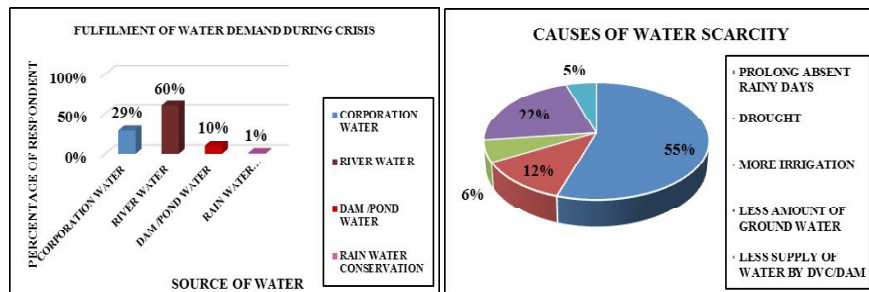


Fig: 16 & 17

Source: Primary Data, 2017

and 5% respondents they said the causes of water scarcity is less supply of water by near dam. The diagram showing (Fig:18) the fulfilment of water demand during crisis. Almost 60% respondents from selected blocks people use River water for fulfilment water demand during water crisis where as 29% respondent use Corporation water that supply by tanker ,10% people use pond or dam water and 1% rich people use rain water that they before conserved in tank. And some of case some people brought purified water from the market as drinking water. In this way they fulfilment the water demand during crisis.The Survey represents the fact that (Fig: 18) availability of water during summer seasons. Maximum (85%) respondent

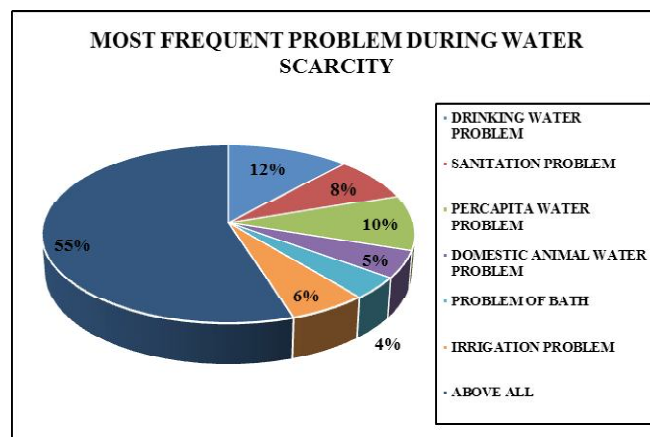


Fig: 18

Source: Primary Data, 2017

of selected blocks says there have not available water in the hand pump and well during the summer seasons. Because this time the ground water level decreases very much so maximum well and hand pump have not water. But 15% respondents says some of place water have available in the well and hand pump during summer seasons and they also told only deep well and hand pump have water but this amount is very few. The

diagram represent per head amount of water needs in one day here 5% respondent of selected blocks said their per head less than 5 liters water needs in one day, 80% people told their needs 5 liters to 10 liters. And 15% respondent replied their needs more than 10 liters in one day. Several water scarcity problems have been identified during primary survey. About 12 percent respondents said the fact that they are continuously facing drinking water shortage and 8 percent people from sanitation problem followed by 5 percent respondents support the fact that problem of domestication in the pond is another problem related to water scarcity. Therefore 55 percent respondents of Bankura district support above all the fact which could be predominant in nature.

Suggestive Measures for Water Scarcity in Selected CD Blocks in Bankura District

- 1) **Increasing Water Storage Capacity:** Activities such as farm ponds, percolation tanks, water reservoirs and construction of small and medium size dams and rivers can retain more surface water, while increasing the ground water recharge.
- 2) **Efficient Irrigation Practices:** Efficiency in irrigation is most essential and it remove the challenge of water crisis. So, at first need micro irrigation system start and do not use ground water for irrigation during the water scarcity.
- 3) **Watershed Development:** Development of watersheds is an important programme to make best use of the rainwater for agricultural production while improving soil conservation and biodiversity. So the Government of India needs to give top priority for watershed development to provide assured water supply of agriculture in rain fed areas.
- 4) **Control water pollution:** Excessive use of water for agriculture, industries and domestic uses is leading to water pollution, because such excess water is transformed into saline water, sewage or effluent. Thus, rewards and punishments should be introduced for persuading people to make optimum use of the precious water. Discharge of sewage and affluent into water bodies and rivers must be banned and recycling of waste water must be pursued and enforced. This will help in keeping the water sources clean and reducing the future demand for water. Treated sewage and effluent can be used for agriculture and industrial production.
- 5) **Research and Development:** There is a need for investing in

research related to ground water monitoring, weather forecasting, breeding water efficient and drought resistant crops and varieties which can cope up with the changing climatic conditions, arising due to global warming.

Conclusion

At the end of the discussion it can be concluded that, water scarcity affects all social and economic sectors and threatens the sustainability of the natural resources base. Addressing water scarcity calls for an interdisciplinary and multidisciplinary approach to water resources management, one that ensures the coordinated development and management of water and related resources in order to maximize economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems. Integration across sectors is needed. Furthermore, protecting and restoring the ecosystems that naturally capture, filter, store and release water, such as rivers, wetlands, forests and soils, is crucial to increasing the availability of water of good quality. Finally by considering the above all facts related to importance of water, impacts of scarcity of water and sustainable water use it is essential to work hand to hand of people of all section of Bankura, governmental organisation, non-governmental organisation in a holistic manner to secure the water for future generation and to protect the natural ecosystem of world.

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10

Ground Water Prospecting using Remote Sensing and GIS in Champhai District, Mizoram, India

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Abstract

Rapid increase in human population and growth of urban areas increase the demand for water supply. The availability of surface water in recent times is erratic and become more and more unreliable. Ground water is one of the major resources and the main available source of fresh water. Therefore, delineating ground water potential areas, monitoring and conservation of this crucial resource has become highly necessary. The present study aims in investigating ground water occurrence within Champhai district of Mizoram, India. This may facilitate the persistent crisis of water shortage. In this study, geographic information systems (GIS) and remote sensing data are utilized to detect the potential areas for ground water. Important geospatial factors which are responsible for the occurrence of ground water like land use / land cover, slope morphometry, geomorphology, lithology, geological structures like faults and lineaments within the district were identified. These important factors were treated as thematic layers and were assigned different ranks based on their relative importance in deriving the potentiality of ground water. Different classes within each thematic layer were assigned weights in ordinal rating from 1 to 10 as attribute information in the GIS environment. Summation of these attributes values and the corresponding rank values of the thematic

layers generate the final ground water potential map. The final map shows the different classes of ground water potential zones within the district which can be used for exploration, development and management of ground water resources.

Keywords: GIS, Remote Sensing, Ground water potential zones, Champhai district.

Introduction

Growth of population and consequent rapid urbanization increase the demand for water supply (Choudhary et al., 1996). Ground water is one of the most important natural resources and the largest reachable source of fresh water (Sharma and Kujur, 2012; Neelakantan and Yuvaraj, 2012; Kumar, 2013). Therefore, delineating ground water potential areas, monitoring and conservation of this crucial resource has become highly necessary (Rokade et. al., 2004; Kumar and Kumar, 2011).

The amount of rainfall in Mizoram is reasonably high. However, due to rugged and hilly topography, majority of rain water is lost as surface runoff causing shortage of water in the post-monsoon season. Springs are the major source of water in rural area of the state. Unfortunately, these are also depleted during the post monsoon period (Central Ground Water Board, 2007).

Mizoram comprises N-S trending ridges with steep slopes and narrow intervening synclinal valleys. Faulting in many areas have produced steep fault scarps (GSI, 2011). Hence, Champhai district also in general, experienced acute shortage of ground water as the monsoon rainfall is rapidly lost as surface runoff. Therefore, it is highly crucial to indentify ground water potential zones of the district so as to adopt proper measures for its conservation and development.

Few efforts were made to study ground water prospect zones within the state of Mizoram. These include Hydrogeological mapping of Aizawl city, Aizawl district (DG&MR, 2003) and Hydrogeological mapping of Champhai town, Champhai district (DG&MR, 2004).

Remote Sensing and GIS techniques allow swift and cost effective survey and management for natural resources (Ramakrishna et. al., 2013). Therefore, these techniques have wide-range applications in the field of geo-sciences including ground water prospecting (Jeganathan and Chauniyal, 2002; Anirudh, 2013). Interpretation of satellite data in combination with adequate ground truth information makes it possible to identify and outline various ground features such as geological structures,

geomorphic features and their hydraulic characteristics that may serve as indicators of the presence of ground water (Raju et al., 2013)

Therefore, many researchers have utilized these techniques successfully in ground water studies (Gustafsson, 1993; Saraf and Jain, 1994; Krishnamurthy and Srinivas 1995, Krishnamurthy et. al., 2000). The same techniques have been proved to be of immense value not only in the field of hydrogeology but also in water resources development as well. (Saraf and Choudhury, 1999; Sharma and Kujur, 2012).

The main purpose of the present study is to make use of several geo-spatial layers in delineating ground water prospective areas of Champhai district, to create vital database for future development and management of ground water within the district.

Study area

Champhai District is situated in the north eastern part of Mizoram, between $24^{\circ} 05' 03.99''$ and $23^{\circ} 00' 03.25''$ N latitudes and $93^{\circ} 00' 31.29''$ and $93^{\circ} 26' 17.66''$ E longitudes. It is bounded on the east by Myanmar (Burma), on the west by Aizawl and Serchhip Districts, on the north by

Manipur state and on the south by Serchhip District and Myanmar. The total geographical area of Champhai District is 3185.00 sq. km. It falls on Survey of India topo sheet nos. 84E/1, 84E/2, 84E/3, 84E/4, 84E/5, 84E/6, 84E/7, 84E/8, 83H/4 and 83H/8. The study area enjoys a moderate climate owing to its tropical location. It falls under the direct influence of the south west monsoon. As such the area receives an adequate amount of rainfall with an average annual rainfall of 2014.80 mm (Lalzarliana).

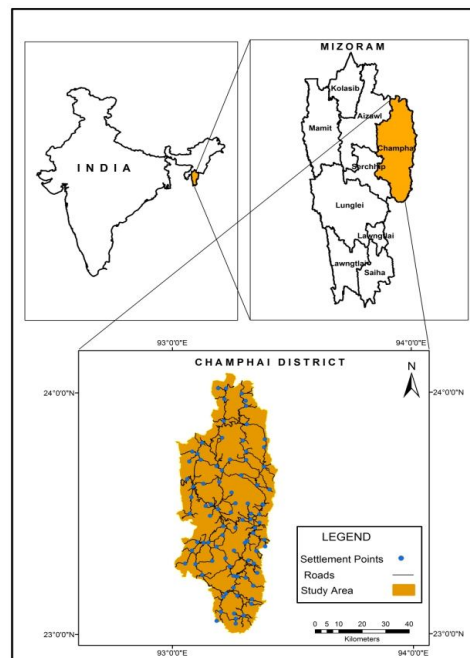


Figure 1: Location map of the study area

Materials and Methods

Data used

Indian Remote Sensing Satellite (IRS-P6) LISS III data having spatial resolution of 23.5m and Cartosat-I stereo-paired data having spatial resolution of 2.5m were used as the main data. SOI topographical maps and various ancillary data were also referred in the study.

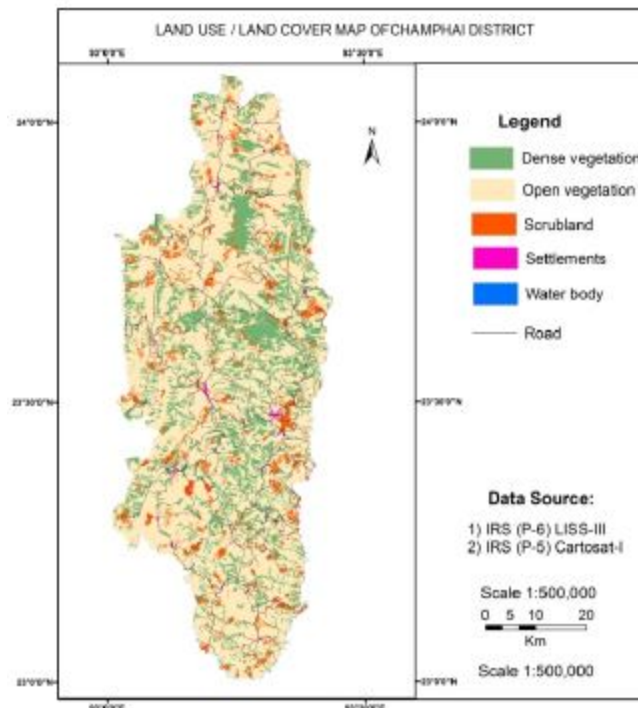


Figure 2: Land use/land cover map of the study area

Thematic Layer

Thematic layers like land use/land cover, slope, geomorphology, geology and lineaments were generated from remote sensing data. These layers were integrated in a Geographic Information System (GIS) environment and utilized for delineating ground water potential zones (Chaudary et al 1996; Kumar and Kumar, 2011). The different layers are as follows-

Land use Land Cover

Remote sensing and GIS techniques provide basic information for landuse mapping and play very significant role in determining land use pattern by visual interpretation (Sharma and Kujur, 2012). The study area was divided into four classes, viz., Dense Vegetation, Open Vegetation, Scrubland and Built-up areas. Water body occupies small part of the area.

Land use/land cover has a close relation with the sub-surface moisture content and water yielding capacity and plays an important role in facilitating natural ground water recharge to the aquifers (Anirudh, 2013; Sidhu and Rishi, 2014). Forest, pastures and grasslands are important for ground water recharge. Impermeable pavements and other structures due to urbanization act as obstacles to natural recharge process. Infiltration and runoff are greatly depending on land use/land cover. Recharge to ground water is high in the cultivable land and irrigated land compared to the wasteland and settlements. (Valliammai et al., 2013). Considering the above facts, weightage values were assigned for the different classes of land use/land cover of the area. The different land use / land cover classes in the study area are shown in Table 1 and Figure 2.

Table 1: Land use/land cover type and area covered

Land use Class	Area (Sq.Km.)	Percentage
Dense Vegetation	987.34	31.00
Open Vegetation	1946.89	61.13
Scrubland	224.74	7.06
Built Up	17.18	0.54
Waterbody	8.85	0.28
Total	3185.00	100.00

Slope

Slope map was generated from Digital Elevation Model (DEM) which is prepared utilising the Cartosat-I stereo-paired data in a GIS environment. The slopes of the area are represented in terms of degrees, and are divided into eight slope classes.

Gentle slope promotes water infiltration and ground water recharge whereas steep slopes acts as a high runoff zone (CGWB, 2000; Kumar, 2013; Al-Bakri1 and Al-Jahmany, 2013; Siddalingamurthy et. al., 2013). Weightage values were given in accordance with the steepness of the slope in such a way that areas having gentle slope were given high weightage

and those which are having steep slope were given less weightage. Slope classes and area covered are given in Table 2, and the slope map is shown in Figure 3.

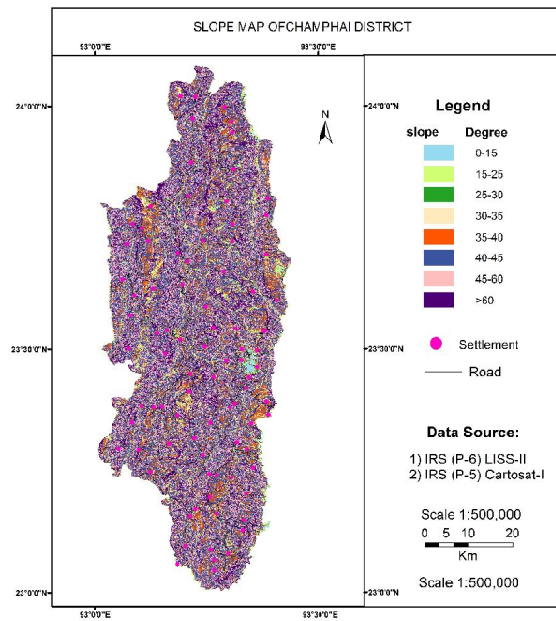


Figure 3: Slope map of the study area

Table 3: Slope classes and area covered

Slope (in degree)	Area (in sq km)	Percentage
0 – 15	16.05	0.50
15-25	193.01	6.06
25-30	5.20	0.16
30-35	129.72	4.07
35-40	352.79	11.08
40-45	1127.96	35.42
45-60	863.56	27.11
>60	496.72	15.60
Total	3185.00	100.00

Geomorphology

Geomorphology is one of the most important features in evaluating the ground water potentiality of an area (Valliammai et al., 2013, Raju et al., 2013). It is also highly helpful for selecting the artificial recharge sites as well (Ghayoumian et al., 2007).

The study area was comprises three main geomorphic units viz., structural hill, valley fill and flood plain. Structural hills were further divided into High, Moderate and Low structural hills with the elevation of above 1000m, 500-1000m and less than 500m above mean sea level respectively (MIRSAC, 2006). High elevated areas are less suitable for occurrence of ground water and following this pattern, weightage values were given to each of the geomorphic classes. Valley fills are considered to be the best potential areas (Edet et al., 1998; El-Baz, 1999). The area coverage of different geomorphic classes is given in Table 3 and Geomorphological map of the study area is shown in Figure 4.

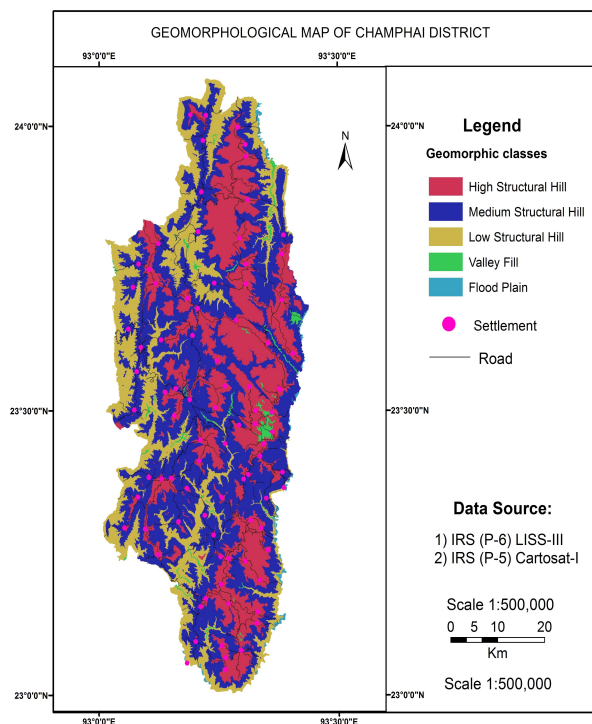


Figure 4: Geomorphological map of the study area

Table 3: Geomorphologic unit and area covered

Geomorphic Unit	Area (Sq.Km.)	Percentage
High Structural Hill	940.84	29.53
Medium Structural Hill	1501.63	47.15
Low Structural Hill	681.47	21.40
Valley Fill	43.17	1.36
Flood plain	17.89	0.56
Total	3185.00	100.00

Lithology

Mizoram comprises great flysch facies of rocks made up of monotonous sequences of shale and sandstone (La Touche, 1891). The study area lies over rocks of Barail Group, Lower Bhuban and Middle Bhuban formations of Surma Group of Tertiary age. Barail Group and Middle Bhuban formation of Surma Group consist mainly of argillaceous rocks while Lower Bhuban formation comprises mainly of arenaceous rocks (GSI, 2011).

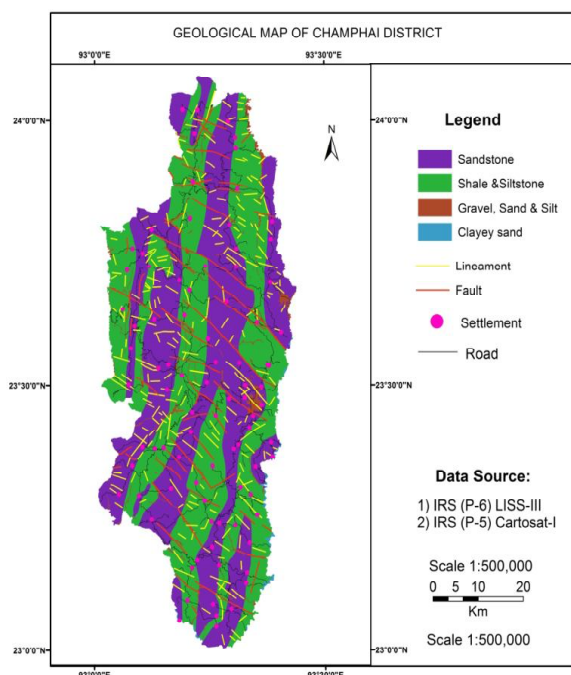


Figure 5: Geological map of the study area

Four litho-units have been established for the study area purely based on the exposed rock types. Detailed knowledge of lithology is an important factor in ground water exploration. In particular, the features to be considered are geological boundaries, porosity, etc (CGWB 2000; Al-Bakri1 and Al-Jahmany, 2013). It was considered that the unconsolidated material units offer more chance for the occurrence of ground water. Considering all these factors, the different lithological units were assigned weightage values. The lithological units and their area covered were given in Table 4.

Geological Structure

Lineaments like faults, fractures and joints can be delineate and analyse using Remote sensing data (Kanungo et al., 1995). The most obvious structural features that are important from the ground water point of view are the lineaments (Bhatnagar and Goyal, 2012). Lineaments provide the pathways for ground water movement and provide potential for ground water recharge (CGWB, 2000; Sankar, 2002). It was observed that the rocks exposed within the study area were traversed by several faults and fractures of varying magnitude and length (MIRSAC, 2006). The geological map of the study area is given in Fig. 5.

Table 4: Lithological units and area covered

Rock Types	Area (Sq. Km.)	Percentage
Sandstone	1538.10	48.29
Shale-Siltstone	1556.22	48.86
Gravel, Sand & Silt	10.52	0.33
Clayey sand	80.16	2.52
Total	3185.00	100

Data Analysis

Geo-spatial factors like land use/land cover, slope morphometry, geomorphology, lithology and geological structure are found to be playing significant roles for demarcating ground water potential zones within the study area. Based on their role in controlling the occurrence, storage and distribution of ground water, all the thematic layers were assigned different ranks (Kumar and Kumar, 2011). Individual classes in each thematic layer are carefully analysed so as to establish their relation in selecting suitable

areas for ground water occurrences. Weightage value is assigned for each class in such a manner that less weightage represents the least influence and more weightage having higher influence. The assignment of weightage value for the different categories within a parameter is done in accordance to their assumed or expected importance based on the apriori knowledge of the experts (Neelakantan and Yuvaraj, 2012). Limited ground information within the study area were also considered. All the thematic layers were integrated and analysed in a GIS environment using ARCINFO (10.1 version) to derive the final map. The scheme of giving weightages in the study is shown in Table 5.

Table 5: Ratings for Parameters on a scale of 1-10

Parameter	Rank (in %)	Category	Weight
Lithology	15	Sandstone	8
		Shale - Siltstone	4
		Gravel, Sand & Silt	10
		Clayey sand	5
Land Use / Land Cover	10	Dense Vegetation	8
		Open Vegetation	5
		Scrubland	3
		Built-up	1
Slope Morphometry (in degrees)	25	0 - 15	9
		15-25	8
		25-30	5
		30-35	4
		35-40	3
		40-45	2
		45-60	1
		> 60	0
Structure (Faults and Lineaments)	25	10m Length of Buffer distance on either side	10
Geomorphology	25	High Structural Hill	1
		Medium Structural Hill	4
		Low Structural Hill	7
		Valley Fill	10
		Flood Plain	10

Results

Integrating all the controlling parameters by giving different weightage value for all the themes, the final map is prepared and categorized into 'Very good', 'Good', 'Moderate', and 'Poor' potential zones. The output map is generated on a scale of 1: 50,000. Various classes are described below:

Very good

This zone includes valley fill, flood plains and low-lying areas. Besides, it includes the intersection of lineaments such as faults, fractures and joints. These geological structures offer channels for the sub-surface flow of water. Ground water can easily move through these fractures, and are found to be highly prospective areas. Lithologically, this zone usually comprises areas where unconsolidated sediments, such as gravel, sand, silt and clayey sand are deposited. These have a high potentiality of retaining water since they allow maximum percolation due to their maximum pore spaces between the grains. This zone spreads over an area of about 325.63sq. km., and forms 10.22per cent of the study area.

Good

All the remaining geologically structure controlled areas fall under the Good potential zone. Other low lying and gentle slopes areas are also included. This is because low and gentle relief areas have much better opportunities for infiltration and subsequent yield of ground water. Sandstones are generally capable of storing and transmitting water through their interstices and pore spaces present in between the grains, and are considered to be suitable aquifer. Hence, parts of areas where sandstones are exposed also come under this zone. This zone spreads over an area of about 754.16 sq. km., and forms 23.68 per cent of the study area.

Moderate

This zone mainly comprises areas where the recharge condition and the water-yielding capacity of the underlying materials are neither suitable nor poor. Topographically, it covers gently sloping smooth surface of the hill. Although the lithology may comprise good water-bearing rock formation such as sandstone, the potentiality is minimized by the sloping nature of the topography where there is maximum run-off. In general, the moderate zone falls within the poor water-bearing rock formation such as silty shale that is, in turn, characterized by the presence of secondary structures in them. The Moderate zone is evenly distributed within the

study area and covers an area of 933.29 sq. km., and occupies 29.30 per cent of the total study area.

Poor

This zone is mainly distributed in the elevated areas. In the area of high relief, a greater part of precipitation flows out as surface run-off, which is a poor condition for infiltration beneath the ground surface. Hence, the ground water yield is generally assumed to be low. Unless the elevated areas are traversed by geological structures, and possess high drainage density and suitable water-bearing rock formation, their ground water yield is generally low. The Poor zone is mainly distributed along the ridges. This zone is predominantly high in terms of aerial extend, and covers majority of the study area. This zone occupies an area of about 1171.92 sq. km., which is 36.80 per cent of the total study area.

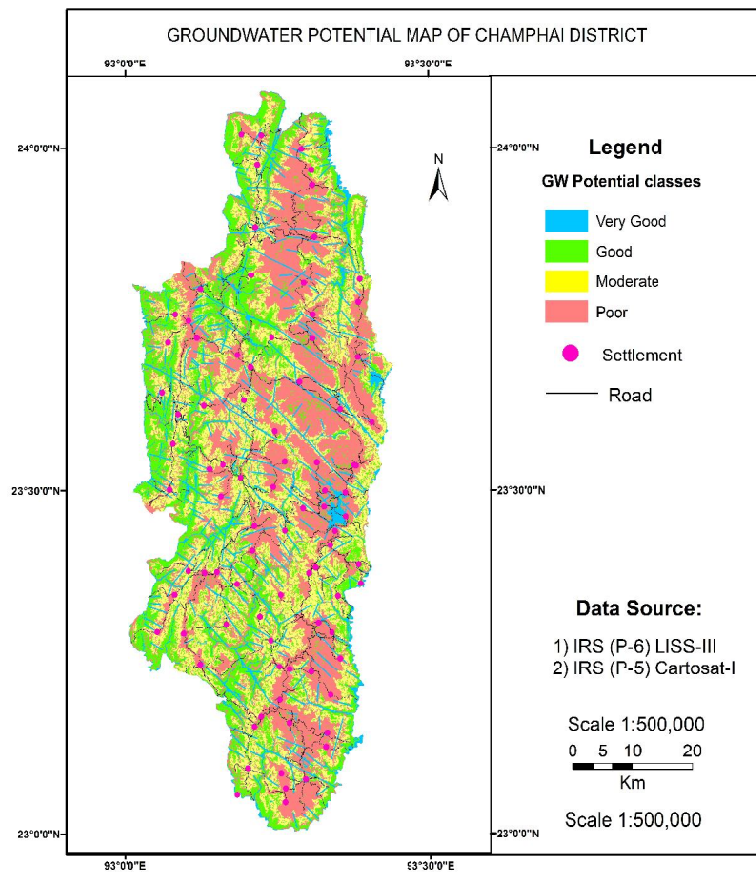


Figure 6: Ground water potential map of the study area

Table 6: Ground water Potential areas

Potential Zone	Area (in Sq. Km.)	Percentage
Very Good	325.63	10.22
Good	754.16	23.68
Moderate	933.29	29.30
Poor	1171.92	36.80
Grand Total	3185.00	100

Conclusion

The present study has proven that geo-environmental factors like land use/ land cover, slope, geomorphology, lithology and geological structure are vital parameters for selecting suitable areas for ground water exploitation. The study also shows that remote sensing and GIS techniques can be utilized as vital tools in delineating ground water potential zones.

The final map prepared through the present study shows detailed idea about ground water potentiality of the area. This, can therefore, forms an important database for developmental activities, and also for identifying critical areas for implementing ground development and management programme.

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11

Conservation and Sustainable use of Biological Diversity by the Instrumentality of Biological Diversity Act, 2002 with Special Reference to North East India

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Abstract

Biological diversity is the variability among living organisms from all sources and the ecological complexes of which they are part and includes diversity within species or between species and ecosystems. Conservation of biological diversity, sustainable use of its components and fair and equitable sharing of the benefits arising out of the use of biological resources are the upmost important goals for survival of present and future generations. Law is an effective instrument to bring these goals. The Biological Diversity Act, 2002 is enacted to achieve these goals. India is a party to the UN Convention on Biological Diversity, 1992. In order to achieve these goals, the National Biodiversity Authority, State Biodiversity Board and Biodiversity Management Committee are established at National, State and local levels. Apart from this Central Government of India is also duty bound to discharge certain specific functions under the scheme of the Act. Exemplary penalties are also provided for contravention of the provisions of the Act to bring. In this aspect, the paper will peruse the effectiveness and *modus operandi* of this legislation in conserving, sustainability and equitable sharing of biological diversity in this fragile region of North East India in the light of judicial pronouncement, international standard and law of the land.

Keywords: Biological diversity, conservation of biological diversity, sustainable use, equitable sharing, and biological resources

Introduction

“Biological diversity” means the variability among living organisms from all sources and the ecological complexes of which they are part and includes diversity within species or between species and ecosystems. It comprises diversity at three levels: genetic diversity (within species), species diversity (between species) and ecosystem diversity. It is important for life on Earth and is one of the pillars of sustainable development. In recent decades, degradation of habitats, pollution and unsustainable use of biological diversity have led to loss of species, thus jeopardizing present and future livelihoods.

India is one of the 17 mega-biodiversity countries with 2.4 per cent of the global land area and 4 per cent of water. It accounts for 7 to 8 per cent of the recorded species of the world. India is also rich in cultural diversity and in traditional knowledge available with tribal communities.

The Government of India on recognizing the potential threats and consequences to biodiversity and as a signatory to the Convention on Biological Diversity enacted “the Biological Diversity Act” in 2002.

Methods and Materials

The researcher adopted collaborative legal research methodology in particular its doctrinal and empirical components. In order to undertake this academic exercise, the researcher formulate research problems concerning conservation and sustainable use of biodiversity related scientific findings and its ways and means of implementation of legal provisions by employing case study and analytical legal method of thought process after a brief review of literature in the field. Primary sources like case law, legal documents, available scientific data, conference proceedings and secondary sources like commentary by authoritative experts and juristic writings are used in the process. And finally, come to generalization and interpretation of the study by tools of legal reasoning through induction, deduction, and analogy and dialectical reasoning.

Result and Discussion

A brief commentary on the result of this academic exercise suffices as separate headings and sub-headings and analytical discussion of the matter.

International law on Biodiversity

The most important law on biodiversity is the Convention on Biological Diversity (CBD). The CBD was opened for signature at the Earth Summit in Rio de Janeiro on 5 June 1992 and entered into force on 29th December 1993. All UN member states – with the exception of the United States – have ratified the treaty (Wikipedia, 2017).

The Convention recognized for the first time in international law that the conservation of biodiversity is “a common concern of humankind” and is an integral part of the development process. It has three main goals including: the conservation of biodiversity; the sustainable use of its components; and the fair and equitable sharing of benefits arising from genetic resources. It covers all ecosystems, species and genetic resources. It links traditional conservation efforts to the economic goal of using biological resources sustainably.

The Convention offers decision-makers guidance based on precautionary principle which demands that where there is a threat of significant reduction or loss of biological diversity, lack of full scientific certainty should not be used as reason for postponing measures to avoid or minimize such a threat. It also banned some forms of geo-engineering.

The Convention’s governing body is the Conference of the Parties (COP), consisting of all governments (and regional economic integration organizations) that have ratified the treaty. The COP reviews progress under the Convention, identifies new priorities, sets work plans for members, makes amendments to the Convention, create expert advisory bodies and collaborate with other international organizations and agreements. The 13th meeting of COP was concluded in Cancun, Mexico between 2 and 17 December, 2016.

The Convention obliges signatory nations to undertake an inventory of their biodiversity to provide basic information about its distribution and abundance. The Convention requires countries to prepare a national biodiversity strategy (or equivalent instrument) and to ensure that this strategy is mainstreamed into the planning and activities of all those sectors whose activities can have an impact (positive and negative) on biodiversity. As on 01-02-2012, 173 Parties have developed National Biodiversity Strategies and Action Plans (NBSAPs) in line with Article 6 of the Convention (Wikipedia, 2017). In addition, in accordance with Article 26 of the Convention, Parties prepare national reports on the status of implementation of the Convention.

The Cartagena Protocol on Bio-safety (CPB) was adopted in Montreal, Canada, on January 30, 2000 by delegates of 128 parties to the CBC and it entered into force on 11 September 2003. CPB regulates the trans-boundary movements of some genetically modified organisms (GMOs) and calls for precautionary principles (PP) by confirming the rights to take action if there is suspicion of any potential environmental damage. Minimum standard of risk assessment and safety measures for trans-boundary movement of GMOs can now be set using CPB. The Protocol can only be effectively used with appropriate national regulation. In addition to it, on 29 October 2010, the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity was adopted as a supplementary agreement to the Convention. The Protocol entered into force on 12 October 2014. It provides a transparent legal framework for the effective implementation of one of the three objectives of the CBD: the fair and equitable sharing of benefits arising out of the utilization of genetic resources, thereby contributing to the conservation and sustainable use of biodiversity.

Apart from this law other relevant law concerning different aspect of conservation and sustainable use of biodiversity are:

- Convention on the Conservation of Migratory Species of Wild Animals
- Convention on the International Trade in Endangered Species of Wild Flora and Fauna
- Convention on Wetlands of International Importance, especially as Waterfowl Habitat
- International Treaty on Plant Genetic Resources for Food and Agriculture
- Migratory Bird Treaty Act of 1918
- UN Convention to Combat Desertification
- World Heritage Convention, 1977

The Biological Diversity Act, 2002

India is a party to the CBD and accordingly India is one of first few countries to have enacted legislation like Biological Diversity Act, 2002.

The primary aim of the Act is to provide for conservation of biological diversity, sustainable use of its components and fair and equitable sharing of the benefits arising out of the use of biological resources, knowledge and for matters, connected therewith or incidental thereto.

Sustainable use in the Act means the use of components of biological diversity in such manner and at such rate that does not lead to the long-term decline of the biological diversity thereby maintaining its potential to meet the needs and aspirations of present and future generations (Sec. 2(e)).

The Act is implemented at national, State and local levels through a decentralized three tier system. At the National level, the National Biodiversity Authority was established by Government of India under Section 8 of the Act. At the State level, State Biodiversity Boards are established by the State Governments as per Section 22 of the Act, while at local level the Biodiversity Management Committees are constituted by the Local Bodies as per Section 41 of the Act.

The Act aims to regulate the access to biological diversity under Sections 3 to 7. To achieve its aim the following prohibitions have been imposed –

- (a) No person (citizen of India, NRI and body corporate) shall undertake biodiversity related activities without the approval of the National Authority (Section 3).
- (b) No person shall transfer to a foreigner/NRI/body corporate not registered in India, any result of any research relating to any biological resources (Section 4).
- (c) Application for intellectual property rights not to be made without the approval of the National Biodiversity Authority inside India or outside India (Section 6).
- (d) Prior intimation must be given to the State Biodiversity Board for obtaining biological resource for commercial utilization (Section 7). (This provision is not applicable to local people and community area, including growers and cultivators of biodiversity, *Vidas & Hakims*, practicing indigenous medicine.)

The National Biodiversity Authority (NBA)

The NBA is an autonomous and statutory body under the Ministry of Environment, Forest and Climate Change performing enabling/

facilitative, regulatory and advisory role to relevant agencies and Ministries of Govt. of India (GOI) on issues of conservation of biodiversity, its sustainable use and ensuring fair and equitable sharing of benefits arising out of such use. The NBA operates through consultative process involving expert committees and stakeholders.

The NBA was established in 2003 with its head office at Chennai and it is headed by a Chairperson who is an eminent person in the field of conservation and sustainable use of biological diversity with 10 *ex-officio* members from related Ministries and five non-official members who are Scientists/Specialists appointed by the Government.

The functions of NBA include:

- Create an enabling environment, as appropriate, to promote conservation and sustainable use of biodiversity.
- Advise the GOI on matters relating to conservation of biodiversity, sustainable use of its components and fair and equitable sharing of benefits arising out of utilization of biological resources.
- Regulate activities and issue guidelines for access to biological resources and for fair and equitable benefit sharing in accordance with the Sections 3, 4 and 6 of the Act. Certain individuals/ nationals/ organizations require prior approval of NBA for obtaining biological resources and/or associated knowledge for use.
- Take necessary measures to oppose the grant of intellectual property rights in any country outside India on any biological resource obtained from India or knowledge associated with biological resources derived from India without following the due procedure provided in the Act.
- Advise the State Governments in the selection of areas of biodiversity importance to be notified as heritage sites and suggest measures for their management.
- The NBA and State Biodiversity Boards provide guidance and technical support to Biodiversity Management Committees for documenting People's Biodiversity Registers.
- Perform such other functions as may be necessary to carry out the provisions of the Act.

State Biodiversity Boards (SBBs)

The SBBs are established by the State Governments by official gazette notification in accordance with Section 22 of the Act. For the Union Territories, NBA or its authorized body exercises the powers and functions of SBB.

The SBBs are structured with a Chairperson as the head, five *ex-officio* members representing the concerned departments and five members appointed from experts in matters relating to conservation of biological diversity, sustainable use of biological resources and fair and equitable sharing of benefits arising out of the use of biological resources.

The functions of SBBs include:

- Advising the State Governments, subject to guidelines issued by the Central Government, on matters relating to conservation of biodiversity, sustainable use of its components and fair and equitable sharing of benefits arising out of utilization of biological resources.
- Regulating by granting approvals or otherwise, the request for commercial utilization or bio-survey and bio-utilization of any biological resource by Indians (S. 24).
- Performing such other functions as necessary to carry out the provisions of the Act or as prescribed by the State Governments (Sec. 23).

So far, 28 States have established the Biodiversity Boards and 15 States have notified the Rules as of March 2014 (NBA, 2013-2014:17).

Biodiversity Management Committees (BMCs)

According to Section 41 of the Act, every local body shall constitute the BMC within its area of jurisdiction for the purpose of promoting conservation, sustainable use and documentation of biological diversity including preservation of habitats, conservation of landraces, folk varieties and cultivars, domesticated stocks and breeds of animals and micro-organisms and chronicling of knowledge relating to biological diversity. “Local bodies” means Panchayats and Municipalities, by whatever name called, within the meaning of clause (1) of article 243B and clause (1) of article 243Q of the Constitution and in the absence of any Panchayats or Municipalities, institutions of self-government constituted under any other provision of the Constitution or any Central Act or State Act (Sec. 2(h)).

BMC is constituted as per Rule 22 of the Biological Diversity Rules, 2004. It consists of a Chairperson and not more than six persons nominated by the local body, of whom not less than one-third should be women and not less than 18% should belong to SCs/STs.

The functions of BMCs include:

- Preparing, maintaining and validating People's Biodiversity Register in consultation with the local people.
- Maintaining a Register giving information about the details of access to biological resources and traditional knowledge about the collection fee imposed and the benefits received and the mode of their sharing.
- Advising on any matter referred to it by the SBB or Authority for granting approval and to maintain data about the local vendors and practitioners using the biological resources.

So far 34,135 BMCs (as on 31st March, 2014) have been constituted across India. National guidelines for BMC are being finalized to facilitate effective functioning of the BMCs. So far, only two states have notified BMC Guidelines and Rules (NBA, 2013-2014:18).

Biodiversity Fund

National, State and Local level biodiversity funds are established under Sections 27, 32 and 43 of the Act respectively. The funds are intended for channeling benefits to *bonafide* claimers and for conservation and promotion of biological resources and / or the associated knowledge and socio-economic development of these areas (NBA:2012). "Benefit claimers" means the conservers of biological resources, their by-products, creators and holders of knowledge and information relating to the use of such biological resources, innovations and practices associated with such use and applications (Sec. 2(a)).

People's Biodiversity Registers (PBRs)

The main function of the BMC is to prepare PBR in consultation with local people. The Register shall contain comprehensive information on the availability and knowledge of local biological resources, their medicinal or any other use or any other traditional knowledge associated with them.

The PBRs focus on participatory documentation of local biodiversity, traditional knowledge and practices. They are seen as key

legal documents in ascertaining the rights of local people over the biological resources and associated traditional knowledge (NBA: 2012).

NBA issued PBR Guidelines in 2009 and revised Guidelines in 2013. All aspect of PBR must be in compliance with the revised Guidelines.

Biodiversity Heritage Sites (BHS)

Under Section 37 of the Act, the State Government in consultation with local bodies may notify in official gazette, areas of biodiversity importance as Biodiversity Heritage Sites. The NBA issued guidelines for the selection and management of BHS in 2009.

Areas having any of the following characteristics may qualify for inclusion as BHS (NBA: 2012):

- Areas that contain a mosaic of natural, semi-natural, and manmade habitats, which together contain a significant diversity of life forms.
- Areas that contain significant domesticated biodiversity component and/or representative agro ecosystems with ongoing agricultural practices that sustain this diversity.
- Areas that are significant from a biodiversity point of view as also are important cultural spaces such as sacred groves/trees and sites, or other large community conserved areas.
- Areas including very small ones that offer refuge or corridors for threatened and endemic fauna and flora, such as community conserved areas or urban greens and wetlands.
- All kinds of legal land uses whether government, community or private land could be considered under the above categories.
- As far as possible those sites may be considered which are not covered under Protected Area network under the Wildlife Protection Act, 1972 as amended.
- Areas that provide habitats, aquatic or terrestrial, for seasonal migrant species for feeding and breeding.
- Areas that are maintained as preservation plots by the research wing of Forest department.
- Medicinal Plant Conservation Areas.

Roles of the Central and State Governments

The roles to be performed by the Central and States Governments

are very important and significant under the Act. As per Section 36 of the Act the important duties of the Central and State Governments are:

- Developing national strategies, plans, programmes for the conservation, promotion and sustainable use of biological diversity.
- Issuing directives to the concerned State Governments to take immediate ameliorative measures for protection of biodiversity or resource rich habitats, threatened by overuse, abuse or neglect.
- Integrating of the conservation, promotion and sustainable use of biological diversity into relevant sectoral or cross-sectoral plans, programmes and policies. Endeavor to respect and protect the knowledge of local people relating to biological diversity, as recommended by the NBA, including the registration of such knowledge at local level.
- Assessing the impact of projects on environment and biodiversity, and regulate, manage or control the risks or adverse impact of use and release of living modified organisms on conservation; and sustainable use of biological diversity and human health.

The Central Government may, in consultation with NBA:

- (a) notify threatened species and prohibit or regulate their collection, rehabilitation and conservation (Sec. 38);
- (b) designate institutions as repositories for different categories of biological resources (Sec. 39). Such repository shall keep in safe custody the biological material including voucher specimens. ; and
- (c) exempt certain biological resources as normally traded as commodities.

State Governments, in consultation with the local bodies, may notify biodiversity heritage sites, and frame Rules for management and conservation of the entire heritage sites (in consultation with Central Government) and launch schemes for compensation/rehabilitation of affected people.

Benefit sharing

“Fair and equitable benefit sharing” means sharing of benefits as determined by the NBA under Section 21 of the Act. Benefit sharing out of usage of biological resources can be done in manner as provided in Section 21(2) of the Act.

Penalties under the Biological Diversity Act, 2002

Whoever contravenes or attempts to contravene or abets the contravention of Section 3 (to obtain biological resources with the permission of the NBA), Section 4 (results of research not to be transferred to a foreigner or NRI without the permission of the NBA), Section 6 (application of intellectual property right not be made without the approval of the NBA) shall be punished with imprisonment which may extend to five years, or with fine up to ten lakh rupees, and where the damage caused exceeds ten lakh rupees such fine may commensurate with damage caused, or with both.

If a person obtains biological resources for commercial purpose without the permission of the SBB, he will be punishable with imprisonment which may extend to three year, or with fine up to five lakh rupees, or with both (Sec. 55). If any of the offences is committed by a company or with the consent or connivance of or is attributable to any neglect on the part of any manager, secretary or other officer, they will be deemed guilty and punishable as per provisions mentioned above (Sec. 56).

The provisions of this Act shall be in addition to, and not in derogation of the provisions in any other law, for time in force, relating to forests and wildlife (Sec. 59). In addition, no court shall take cognizance of any offence under this Act except on complaint made by

- (a) the Central Government or any authority or officer authorized in this behalf by the Government, or
- (b) any benefit claimer who has given notice of not less than thirty days in the prescribed manner of such offence and of intention to make complaint, to the Central Government or the Authority or officer authorized as aforesaid (Sec. 61).

Any offence under this Act is non-bailable and cognizable (Sec. 58).

To implement the BD Act, 2002, Rules have been notified in 2004.

List of Biodiversity Related Acts and Rules

Following table summarizes the list of Acts and Rules relating to biodiversity conservation and sustainable use of it and related matters.

Table No. 1: Biodiversity related Acts and Rules till date

Sl. No.	Acts and Rules
1.	The Fisheries Act, 1897
2.	The Destructive Insects and Pests Act, 1914
3.	The Indian Forest Act, 1927
4.	The Agricultural Produce (Grading and Marketing) Act, 1937
5.	The Indian Coffee Act, 1942
6.	The Import and Export (Control) Act, 1947
7.	The Rubber (Production and Marketing) Act, 1947
8.	The Tea Act, 1953
9.	The Mining and Mineral Development (Regulation) Act, 1957
10.	The Prevention of Cruelty to Animals Act, 1960
11.	The Customs Act, 1962
12.	The Spices Board Act, 1986
13.	The Seeds Act, 1966
14.	The Patents Act, 1970
15.	The Marine Products Export Development Authority Act, 1972
16.	The Wildlife (Protection) Act, 1972 and its Amendment Act of 1991
17.	The Water (Prevention and Control of Pollution) Act, 1974
18.	The Tobacco Board Act, 1975
19.	The Territorial Water, Continental Shelf, Exclusive Economic Zone and other Maritime Zones Act, 1976
20.	The Water (Prevention and Control of Pollution) Cess Act, 1977
21.	The Maritime Zones of India (Regulation and Fishing by Foreign Vessels) Act, 1980
22.	The Forest (Conservation) Act, 1980
23.	The Air (Prevention and Control of Pollution) Act, 1981
24.	The Agricultural and Processed Food Products Export Development Authority Act, 1985
25.	The Environment (Protection) Act, 1986
26.	The Spices Act, 1986
27.	The National Dairy Development Board Act, 1987

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28. Rules for the manufacture, use/import/export and storage of hazardous microorganism/genetically engineered organisms or cells, 1989
 29. The Foreign Trade (Development and Regulation) Act, 1992
 30. The Protection of Plant Varieties and Farmer's Rights Act, 2001
 31. The Biological Diversity Act, 2002
 32. Plant Quarantine (Regulation of Import into India) Order, 2003
 33. The Biological Diversity Rules, 2004
 34. The Food Safety and Standards Act, 2006
 35. The Scheduled Tribes and other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006
 36. The National Green Tribunal Act, 2010 Insertion of new Section 52A in BD Act, 2002
 37. Guidelines for International Collaboration Research Projects involving Transfer or Exchange of Biological Resources or information relating thereto between Institutions including Government sponsored Institutions and such Institutions in other countries, 2006
 38. Guidelines on Access to Biological Resources and Associated Knowledge and Benefits Sharing Regulations, 2014
 39. Exemption of Crops listed in the Annex I of the International Treaty on Plant Genetic Resources for Food and Agriculture from seeking approval of NBA under Sections 3 and 4 of the BD Act, 2002 (Notification dt. 17.12.2014)
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(Based on compilation of NBA)

These various central Acts and Rules are supported by a number of state laws and statutes concerning forests and other natural resources.

North East India Chapter on Implementation of Biological Diversity Act, 2002

Northeast India is composed of eight states viz. Assam, Arunachal Pradesh, Nagaland, Meghalaya, Manipur, Mizoram, Tripura and Sikkim. The region holds great significance from ecological and evolutionary point of view.

This region is rich in biodiversity and harbours largest number of endemics and Schedule I species as compared to any other part of India (MacKinnon & MacKinnon, 1986). This region represents a confluence of the Indo-Malayan and Indo-Chinese bio-geographical realms. Also, it exhibits intermixing of the Himalayan and Peninsular Indian elements. The region was considered a cradle of flowering plants and highly

evolutionary activities (Indiaenvironmentalportal.org). According to recent studies by Roy (2012) the NE India, despite various anthropogenic pressures, has still stands one of the highest biodiversity ranking areas in the country. Biodiversity conservation initiatives in NE India may be summed up as:

Protected Area (PA) Network

Government of India has launched different programmes from time to time for the *in situ* conservation of biodiversity through protected area networks. Through protected area network, the country has 96 national parks, 603 wildlife sanctuaries including 18 biosphere reserves which cover about 4.8% of the geographical area of the country (Tripath, 2016:7). Following Table shows a list of protected area networks in different states of NE India.

Table No. 2: Protected areas in Northeast region of India

Sl. No.	State	Total Protected Area (Km ²)	No of Biospheres	No of National Parks	No. of Wildlife Sanctuary	No. of Tiger Reserves
1.	Arunachal Pradesh	5000	1	2	11	2
2.	Assam	3010	1	5	18	3
3.	Manipur	2500	-	1	1	-
4.	Meghalaya	3500	2	2	3	-
5.	Mizoram	2200	-	2	8	1
6.	Nagaland	2250	-	1	3	-
7.	Sikkim	4500	1	1	7	-
8.	Tripura	1600	-	2	4	-
9.	Total	24560	5	16	55	6

(Source: India State of Forest Report (2011), Forest Survey of India)

It is found that the PA coverage in the NEI (7.6%) is higher than the national average (4.75%). The existing figures of PAs are apparently indicative of the satisfactory state of network system for conservation of representative ecosystems in the region. It is also found that most of the protected areas are having small size and are under the pressure because of the use and abuse of resources by the neighbouring human settlements.

Biosphere Reserves (BRs)

Besides the legally designated PAs, the NE region of India is well

represented under coverage of BRs. A total of five BRs to conserve the representative habitats, biota and to support the harmonious co-existence of man and nature have been established in the NE region. The BRs in NEI are highlighted in the following table:

Table No. 3: Biosphere Reserves in NE India

Sl. No.	Name of the Biosphere Reserve	Area (in Km ²)	Location
1.	Dehang-Dibang	5111.50 (Core 4094.80 & Buffer 1016.70)	Part of Siang and Dibang Valley in Arunachal Pradesh
2.	Dibru-Saikhowa	765(Core 340 & Buffer 425)	Part of Dibrugarh and Tinsukia Districts (Assam)
3.	Khangchendzonga	2619.92(Core 1819.34 & Buffer 835.92)	Parts of Khangchendzonga hills and Sikkim
4.	Manas	2837(Core 391 & Buffer 2,446)	Part of Kokrajhar, Bongaigaon, Barpeta, Nalbari, Kamrup and Dabang districts (Assam)
5.	Nokrek	820(Core 47.48 & Buffer 227.92, Transition Zone 544.60)	Part of Garo hills (Meghalaya)

(Source: indiaenvironmentalportal.org)

Ramsar Sites

Among others, three wetlands (i.e. Deepor Beel – Assam, 4000 ha; Rudrasagar Lake – Tripura, 240 ha; Loktak Lake – Manipur, 2600 ha) with global significance in NE region have been listed as Ramsar sites (ramsar.org).

People's Biodiversity Register (PBR)

The following table shows status of model PBR under the provision of the Act in the different states of India.

Table No. 4: Model People's Biodiversity Register

Sl. No.	State	No of People's Biodiversity Register
1.	Andhra Pradesh	28
2.	Arunachal Pradesh	-
3.	Assam	6
4.	Bihar	-

5.	Chattisgarh	7
6.	Goa	-
7.	Gujarat	133
8.	Himachal Pradesh	-
9.	Haryana	-
10.	Jharkhand	11
11.	Jammu & Kashmir	-
12.	Karnataka	468
13.	Kerala	758
14.	Madhya Pradesh	704
15.	Maharashtra	37
16.	Manipur	10
17.	Meghalaya	-
18.	Mizoram	3
19.	Nagaland	-
20.	Odisha	76
21.	Rajasthan	-
22.	Punjab	-
23.	Sikkim	-
24.	Tamil Nadu	-
25.	Telangana	9
26.	Tripura	126
27.	Uttar Pradesh	11
28.	Uttarkhand	22
29.	West Bengal	76
	Total	2,485

Last updated on 02/09/2015 (Source: NBA: 2015)

From the table, it is found that Arunachal Pradesh, Meghalaya, Nagaland and Sikkim has nil Register and other States of NE region India also have comparatively very less in numbers except Tripura.

Agro-Biodiversity Hotspots (ABHs) of India

There are 22 such hotspots in India, out of which four are concerned of NE India. The following table listed Hotspots in NE India.

Table No.5: Agro-biodiversity Hotspots of NE India

Sl. No.	Hotspot Region	Areas Covered
3.	Eastern Himalayan	All the districts of Arunachal Pradesh, Sikkim and Darjeeling district of West Bengal
4.	Brahmaputra Valley	Dhubri, Kokrajhar, Bongagaon, Barpeta, Nalbari, Goalpara, Kamrup, Golaghat, Darrang, Morigaon, Nagaon, Sonitpur, Jorhat, Lakhimpur, Sibsagar, Dibrugarh, Dhemaji and Tinsukia
5.	Khasi-Jaintia-Garo Hills	All the seven districts of Meghalaya, i.e. Eastern Garo Hills, Western Garo Hills, South Garo Hills, East Khasi Hills, West Khasi Hills, Jaintia Hills and Ri-Bhoi
6.	North-Eastern Hills	All the districts of Manipur, Mizoram, Nagaland, Tripura and the adjoining Cachar and North Cachar districts of Asom

(Source: PPVFRA, New Delhi)

The table shows that most of region of NE India are under ABHs of India.

State Biological Diversity Rules

In exercise of powers conferred under Section 63 of the Act, any State Government may make rules prescribing provisions for implementation of the Act in the concerned State. It is a commendable that all the States of NE India framed the Rules concerning Biological Diversity in their respective areas.

Species of Plants and Animals which are on the Verge of Extinction

In exercise of the powers conferred by Section 38 of the Act, the Central Government, in consultation with the State Govt. notifies the species of plants and animals which are on the verge of extinction for the concerned State. Moreover, the collection of the species of plants and animals listed in the notification are prohibited, except with the approval of the concerned State Biodiversity Board (SBB) only for the purposes viz. (a) scientific research, (b) herbarium and museum of scientific and academic institutions, (c) propagation, and (d) any other scientific investigation. In addition to this, the concerned SBB are also undertaken–

- (i) studies on all aspects of the notified species for holistic understanding;
- (ii) propagation of the notified species for the purpose of *in situ* and *ex situ* conservation and rehabilitation; and
- (iii) awareness programmes and provide educational materials on notified species for forest department personnel, Biodiversity Management Committees, ecotourism programmes, and forest dwellers and tribals.

Table 6: Notification concerning species of plants and animals which are on the verge of extinction in NE India

State	Date of Notification	No. of Plants	No. of Animals
Meghalaya	30 th September, 2009	6	5
Mizoram	30 th September, 2009	8	8
Tripura	3 rd February, 2011	1	2
Manipur	26 th October, 2012	5	6

(Compiled from Ministry of Environment, Forest & Climate Change Notifications)

It is found that concerning Assam, Arunachal Pradesh, Nagaland and Sikkim there is no notification under the Act concerning species of plants and animals which are on the verge of extinction. It does not mean that there is no species of such in the above mention States. This much be seriously taken into account.

Conclusion

In the final analysis, the very survival of the human race is dependent on conservation of biodiversity. It is evident that this invaluable heritage is being destroyed at an alarming rate due to several reasons. Measures including enactment of proper legislation are being taken up at national and international levels to address this issue. In case of India, the BD Act, 2002 is an important instrument to conserve and sustainable use of biodiversity in India.

The need of the hour is conservation and sustainable use of biodiversity as an integral component of economic development. It is being recognized that no legal provisions can be effective unless local communities are involved in planning, management and monitoring conservation programmes.

In this regard several critical needs which need to be addressed

immediately to secure better progress in implementation of Biological Diversity Act in NE India prominent among which are:

- The Act supposedly empowers the BMCs to take decisions on conservation and control. However the Rules severely dilute this and state that the main role and function of the BMC is to merely maintain Peoples Biodiversity Register (PBR). As on date, there is no legal protection available for the knowledge recorded in the PBR.
- An effective legal safeguard against bio-piracy assumes enormous importance for a country like India.
- Considering the general lack of biodiversity and climate datasets for the region there is a need to have in place a systematic and robust data/information generation mechanism, which also takes care of collection, collation and consolidation of available information.
- The PA coverage in NE bio-geographic zone, particularly in NE hill province is poor. It would require immediate attention for bringing in adequate and representative areas under PA network to ensure *in situ* protection of important bio-resources of the region.
- Realizing the uniqueness and richness of genetic resources, there is a need to place special attention to maintain the evolutionary significance of Traditional Ecological Knowledge (TEK) of the region. This calls for proper integration of cultural values and TEK system with modern approaches of management.
- Unplanned activities of development infrastructure are resulting into a great pressure on fragile ecosystem of NE region. The adequate facilities for monitoring, baseline data, impact assessment and threat or risk assessment still need to be developed in the NE states. Lack of coordination between developmental departments and proper planning may be taken as major factors. Mining and big dams have been a cause of great concern in most part of NE region particularly in Meghalaya and Manipur.
- The region is experiencing high degree of anthropogenic pressure mainly because of age old shifting agricultural practice for livelihood of growing population. The practice is detrimental for the health of forest and the environment of the region. In this regard, Govt. of Mizoram has launched a New Land Use Policy (NLUP)

for farmers to replace the age old shifting cultivation. Such policy needs to be framed by other States of NE India so as to effective implementation of the Act.

- Implementation of the Act and Rules are very poor in some States of NE India. It is evident from Model PBR. Regarding notification of species of plants and animals which are on the verge of extinction, surprisingly in some States, there is no notification as such.
- Enhancing technical and legal expertise and need for enhanced financial support for the region
- Need for the state governments to understand the nature and responsibility of SBBs and BMCs that are statutory bodies for better provision of funding and facilities for optimal performance of the Boards
- Increasing social awareness on biodiversity and traditional related issues and developing linkages with other activities, programmes, initiatives of Government Agencies being implemented in the region and at state level.

Last but not the least, the progress in implementation of the Biological Diversity Act can be better achieved by networking among the SBBs of Northeast and sharing of expertise among the SBBs. It needs the pooling together the cooperation of all the stakeholders in biodiversity conservation.

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12

Natural Resource Management and Rural Livelihood Development in Churchu Block of Hazaribagh District, Jharkhand

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Abstract

The maintenance of 'natural resource' through scientific and sustainable techniques is called 'Natural Resource Management' (NRM). The aim of this paper is to focus on the techniques which have been employed for community based Natural Resource Management and to explore its impact on sustainable livelihood development in the rural areas of Churchu block of Hazaribagh district. This study is basically analytical and empirical in nature. Primary data has been collected on the basis of questionnaire, observation and Focus Group Discussion (FGD). Secondary data has been collected from the different articles, reports, Government websites and offices. So many programmes have been taken by the Government and Non Government Organization (NGO) for Natural Resource Management to encourage the rural livelihood. For improved income generation, the degraded uplands of this block have been converted to WADI for horticulture and vegetable cultivation. Now, in this area, Kitchen Garden and Non Timber Forest Product (NTFP) have been widely promoted for the suitable use of homestead land and forest conservation respectively. The chronic level of poverty in this block has been reduced due to the improvement of agriculture by water harvesting and land development.

Key Words: Dug Well, Land Development, Horticulture, Agriculture, Non Timber Forest Product

Introduction

Natural Resource Management has direct impact on livelihoods. Soil erosion and water scarcity have created difficult situation for agriculture throughout the world, on the other hand continuous increase of population pressure in agriculture land have accelerated the intensity of degradation of land. In this regard proper use of natural resource for livelihood development is getting paramount importance. In the past the Natural Resource Management (NRM) program was a top-down approach where large area development concept was taken into consideration, due to this the management cost was increased and exploitation of resource was not controlled significantly. But now the concept shifted to bottom-up approach. The management methods have been find out in accordance with the local needs. This paper tries to emphasise the impact of natural resource management on rural livelihood development.

Location of study area

Churchu block is situated in the south-eastern part of Hazaribagh district. This block is surrounded by Daru block in the north, Hazaribagh block in the west, Tati Jhariya in the north east, Barkagaon in south west, Dari block in South and Gomia block of Bokaro district in east. The extension of this block is 23°50' 03 N to 23°58' 14 N latitude and 85°22' 14 E to 85° 36' 05 E longitude. The area of this block is 201.46 sq km, out of which 197.67 sq km is rural area. This block is located under Agro-Climatic Zone VII (Eastern Plateau and Hills Region).

Objectives

The objectives of this study are as follows;

To analyse the techniques which are used mainly for agriculture based Natural Resource Management.

To find out the impact of Natural Resource Management on rural livelihood development.

To identify the problems, prospects and the possible solution of Natural Resource Management.

Methodology

This study is basically analytical and empirical in nature. Primary information has been collected from purposive sampling method through employing questionnaire, observation and Focused Group Discussion (FGD) techniques. Total sample size was 100. The secondary data have

collected from different articles, reports, Government websites and offices. To represent the data, several diagrams have been used.

Result and Discussion

Characteristics of agricultural land: According to the utility, water availability, elevation and slope the land is subdivided mainly into 4 parts, i.e. *dry upland*, *dry middle land*, *wet low land* and *homestead land*. The dry uplands are the upper reaches of the slope having shallow soils depth, lower water retention capacity and very low fertility and productivity. Most of the lands are devoided of vegetation cover and barren in nature. The dry middle lands are in the middle reaches of the slope having relatively deeper soil and relatively high water holding capacity than uplands. These lands are used for monsoon crops. The wet lowlands are better in every aspects of fertility, water retention capacity, productivity than other parts. Due to water availability these lands are useful for crop production not only in monsoon but also in summer and winter. The remaining lands beside their residential plot (*homestead land*), have been used for vegetable cultivation. It was estimated that the percentage of area under *wet low land*, *dry mid land*, *dry upland* and *homestead land* are 16%, 29%, 35% and 20% respectively. These diversified characteristics of lands make Natural Resource Management (NRM), very challenging and complex in nature in this area.

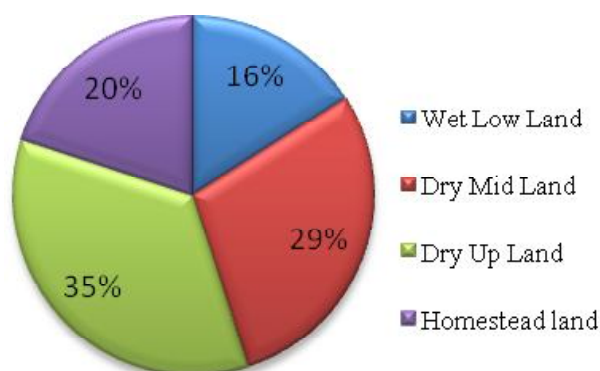


Fig:1: Percentage Share of Different Types of Land.

Source: Field Survey, 2015- 2016

Need of NRM in this region:

- To increase crop intensity through systematic improvement of crops production by securing the irrigation coverage.

- Farmers are dependent primarily on monsoon. So their vulnerability level is considerably high. The long dry spells affects the crop production. The production and the variety of rabi crop is very low and the summer crops which have significant impact of economy in the assured irrigation area, are not practiced properly in this block due to scanty coverage of irrigation.
- High percentage of population is below poverty level (54.66%, Computed by authors from Churchu Block BPL list) facing food scarcity. To maintain the food security level throughout the year, to reduce the obligation for distress migration and to check the intensity of poverty, landless and marginal farmers should be allowed unimpeded access of opportunities over subsistence type of agriculture and home based very small scale economic activities.
- To increase food security and enhance the workability of Public Distribution System (PDS), integrated farming system based natural resource management is very important in this area.
- Absence of pasture land leads to poor livestock husbandry in this block. To reduce the vulnerability of life in rainfed areas livestock ranching has been promoted as a significant source of income. To reinforce this activity in this block with sustainable manner Natural Resource Management is very necessary.
- The average rainfall of Hazaribagh district is 1347mm/year (Ground Water Information Booklet, Hazaribagh District). This block as well as the district is characterised by huge surface runoff which leads soil erosion. To check the soil erosion and to manage the rain water, Natural Resource Management is very necessary.

Techniques for agricultural development through Natural Resource management:

Kitchen Garden in Homestead

Homestead open areas are used extensively for kitchen garden. Farmers are producing mainly vegetables throughout the year to meet their daily needs. Near about 60% families of this block have practiced kitchen garden. It is fully subsistence type agriculture and not to be shown for commercial purpose. Besides this the concept of kitchen garden helps to alter their daily diet by the introduction of different types of vegetable. This concept helps to reduce the nutritional deficit among the beneficiaries. The waste water of the kitchen is channelized to the cropping area which

helps to reduce the deficiency of irrigation. The wastage materials of the vegetable, litter and dung of domestic animal etc. are used as organic fertiliser in this regard. Brinjal, Lady's Finger, Tomato, Chilli etc. are cultivated here. This technique helps to convert the uncultivated fallow lands to agriculturally developed land. From this method the poor families are not only able to meet their nutritional deficiency but also manage economic benefits indirectly.

Intensive agriculture through Dug well

A dug well is an irrigation structure created in the lower most location of an agricultural plot to accumulate water for cultivation. It is observed that in this block the wells are constructed as seepage dag well. These are made of stone, sand and cement and most of the case these are characterised by 16 to 18 feet in diameter (after construction of wall) and 20 to 24 feet in depth. The ground water table can found at the depth of more than 10 meter (> 32.81 feet) below ground level in pre-monsoon season and 2.1mbgl (6.89 feet) to 8.90mbgl (29.20 feet) in post monsoon period (Ground Water Information Booklet, Hazaribagh District). It can be estimated that more than 8 feet gap has been maintained between the floor of well and ground water table in pre monsoon time, due to this the ground water table never been disturbed in the low rain fall period for irrigation. Most of the case they are interested to build a dag well in low and middle land to accumulate more seepage water though some dug wells have been developed in upland and homestead land under Individual Beneficiaries Scheme (I.B.S) of Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA). These wells are not excavated below the ground water table. The sub surface water is accumulated in this storage which in later use for agriculture. Due to this the farmers are practiced agriculture without affecting the ground water.

Irrigation area: There are eight to ten beneficiaries who have been facilitated by each seepage dug well in this area. It has the potentiality to irrigate 30 to 40 decimal of land in Rabi season and on average 15 decimal of land in summer season at a time. The net irrigated area varies between 2.5 acre to 4 acre and 1.2 acre to 2 acre per well in winter and summer season respectively. One can irrigate after 4 to 5 days because of low water necessity for Rabi crop where summer crops need irrigation within 1 to 2 days and due to this the potential area of irrigation in Rabi season is larger than summer season. To use the water properly and to increase the potential irrigation coverage of the wells, the group of beneficiaries have been provided water lifting device (3hp to 5hp pump and 600 m to 800 m delivery

pipe) not only for human resource management but also for minimum leakage and maximum usage of water. To increase the potential irrigation, 'Solar Power Based Irrigation System' has been promoted to install. At Kajri village of this block, a 'Solar Power System' has installed by solar powered water pumping solution company named 'CALRO' on behalf of a 'Self Help Group' named Barsa Mahila Vikash Sangh by the financial support of 'TATA Trust'. Due to this the pumping capacity has increased and the potential irrigation areas have increased up to 6 acre in Rabi season and 3 acre in summer season.

Production increases: Before the availability of secure irrigation the farmers depend upon the rainfed agriculture which is characterised by high level of Natural Resource fragility, vulnerable production, low level of agricultural input and unsecured income generation, low crop intensity, low level of crop diversification etc. These in turn reduce the standard of well-being. After the introduction of water management practice through seepage dug well, the types of production diversified and the number of times of agricultural practice increases. It has been observed that after the procurement of secure irrigation in the upland areas, agricultural practice has been conducted two times i.e. Kharif and Rabi crops where in mid upland and low land it has been conducted three times in a year i.e. Kharif, Rabi and Summer crops are practiced due to the assured irrigation facilities.

Farmers, in most instances, used primitive technologies but in recent years they are using some advanced technologies for cultivation. The factors working in tandem are small and fragmented land holdings, lower level of farm mechanization, extensive mid up land and up land, lower level of fertility and productivity of lands, little coverage of assured irrigation etc. But after the development of seepage wells, the beneficiaries not only have able to increase the production level of paddy but also have diversified the agriculture. After secure irrigation beneficiaries are motivated to take System of Rice Intensification (SRI) techniques for paddy cultivation. SRI technique has reduced the requirement of water by 25% to 30% but it needs frequent irrigation. It has been estimated that, they had produced 5 to 6 quintal of paddy per 33 decimal (1 Bigha) of land by using traditional technique but after the introduction of SRI technique they have able to increased the production to 8 to 9 quintal per 33 decimal (1 Bigha) of land. The production has increased about 1.55 times after the adaptation of this technique. After secure irrigation diversification of crops can be found here. Where the beneficiaries were concentrated only on paddy in the past but now they have taken several crops for commercial purpose. At present, 64.69% of Kharip agricultural lands are occupied by paddy and

34.83 % of land developed for tomato cultivation. 80.54% Rabi crop lands have been cultivated by potato, followed by tomato (12.9%), green pea (4.73%). In summer season most of the lands have cultivated by Bottle gourd (92.46%).

Table: 1: Percentage of Land Occupied by Different Crops, Fruits and Vegetables

Season	Crop, Fruits and Vegetable			
Kharif	Paddy	Tomato	Others	
	64.69	34.83	0.48	
Rabi	Green Pea	Potato	Tomato	Others
	4.73	80.4	12.9	1.83
Summer	Bitter gourd	Bottle gourd	Water Melon	Others
	3.14	92.46	3.77	0.63

Source: Table computed by authors on the basis of field survey, 2015 and 2016.

It has been found that, after possessing assured irrigation the beneficiaries have increased their agricultural production. Crop intensity (Percentage of Gross Crop Area/Net Sown Area) has increased approximately 38% among the surveyed farmers. After secured irrigation the magnitude of 7 to 10 days long dry spell of July and August on paddy cultivation has been reduced, due to this farmers are much interested in SRI technique day by day. It has been estimated that from 2015 to 2016, 112% more lands have adopted for SRI technique.

Table:2: Impact of Seepage Dug Well on Agriculture and Income generation.

Increase of Crop Intensity through Seepage Dug Well	38 % approximately
Increase of Land under SRI cultivation	112% approximately
Increase of Paddy production (per 33 decimal)	1.55 times on average
Increase of income per annum	21000 to 30000 rupees approximate

Source: Table computed by authors on the basis of field survey, 2015 and 2016.

Case Study: At Kajri village of Churchu block a tribal dominated Self Help Group known as Barsa MVS had planned to cultivate tomato for commercial purpose in 2015. They had earned approximately 86600 rupees by cultivating kharif season tomato. They had converted 2.5 acre of degraded fallow land beside their homesteads to cultivable land by proper land development processes. After the successful effort of income generation they interested to cultivate summer crops for the first time. But due to

scarcity of irrigation water they had faced problems and to solve the problems they developed seepage dug well. Interestingly, when the well was constructed the seepage water which had to be removed, was used for irrigation and 1.7 acre of paddy land had been used for Bottle Gourd cultivation. From that summer crop they earned approximately 48200 rupees. After that in 2016 they have converted 4.2 acre degraded fallow land to cultivable land and have cultivated kharif tomato on 6.7 acre of lands. It can be estimated that each family has increased their cultivable land coverage from 15 decimal to 40 decimal by proper management of natural resource (Source: A NGO named SUPPORT).

WADI development in upland

Horticulture has been considered as one of the best practices in this block for sustainable use of dry upland substantially. The degraded uplands which are not suitable for cereal crop cultivation due to water draining characteristics have been used for horticulture. NABARD have taken up WADI (WADI means small orchard usually covers one acre per beneficiary who must be a marginal farmer) programme for the development of sustainable livelihood. Two or more fruit trees are geometrically planted in WADI Model to reduce the biological, climatic and economic risk. High breed mango and guava have been producing intensively in this block. It was observed that the spacing of 5 meter X 5 meter has been considered for plantation on average. For maximum retention of moisture in the WADI plot the surroundings of the plants are tilled, due to which the intensity of surface runoff also reduces. The intermediate land among the trees have been used for commercially important rhizomatous herbaceous perennial plant like Ginger and Turmeric and short lived with single trunk perennial plant like Papaya. This model not only has improved the livelihood condition along with the food and nutritional security but also has improved

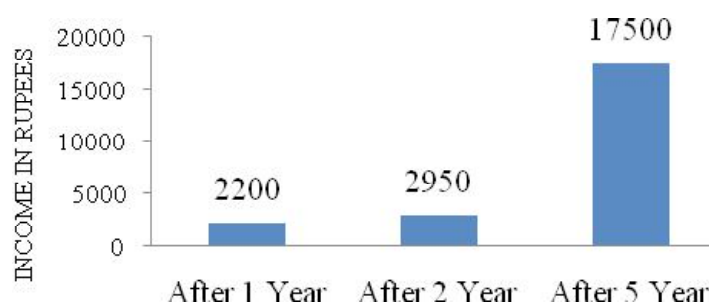


Fig: 2: Average Income from WADI

Source: Field Survey, 2015 and 2016

the marketing scenario and economy of the farmers. According to the information provided by a non Government organization (NGO) named 'Society for Upliftment of People with People's Organization and Rural Technology' (SUPPORT) that in collaboration with NABARD, this organization has planned to promote mango and guava orchard since 2010. 500 acres of uplands of 500 marginal tribal families have been taken for WADI programme in this block. It has estimated that in first year of plantation each household has earned approximately 2000 to 2400 rupees (Average 2200 Rs), in second year of plantation the household has earned 2500 to 3400 rupees (Average 2950 Rs) and after 5 years the earnings can be reached to 15000 to 20000 rupees (Average 17500 Rs) to the household.

Lac Cultivation, a Non Timber Forest Product based Livelihood

The people having forest based livelihood have been motivated to adopt Lac cultivation in the forest area. The promotion of Non Timber Forest Products (NTFP) based livelihood not only has reduced the rate of deforestation but also has increased the income level of the beneficiaries. Ber, Palas and Kusum trees are used for Lac cultivation. They are also insisted to plant these trees. Lac cultivation has been done two times in a year i.e. January-February to June-July and June-July to January-February. The value of Lac in market is on an average 110 rupees/kg and the beneficiaries are showing very much interest in this practice. The necessary pest management training, medicines, plant and brood Lac have been provided by the local governing body as well as NGOs.

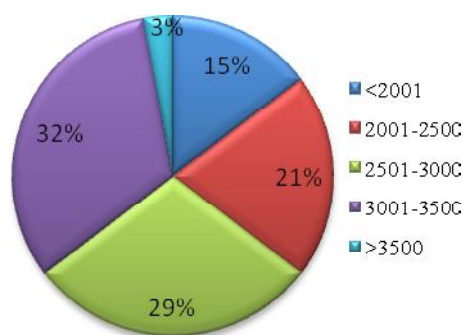


Fig: 3 : Income Generation from First Cycle Lac Cultivation

Source: Field Survey, 2015-'16

It can be estimated that the 15%, 21%, 29%, 32% and 3% of households have earned less than 2000, 2001-2500, 2501-3000, 3001-3500 and more than 3500 rupees per annum respectively from first cycle of Lac cultivation in this block. It can be estimated that after three cycles the income would reached to 15000 to 20000 rupees per household per year. There are some people who are associated with Lac cultivation for a long time, become extremely successful in this regard. A case study provided by a NGO named 'SUPPORT' which reveals the fact that Purni Devi, a member of Laxmi MVS of Kajri village of this block in 2015 had earned around 78500 rupees from only Lac cultivation.

Perception on the impact of Natural Resource Management

The five point scale has been used for understand the perception about the impact of Natural Resource Management on their natural and social environment. More than 60% respondents have expressed their satisfaction (Extremely Satisfactory and Satisfactory category) in the issues of *water availability*, *crop production*, *income* and *forest conservation*. 57% and 47% people have expressed their satisfaction on *food security* and *use of fallow land* respectively. The percent of unsatisfied people (Unsatisfactory and Extremely Unsatisfactory category) are very low ranging from 3% to 8%.

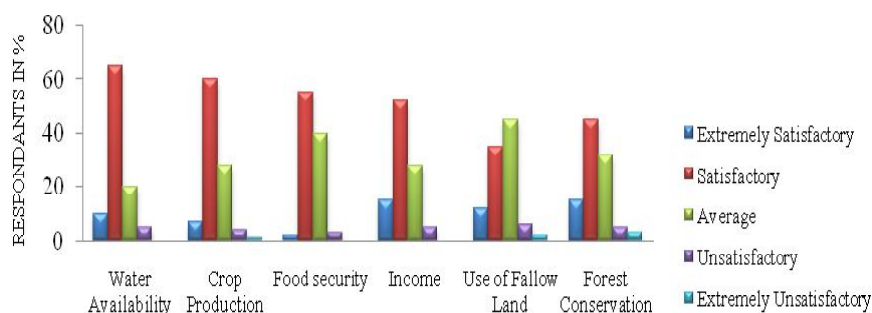


Fig: 4 : People Perception about Impact of Natural Resource Management

Source: Field Survey, 2015 and 2016

Problems

Insufficient database: In this block several government and non government organizations have been working but there is, no integration of database. Some convergence among projects can found but the databases are not put on open source. The NGOs are working individually at local level so that the data bases related to NRM cannot be easily accessed by other organization. Due to this a single window

data base can not developed which creates problems in future planning.

Improper planning: The water harvesting and conservation methods are not fit for every area. It has been observed that so many seepage dug wells have constructed in the upland area where the accumulation rate of water is very low and in dry season the quantity of water is very low. In the low land area the accumulation rate of water is much better and the rocky layer is situated at a greater depth than up land. So the methods of seepage well in low land area become successful but in upland area it has failed to achieve the success.

Little coverage of micro irrigation project: To increase the productivity, water is very essential but due to geographical hindrances, water scarcity has been present in most of the upland and middle lands. So many methods of water conservation are initiated but the percentage of irrigated land is still very low. Due to this the diversification of crops cannot be found significantly good and the crop intensity is not much high. The monsoon dependency and lower access of irrigation consequently increase a huge gap between the expected and real productivity.

Suggestions

Convergence among programmes: According to the needs of local people and the availability and potentiality of resource, local level governing body should take water management and plantation programme effectively along with the non government organizations. To reach optimum level of success the convergence among the programmes like wage based employment (MGNREGA), self employment (NRLM), agriculture related programmes, micro irrigation project and forestation programmes should be done effectively through one window operation.

Detail Database: A detail data base of natural resource and its management should be prepared and that should be openly accessed by everyone.

Conclusion

Natural resource management helps to optimise the production and minimize the risk. Though the coverage of Natural Resource Management is low in this block but it has been taken into consideration for the sustainable rural livelihood development. Through development of homesteads land as kitchen garden, converting upland into horticulture

land and improvement of the mid land and low land into intensive agriculture land, small and marginal farmers have ensured their food security over the year. With the reduction of dependency on monsoon and the vulnerability of production, the agriculture intensified and stabilised. The stability of agriculture and Non Timber Forest Product (NTFP) based practice have played pivotal role in livelihood development in this block.

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Community Based Ecotourism as a Means of Resource Management: an Assessment in Nameri National Park of Assam

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Abstract

Community-Based Ecotourism (CBET) has been gaining impetus as an emerging concept. It is being debated upon as important tool for economic upliftment of communities that have something to offer to fill a tourist's desire for uniqueness. Ecotourism have always been deemed as important resources for livelihood among the community reside nearby protected areas.

Here an attempt has been made to evaluate the ecotourism initiatives that have been introduced by Assam (Bhorelli) Angling and Conservation Association (ABACA), an organization started ecotourism ventures in the year 1956 benefiting local populace in terms of income, improved infrastructure, employment opportunities and exposure. The community's capacity to facilitate resource related conflicts has improved following support from development institutions and facilities provided by the organization. An expanding livelihood base is reducing local vulnerability of resources and man-animal conflicts.

This paper tries to emphasize on the community based ecotourism initiatives and its impact on livelihood in the fringe of Nameri National Park in Assam. Through the paper the researcher emphasizes such possibilities on the basis of assessment of potential ecotourism resources of the Park as a means of natural resource management during field experience gained different parts of the study area.

Keywords: CBET, Nameri National Park, Tourist resources, Local community, Ecotourism, and Livelihood.

Introduction

Tourism is one of the world's largest industries, generating an estimated 11 per cent of global Gross Domestic Product (GDP), employing 200 million people and transporting nearly 700 million international travelers per year - a figure that is expected to double by 2020 (Pruthi, 2006). Further the importance of tourism as a creator of job opportunities can be understood from the fact that in India every 1 million invested in tourism creates 47.5 directly and around 85-90 jobs indirectly. Community-based ecotourism (CBET) has, for over three decades, been promoted as a means of development whereby the social, environmental and economic needs of local communities are met through the offering of a tourism product. CBET is gaining impetus along with the concept of rural tourism as most of a nation's culture, traditions and heritage can be observed mainly in the rural areas. This can be elucidated by examples throughout India and in Northeast India. Some of the characteristics of Community-based ecotourism are:

- Benefits going to individuals or households in the community.
- Collective benefits—creation of assets which are used by the community as a whole, roads, schools, clinics etc.
- Community benefits where there is a distribution of benefit to all households in the Community.
- Conservation initiatives with community and collective benefits.
- Joint ventures with community and/or collective benefits, including an anticipated transfer of management.
- Community owned and managed enterprises.
- Private sector enterprises with community benefits.
- Product networks developed for marketing tourism in a local area.
- Community enterprise within a broader co-operative.
- Private sector development within a community owned reserve.

Many of the world's most beautiful resources exist in endangered habitats and vulnerable communities. Community-based ecotourism is a form of ecotourism that emphasizes the development of local communities and allows for local residents to have substantial control over, and involvement in, its development and management, and a major proportion of the benefits remain within the community. Community-based ecotourism

should foster sustainable use and collective responsibility, but it also embraces individual initiatives within the community.

With this form of ecotourism, local residents share the environment and their way of life with visitors, while increasing local income and building local economies. By sharing activities such as festivals, home stays, and the production of artisan goods, community-based ecotourism allows communities to participate in the modern global economy while cultivating a sustainable source of income and maintaining their way of life. A successful model of community-based ecotourism works with existing community initiatives, utilizes community leaders, and seeks to employ local residents so that income generated from tourism stays in the community and maximizes local economic benefits.

Community-based ecotourism is travel to local indigenous communities that have invited outsiders to experience their customs, food, lifestyle, and set of beliefs. These communities manage both the impacts and the benefits of this tourism, strengthening their self-governance, economic alternatives, and traditional ways of life in the process.

Key Characteristics of Community-Based Ecotourism are:

Indigenous Leadership

Community-based ecotourism is managed by indigenous communities. This means the community assumes collective responsibility for all aspects of stay, including accommodations, internal travel, local food, and cultural activities. Through community-based travel, collective wellbeing is valued over corporate or individual profit.

Sustainability

Communities will only accommodate as many people as they are able, keeping in mind long-term sustainability, and avoiding unnecessary strain on their own resources. Aside from physical resources, revenue from community-based travel helps to sustain indigenous cultures and traditions in a rapidly changing world. Stimulate the local economy by generating income through the sustainable use of natural resources.

Cultural Immersion

Tourist is able to experience the diversity and customs of another culture, and to interact with the community. Unique lodging, cuisine, and activities form a foundation for increased knowledge and awareness of another culture, different set of beliefs, and social norms. By choosing

community-based ecotourism and travel, tourist shall be respecting the place that are visiting and its ancestral stewards, while still enjoying an unforgettable journey.

Identity

Respect and preserve all the characteristics of the environment, help residents reclaim historical practices, revitalize productive activities, highlight the ethnic background of the population, and highlight the unique aspects of the locality, such as topography, climate, architecture, cuisine and handicrafts.

Roots and Customs

Highlight local cultural practices so that communities share their cultures and traditions with tourists with authenticity. Invaluable educational opportunities such as home stays and town-hall-style round of talks are encouraged so that tourists and local community members can mutually share cultural aspects such as food, music, folklore, and goods. Both visitor and community cultures will always be treated with appreciation and respect.

Ecological Consciousness and Harmony

Seek to conserve natural ecosystems and cultures by being a part of a larger development plan. All plans have a low impact on the local environment while highlighting the unique aspects of the locality, such as topography, climate, and architecture. The conservation of nature and rigorous concern with the environment influence the development of infrastructure for community-based ecotourism activities.

Local Control

Local leadership leads plans and encourages clear and transparent decision-making. Community members actively make decisions on strategies and acceptable levels of tourism based upon the community's culture, heritage and vision.

Ecotourism initiatives that have been introduced by Assam (Bhorelli) Angling and Conservation Association (ABACA), an organization started ecotourism ventures in Nameri National Park in the year 1956 benefiting local populace in terms of income, improved infrastructure, employment opportunities and exposure. The community's capacity to facilitate resource related conflicts has improved following support from development institutions and facilities provided by the organization. An expanding

livelihood base is reducing local vulnerability to disaster and man-animal conflicts. The numbers of inhabitant wildlife species in the park have increased due to adequate protection and reduce frequency of livestock in nearby villagers. There is need to build the community's capacity for the promotion of activities that compliment ecotourism.

Background of the Study Area

Assam is a part of mega biodiversity hotspots of the world. It also forms parts of two endemic bird areas, viz. eastern Himalayas and Assam plain (Choudhury, 2000). Nameri National Park is a part of the north bank landscape designated by WWF and also a part of Eastern Himalayan biodiversity regime rich in endemic biota of the world.

The study region covers Nameri National Park of Assam located in 26°50'48"/N to 27°03'43"/N Latitudes and 92°39'E to 92°59'E Longitudes covering an area of 200 km² in the northern bank of river Brahmaputra, in Sonitpur district of Assam. Nameri is covered by tropical evergreen, semi-evergreen, moist deciduous forests with cane and bamboo brakes and narrow stripes of open grassland along rivers. Grassland comprises of less than 10 per cent of the total area of the park while the semi-evergreen and moist deciduous species dominate the area. The park is enriched with threatened plants and animal species under International Union for Conservation of Natures (IUCN) Red List categories (Barua et al. 1999). Parts of the area were declared as Naduar Reserve Forest (Present East Buffer) in 1876 and Nameri Wildlife Sanctuary in the year 1985. The Nameri National Park was formed in the year 1998.

During the British period this rserve forest was designated as Game Century for gaming and hunting of animals. There are 4(four) forest villages and 1(one) agriculture farming corporation has been situated in the west buffer of the park. Similarely 5(five) forest villages are located in the east buffer. There are total of 18(eighteen) revenue villages situated outside but along the southern and south-western boundary of the park. The villagers in the south buffer area are dependent on the park for sustainance of their livelihood. They have been traditionally engaged in collection of NTFP (non-timber forest produce) and grazing of livestock. A sizable proportion of local populace is also engaged in ecotourism activities as tour guide, providing local accomodation, selling handicraft, engaging in the ecocamp accomodation, etc for their livelihood (Bhattacharya, 2003). The Assam (Bhorelli) Angling & Conservation Association (ABACA) in the park has been organizing white water rafting with the assistance and cooperation of the department of sports; department

of tourism and department of environment and forest, Government of Assam.

Review of Literature

Studies on community-based ecotourism and livelihood are of recent origin and the available literature/ records in this field are rather few. However, much of the studies done earlier are mostly confined to the areas outside India. Such studies are inherent in analysis pertaining to ecotourism industry itself.

Gossling (1999) suggests that community-based tourism is derived from the existence of natural areas with no specific concern for their protection, whereas ecotourism is concerned with the protection of natural areas (Naidoo, 2005). Typical services offered at ecotourism destinations might include local arts and crafts, guided hikes and wildlife viewing, publications, natural history lectures, photography, and local food. Revenues are generated from fees for these services, as well as natural area user fees and local expenditures for hotels, restaurants and bars, and transportation services (Seidl 1994). Orams (1995) argues that community based ecotourism must provide more than mere enjoyment; it must foster changes in the attitudes and behavior of tourists about the protection of natural resources. Researchers also have discussed CBET in the context of the tourism life cycle (Butler 1980).

Measuring the economic impacts of tourism and outdoor recreation has received considerable attention in academic literature (Eadington and Redman 1991, Frederick 1992). Economic impacts of CBET generally are examined within a cost benefit framework (Dixon and Sherman 1990, Walsh 1986) with the benefits measured by using expenditure surveys combined with input-output analysis (Briassoulis 1991, Propst 1985). Travel cost or contingent valuation methods also are commonly used in CBET to place dollar values on natural areas or marginal changes in their characteristics (Bostedt and Mattsson 1995, Echeverria and others 1995, Forster 1989, Lee 1997, Lee and others 1998, Loomis 1989, Moran 1994). When community based ecotourism is defined less restrictively, as simply tourism derived from nature preserves, parks, or refuges, researchers tend to assume that all economic impacts derived from those natural areas are ecotourism-derived impacts (Boo 1990). Economic impacts are measured by using expenditure surveys of tourists visiting those areas.

Most potential ecotourism sites are inhabited by ethnic minorities (Nepal, 2000). The principle of 'encouraging community participation in

ecotourism activities' create income and maintain cultural identity of the host community. These communities have a deep understanding of traditional festivals, cultivation and land use customs, culinary culture, traditional lifestyle and handicrafts including historical places (Zurick, 1992). Ecotourism highly depends on the elements available in a particular tourist destination. The strength of these elements directly affects the flow of tourists into the spot (Gee, 1959).

Status of Economy, Land use and Forest Resources of the Park

The forest villages located in the area acquire culture of different ethnic identities. The Mising, Garo, Karbi, Bodo, Napali, Adivasi and other groups of indigenous community resides in the south buffer area.

The villagers mostly depend on agriculture. There is no industry nearby for employment. Most of the villagers are below poverty line and as such they depend on the well to do households of the villages for their employment as seasonal agricultural labour. The vocations of the villagers are limited to cottage industry particularly cane and bamboo crafts, carpentry etc. Some people are adopting dairy farming with the traditional system and indigenous cattle.

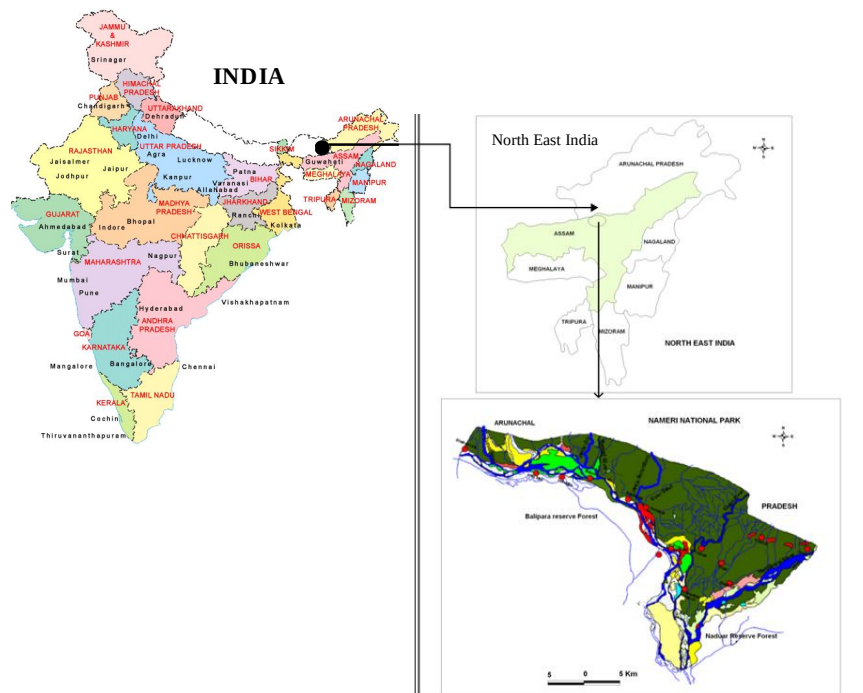


Fig: 1 Location Map of Nameri National Park

The lands in possession of the villagers are used mostly for their small homestead where they marginally grow areca nut, banana, bamboo and other vegetables. Very limited people have fuel wood in their homesteads. The paddy lands are cultivated for one crop only due to lack of irrigation facilities. People use to collect their firewood and agricultural implements and house construction materials from the forests of and the buffer area. Grazing has been done in these areas. Seasonally some villagers do take up cottage industry of weaving bamboo and cane crafts.

The land use pattern of the locality is gradually changing by way of increasing horticulture, fishery etc. The irrigation facility and acceptance of modern agriculture improves the economic condition of the people. Due to high dependency of the people on the resources of the forests the conservation of the park has become difficult as the community land reserved for the villagers is insufficient and has been utilized for agricultural and other developmental works. The fallow land near by the areas has been decreases due to encroachment.

Objectives

The objective of the present study is;-

- i. to highlight the concepts and principles of CBET; and
- ii. to evaluate the community-based ecotourism on livelihood in the Nameri National Park.

Research Methodology

The present reserach is based on data collected between Januaray and April 2014 using semi-structured interviwes, and update using information gathered during successive local meetings. A process of tringualtion was ensured where by key informants and focus group were interviewed and different sites (e.g. homestead, ecocamp, village market, river bank and in the forest) visited. Snowball sampling procedure was used. This is a procedure where the researcher start off with one informant who in turn introduces the next person considers usefull to the investigation. Interview questions touched on livelihood options, wildlife conservation, and tourist resource management. The operation of ecocamp and the management committee was also invesitigated. A total of 28 individuals (10 local tour guide, 6 women group, 4 boatman, 4 cultivtor and 4 four forest personal) interviewed during the visit.

Ecotourism Activities in the Park

Protected areas have great potential for recreation and ecotourism. Recreation and ecotourism have been introduced into protected areas which have helped to reveal the ecological value and fragility of the area (Brechin, *et. al.* 1991). The impression of Nameri National Park on tourists and visitors has always been associated with outdoor recreation. Despite being small in area, it has a significant array of landscape, scenic beauty and cultural variety of the communities residing near the park. This natural setting also embraces a variety of ecological habitats and various animals and plant species, essential for the development of ecotourism (Bhattacharya, 2004).

As mentioned in the previous section, Nameri National Park and its adjoining areas are rich in culture with different communities inhabiting around it. The following pleasure seeking activities attracts tourist to Nameri National Park.

Rafting

Rafting is one of the recreational activities in the park's rivers. This is usually done on whitewater or different degrees of rough water, in order to thrill and excite the riders. The Jia-Bhoreli River has been a part of Nameri National Park and is well looked after by the Department of Forest (Wildlife), Government of Assam. A stretch of 20 Kms. in length of Jia-Bhoreli River from 16th mile point to Potasali is included for rafting. Tourists may avail a shorter distance in this route starting from other rafting points from 13th mile area. Rafting period starts from 1st November to 31st March. It is a popular tourist activity in the park which is preferred by 10.47 per cent and 9 per cent of domestic foreign tourist respectively (Das, 2014). Large number of boatmen is engaged for rafting from amongst the local people who also earn for their livelihood from this activity.

Trekking

Nameri National Park offers some of the most awesome trekking opportunities to the tourists. It has breathtaking trekking trails all across, from north to south and from east to west. The trekking season in the park starts from late spring to late winter and covers almost the whole year. The park also offers a considerable bonanza for trekkers that range from moderate to strenuous treks and which takes about 3 to 5 days. Though the season starts from October to March the ideal trekking time is between the months of October to May. However, trekking can also be done in the summer months. This activity attracted 4.76 per cent of and 4 per cent of

domestic and foreign tourists (Das, 2014).

Elephant Safari

Elephant safari is ideal in and around the wild regions where riding the elephant can give easy access for viewing the wildlife. In Nameri National Park elephant safari is the best option for exploring the wildlife distributed all along the park, about 9.84 per cent domestic and 13 per cent foreign tourist enjoyed the trails (Das, 2014). It offers an opportunity to view some of the rare and endangered animals occasionally migrated from the adjacent Pakhui Wildlife Sanctuaries of Arunachal Pradesh.

Bird Watching

Nameri National Park is famous for avian species. Certain locations in the park such as the forest, rivers and wetlands may be favoured according to the position and season. Nameri National Park is gifted with more than 337 species (Baruah, 1999) of both resident and migratory birds. The tourist can enjoy a long season of bird watching during winter (November to March). During the season, 21 per cent and 13 per cent of foreign and domestic tourist enjoy bird watching (Das, 2014).

Impact of Ecotourism

The Assam (Bhorelli) Anglers and Conservation Association (ABACA) is a joint venture between the local community and the tourism entrepreneur. Since its inception in 1956, ABACA has contributed to livelihood opportunities and natural resource management initiative to the local community in Nameri National Park in different way. The community has been benefitting from a fee that is paid by ABACA for the lease of land. About 2 hecter of land have been leased at a fee of Rs. 94,000 per year. Over and above the community receives amounts ranging between Rs.3000 per year as bed charges (local accommodation) paid by the tourist who visits the area. The community uses these earnings to support different community livelihood initiatives such as the provide money to self-help group, construction of schools, community houses, roads and expanses for community festivals.

Eco-camp provide eco friendly accommodation in the park and pays monthly salaries to 18 members of staff, drawn from the local community who serve at the camp. The workers include security guard, camp attendants, maintenance and clerical stuff as well as cultural troops (performing local dances in the camp during tourist seasons) from nearby villages. More and more local people are complementing their sources of

income with payments receive as casual workers. Up to 15 casual workers are absorbed by ecocamp especially during construction and repairs. Individual households benefit from the sale of firewood and charcoal and the different organic food stuff that are sold at the camps and tourist. Earnings received from ecotourism are used in various ways, including purchase of livestock; land as well other necessary item, initiatives that are contributing towards livelihood in general and local food security in specific.

The community reside nearby the park is benefitting from improved infrastructural systems. These include over 8 km earth road network that has been constructed by the forest department in the conservation area and outside. The all weather road has improved community accesses to outside markets. To increase the resident wild life and bird, the community constructed five small barrages on the tributaries and planted fruit bearing trees and trees which is most favourable for wildlife habitation. These water sources and plantations have reduced competition for grazing resources between livestock and wildlife. The camp authority allowed to the community to use grazing especially during drought. Access to the new water sources has reduced community vulnerability to drought related disasters. Community contact to the outside world has improved following access to electricity and telephone line provided by ecocamp authority and forest department.

More benefits to the local community come in a form of contribution from the department of forest and environment, Government of Assam. The forest department has been involved in the establishment of ABACA and also facilitated negotiations between the community and ABACA through workshops and exposure tours, helped to build trust for the project among the members of the community. Amounts are paid to local people in the area who have livestock and have agreed to share grazing resources with wildlife. This contribution is meant to offset the costs incurred by the communities for living with wildlife and, build trust and ownership of wildlife resources among the local people. The positive impact of this contribution, notwithstanding, the beneficiaries have expressed disappointment over this amount, pointing out that it is too little compared with the costs incurred. This is partly associated with poor negotiation skills by the ABACA coupled with limited knowledge of market value of resources involved and the implications of the lease agreement on the local economy. The major investment of ecotourism-related earnings is used for livelihood because there is no other foremost means of income generation.

The affected individuals called for diversification of the investment of wildlife-related earnings beyond community projects. The women's groups have, for instance, approached the ABACA for funding to improve their small-scale business opening self-help group. Awareness and mobilization workshops that were funded by department of forest and ABACA have improved the capacity of individuals working in different sectors. The members have been empowered through exposure tours organized to surrounding areas. Selected members were exposed to different ecotourism complementary technologies in the other parts of the states like Kaziranga, Dibru-Saikhowa, Mazuli River Island and Manas National Park etc. Tour participants identified organic fodder production, handicraft, local cuisine eco-friendly accommodation and beekeeping as ecotourism complementary packages suitable to the local setting and conditions. A proposal has been developed and resources are being mobilized to implement selected packages.

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Following exposure tours and consultative meetings local members have identified various forums for sharing information on technological innovations and possible funding. Tour participants have been instrumental in facilitating negotiations on wildlife-related conflicts, using experience gained as they listened to narration by host institutions during the tours.

Impacts on Natural Resource Management

Impacts on natural resource management on community based ecotourism initiatives have made positive impact on natural resource management. This is primarily because of lack of a national policy to

integrate the initiatives with resource management and conservation. Conservation is still being influenced by the premise that wildlife needs to be protected to avoid overutilization and/or through competition with livestock. Despite this orthodox practice, there is evidence that the numbers of wildlife (including charismatic species) in the park have either remained stable or increased. The number of White Winged Wood Duck (*cairina scutulata*) stands at 424, having risen from almost few at the time of project inception in 1981. Elephant, bird species and bush-loving wildlife have more than doubled following the increase in biomass and anti-poaching campaigns spearheaded by community reside near by the park. ABACA has plans to introduce certain floral species to meet 'customer demand'. Following exposure tours, the community has expressed interest to introduce an orchid sanctuary, vermicomposting plant and an organic orchard.

The different interventions have reduced competition on resources available for livestock, especially from resident wildlife species. Abject poverty, improved contact with the outside world and increased numbers of resident wildlife have contributed to poaching. This situation leads to either the community losing valuable sources of income or the numbers of the specific animal species exceeding the ecological limit leading to environmental degradation. Respondents confirmed that poaching was caused by individuals who feel that they do not own community based ecotourism initiatives.

Conclusions

This paper has established how pilot community-based ecotourism initiatives under the Assam (Bhorelli) Angling and Conservation Association (ABECA) have changed local practices and attitudes towards wildlife and natural resources. The impacts that include accumulation of savings by individuals are leading to social differentiation beyond traditional realms further marginalizing the already impoverished groups/ individuals at the expense of the elite. Young well-to-do local who are increasingly controlling power in the community following their exposure to the outside world and the wealth they have accumulated, are eroding long-established settings. This new form of marginalization have to be addressed, especially through empowerment of individuals and are motivated to actively participate in emerging livelihood options.

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14

Tribes, Sacred Jungles and Natural Resources Management in West Bengal

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Abstract

Cultural clash and mixed culture have reduced the tribal traditions, nature oriented cultures and tribal-worshipping. In this situation we have to conserve our tribal-traditions like Sacred Jungles tradition; to maintain our environmental status and to reduce the diseases of the environment. On the basis of different folk-Gods tribal-folks arrange their Sacred Jungles. For example, the popular Gods of Santal tribes are: Marang Buru, Moreko, Jair era, Gramadevata, Gosain era, Pargana, Manjhi. All the Gods have their allotted place in the Sacred Jungles, and are worshipped only in public place. Marang Buru alone is also worshipped privately in the family. Sacred Jungles are basically related with tribe and their life. From the whole survey total 63 tribal Sacred Jungles have been observed. In tribal society the per capita nourishment of Sacred Jungles is higher comparative to all religions because tribal society mainly practices the traditional worshipping methods and the result is like 1 tribal person are conserving 2 Sacred Jungles averagely in West Bengal. Present researcher will present the detail of tribal sacred Jungles in West Bengal and a relational Natural Resources Management in West Bengal.

Keywords: Marang Buru, Moreko, Jair era, Gosain era, Pargana.

Introduction

A Tribal Sacred Jungle forms the relic of the age-old traditional

practice in our geographical territory and it has great ecological as well as non-ecological impact (social, folk-culture, traditional, economical, and therapeutic) toward the conservation of our environment in a fruitful way. People tie yarn/plastics/cloths/small pitches around these 'so-considered' sacred trees, as an omen, fulfilling their wishes. Frequent changes in human demand and behavior led to a great deal of suffering to our *dear Earth* lending a toxic as well as polluted touch through environmental degradation. Moreover with the passing days we tend to forget the flavor of Tradition and Culture towards the revival of the health of Environment. Culture of 'do Ecology' is the lane to environmental redecoration. It means meeting the need of the current and future generation without inducing any ecological harm.

Motivation of the Study

We have already covered more than 22 International Conventions and Summits after 1972, but we tend to forget the traditional culture through which we can see 'A Healthy Earth'. The degradation of tropical forests and destruction of habitats due to anthropogenic activities are the major causes of decline in the global biodiversity. The high rate of extinction of tropical species is aggravated by the conversion of forest land for agriculture, harvesting non timber forest products, extraction of mature trees, collecting fuel woods and plantations which threaten to erode the biodiversity seriously. It has been estimated that over 40% of all living species on Earth are at risk of going extinct. Internationally, 199 countries have signed an accord agreeing to create Biodiversity Action Plan to protect endangered and other threatened species which means that 199 Countries have felt the seriousness of biodiversity loss. A curtailed crop cycle amounts to a lower yield per unit area that an overpopulated country like India can't afford. Surface air temperature is rising alarmingly at a rate of 0.4 degree Celsius per century and the most worrying part of the prediction is the estimated increase in winter and summer temperatures by 3.2 degree and 2.2 degree Celsius, respectively, by 2050. If one meter sea water rises then 35% land of Bangladesh would be submerged under sea water. In last 15 years, India has experienced different devastation like: unexpected splash floods (for example - Bagmundi in 2004, Rajasthan in 2008, Mumbai in 2009 and Leh in 2010), super cyclone (for example- Andhra Pradesh in 1996, Orissa in 1999, Jammu, Kashmir in 2004 and Aila and Lyla in 2010). At the onset of 21st century, we are feeling that, our mother has fallen sick as she is not being able to bear with our obnoxious activities and rampantly she is taking revenge on us with the changing climatic status, extreme

climatic condition vies-a-vies ecological disaster. So our all *eco-doors* are closing as well, moreover our survival on earth is becoming a growing challenge. The concept might be tough to achieve but not impossible if we try to achieve it through tribal *green-gate* i.e. Sacred Jungle.

Selection of the Study Area

Diverse landforms and cultures are prevailing in the lap of West Bengal i.e. mountain in the north, plain in the middle, plateau remnant in west and littoral Bengal in the south. Like diverse physio-geographical formation, sporadic cultural (tribal) identities and diverse human perceptions are also found in West Bengal and all these are the area of interest to select the study area in respect of research topic.

Objective

1. To search out the present sacred Jungle in tribal geography of West Bengal and give a relational analysis.
2. To explain the importance of Sacred Jungle in Natural resource management.

Hypothesis

1. Sacred Jungle conservation and nourishment is present among tribal society in West Bengal and have a significant relationship between these.
2. Sacred Jungle abides Natural resource management.

Methodology and Data Sources

Pre-field

Literature Review: The relevant write-ups have been collected from various literature, journals, magazines, published reports, articles, leaflets (hard copy), internet, etc. and those information help to pre-visualize and create a pre-mental image about all the aspects on this topic. Researcher studied several articles like “Sacred Jungles-the virgin forests” of A. Bijukumar; ‘Studies on Sacred Jungles and Taboos in Puruliya District of West Bengal’ of R. Basu; “Sacred Jungles of Western Ghats of India” of M. Gadgil and V. D. Vartak (1997); “Sacred Jungle in India” of Malhotra et. Al. ; religious beliefs” of M. Gadgil and V.D.Vartak (1973); “Sacred Jungles” of Geeti Sen (ed.); “Indigenous Vision, Peoples of India Attitudes to the Environment” of M. Gadgil and M. Chandran (1992); “Indian Agriculture and Climate Change Sensitivity, Global Environmental

Change” of K. Kumar and J. Parikh (2001); needs highlighted mentioned.

During Field

Sampling Method, Frame and Size: The primary data has been collected through an extensive Random Sampling method vis-a-vis “Quadrat method” (Bhakat and Sen, 2008, p.767). During counting the total number of Sacred Jungles in respect of geographical area (for comparative analysis between Sacred Jungles of plateau and hill-foot hill area) a special category has been applied i.e. atleast 100 km² area on land. The size of Sacred Jungle demarcation is not fixed anywhere but some measurements are used by different fellows. For example, R. Ray and T. V. Ramachandra (2010, p.1178-1180) used the criterion of its size, that is from West Medinipur, if the size is less than 1 hectare then it would be called as Small Sacred Jungle and if more than 1 hectare then it would be called as a larger Sacred Jungle. Again R. Basu (2008) demarcated the 400 km² atleast to mark it as Jungles from Bankura district. Again R. K. Bharat and U. K. Sen (2008, p.55-58) used 0.6 hectare in their article “ethno-medical plant conservation through Sacred Jungles in West Medinipur.” But in respect to whole of West Bengal, present researcher used 100 km² areas to mark a patch of forest as Jungles and not 1 hectare or 400 km² because he finds it suitable to call it as a dense jungle area of Puruliya, Bankura and West Medinipur districts, but this scale is not very much desirable for the whole of West Bengal. Moreover, in plain areas, the impact of uriculture is higher.

Units of Observation

In respect of geographical location: All districts of West Bengal during 2012-13

In respect of direction of research: Tribal Sacred Jungles

Data Collection

Primary: Field Survey 2012. **Secondary:** Research article, web, newspaper, tribal journals, magazine, District Hand Book, Statistical Hand Book.

Tools and Techniques for Collection of Various Categories of Proposed Data:

Questionnaire (open ended) and Interview (prefer to village headman)

: There are lots of areas in West Bengal that are inaccessible for different causes like geographically harsh, social or tribal restriction, lack of security or any communication network. A daily logbook on observed floral groups was maintained for this list, number and space. Digital camera (14x),

physical and political Maps (Govt. of India copyright, 2005, TAC Publisher of Kolkata, based on Survey of India Map) of West Bengal were used during the survey. Hunters and local people (more than 40 aged people, especially most elder persons of the villages) are interviewed for additional information on present and past

District	Name of the Village	Name of the Sacred Jungle	Tribal Tale / Myth	Age and size (Approx.)	Identity	Time of Worshipping	Sacrifice Associated or not	Traditional cultures (Rock/Tree/Tila/Soil/Jungle/tribal-Gods/Water worship-ping)	Name of the tribe	Traditional use of Sacred Jungles
A...										
...X										

Observation (direct): To find out the relation between Tribe and Sacred jungle the observation method has used promptly. Researcher covered total 6637 km for 37 days on motor-bike to observe the present sacred jungles of West Bengal. **Postfield:** Data has been presented with the process of analysis and descriptive statistical techniques, charts, photo and diagrams have been used.

Constraints of the Study

During field research some constraints have been found out by the researcher. These are: 1. geographically all areas of West Bengal are not accessible (ex. interior part of Jangalmahal, eastern Gopiballavpur, mountain area of Darjiling district etc.); 2. Socially and culturally some geo-pockets are not accepting this type of survey (tribal villages of Bankura, West Medinipur, and Puruliya district etc.); 3. Due to Political turmoil some areas are horrible (some portion of Nandigram, Singur, Jhilimili, Baghmundi, Ajodhya hill, and Balarampur etc.).

Result and Discussion

Tribal Sacred Jungles in West Bengal

Lodha: They form a peculiar possessiveness towards their tradition and love to keep it confined within their own community where locals are mere spectators. For example, in Lodhasol tribal village of Keshyari block of West Medinipur district, neighbour can enjoy only the rituals of tree

worshipping (Sal puja/worshipping of Sal tree/*Shorea robusta*, plate 1)



from far and they can't interfere directly into the tree-worshipping of Lodha tribes. Actually, the time of blossoming of Sal trees is the time of worshipping of Salai puja. Among Lodha tribes Manasa puja is also celebrated with pomp. For example, in Lodhasol village (the Lodha tribe oriented) of Keshiyari block (West Medinipur district), Bot tree (*Ficus benghalensis*) is being conserved for Manasa worshipping.

MURA: The tribal based Sacred Jungle are mainly Jungle-shaped and they have special rules. For example, Baghmundi, (Puruliya district) Sacred Jungle (plate 2) is found and within this jungle Marang Buru deity is worshipped by Mura tribes where females are not allowed to enter. Different trees are being conserved within this Sacred Jungle like: Sal (*Shorearobusta*), Akar (*Aquillaria malaccensis*), Simul (*Bombax indica*), Khejur (*Phoenix sylvestris*) etc. The nature of worshipping is completely nature oriented and people associate their sacred identification with their jungle erecting red flags. The mud horses and elephants are used by Mura tribe during the worshipping at a specific place within this jungle. In whole year, entry to this sacred area is completely restricted and only during Chaitrya month (only the day of worshipping) people can visit here.



Santal: In Santal community the worshipping is mainly confined under the clump of trees. Santal people maintain the sacred tradition of Marang Buru. It is said that He (Marang Buru) possesses the widest possible powers and is associated with both God and mischievous God-lings. Among Santals a tale is endorsed, that is, during the flood hazards they migrated to the peak of mountain to protect themselves and they believe the mountain to be the God who saved them from dying (flood hazard). But due to globalization the mountain worshipping of tribal people has changed and the Marang Buru festival is being maintained under the Sal trees (*Shorearobusta*) or Pakur trees (*Sicus infectoria*). Among them some examples are: Marang Buru puja of Khash jungle village of West Medinipur district, and Mokorkol village of Sarenga block of West Medinipur district

(plate 3) where people worship a *moram* rock and place the vowed horses under sacred Pakur tree. In Santal community the worshipping of Kali within the clump of trees is also prevalent in Saluni village of West Medinipur (plate 4) where different trees are being conserved such as:



Pakur (*Sicusinfectoria*), Eucalyptus (*Eucalyptus Globus*) and people worship the Goddess Kali on a 'holy place' and they believe that the enclosed trees this Sacred-Thaan is the abode of Devi, so, they conserve this Sacred Island as Sacred Jungle. They are supposed to preside over particular rural areas in which they live.

Another village deity is Monrenko Turuiko. The Santals believe that they were five brothers. They are supposedly responsible for the welfare of the village. His younger sister Gosane era constitutes a separate deity of Jaher Thaan (Holy Jungle) and is worshipped in a different hut, Jaher era, another sister of Monrenko is the Goddess of Jaher Thaan named after her. She has a stone assigned as her symbol. The Santals worship her for the general welfare of the village. So that their children may have good health, crops may grow in plenty and youths and maids of the tribe may be married quickly. Bandna means 'bandana' or worship. This festival is celebrated during Kali Puja in autumn. Bandna Parab welcomes Shashya Devi (Goddess of grains) by worshipping her through different rituals. On the basis of folk-Gods of particular tribe, different sacred trees are conserved. For example, in Mokorkol village of Sarenga block of Bankura district, Sidhu-Kanu-Hull festival was held under Pakur tree (*Sicus infectoria*) and through this way the Pakurtala/the shade with that tree became the part of Sacred Jungle. Folk-God means any human-being who may be treated as Gods or Goddesses when his/her activities will be popularized as the activity of God. Thus Sidhu and Kanu were the pioneers and pathfinders for the development of Santal community and these two persons are worshipped till now by Santal community. In this way several folk-tales are associated with Sacred Jungle. Some Adibashi people of Brahmandiha village in

Sarenga block of Bankura district (plate 5) maintained their traditional Sacred Jungle with the celebration of Masadbouni festival and in this way Ashwattha tree (*Ficus religiosa*) is being conserved for more than 100 years. People give the 'gift of mannat' or vow items to their God like black and brown coloured mud-made horses and elephants and all these are preserved in this Sacred Jungle throughout the year.



Loha: Among Loha tribe Sacred Jungle is also prominent. In Kurchidanga village (Bikrampur) of Sarenga block of Bankura district, Loha tribe worships the Gariasan thakur under the Ashwattha tree (*Ficus religiosa*). In Manikdipa village of Garbeta there are two Sacred Jungle are being conserved in the form of jungle and the Loha tribe performs the Ergakumari puja in the interior of this jungle. In this way, Chalta (*Dillenia indica*), and Sheora trees (*Streblus asper*) are being conserved (plate 6) here.



Bhumij: They are mainly found in Barabhum, Baghmundi, Patkum, and Dhalbhum of Puruliya district. They are nourishing different Sacred Jungle in the process of nourishing of folk-deities. For example, Bhansingh festival (there is no image of Bhansingh who is regarded as God to protect cattle, held during the Bengali month of Magh/15th January to 15th February), Akhan Jatra (first day of Magh is regarded as Akhan Jatra) and people believe as a very auspicious day.

Rabhas: Various spirits and natural objects pervade the religious world of the Rabhas. The main deity of the Rabhas is Rishi. Rishi, for the forest Rabhas as well as village Rabhas, is a male deity and is also known as Mahakal (for example, Chooto Mahakal dham of Jalpaiguri district).

Management of Natural Resources

Ecological:

A. Conservation of Trees:

Table 3: List of conserving Natural resources (Sacred Jungles, trees) among Tribal societies of West Bengal.

Name of Sacred	Conserving by tribal Jungle	Location community	Conserving trees	Name of Sacred	Conserving by tribal Jungle	Location community	Conserving trees
Bagra Thaan	Santal	Chipu village,	Mol, Sal	Gagoram, Bhansingh	Bhumij	Salboni, Puruliya district	Bot
Boram Thaan	Loha	Sarup Narayanpur village, Lalgarth, West Medinipur	Bot, Neem, Kuchla, Shera, Challa	Gagoram, Akhanjanjatra.	Bhumij	Chipu village, Manbazar, Puruliya district	Eucalyptus
Boram Thaan	Loha	Birkhara village, Lalgarth, West Medinipur district	Sal	Garamburi Thakur	Santal	Merechoki village, Khesariya, West Medinipur district	Kadam
Boram Thaan	Loha	Jhilimili, West Medinipur district	Sal	Gonamundi	Santal	Bastavpur Sonamukhi, Bankura district	Babla, Knegur, Geol
Burisani	Santal	Burisol village, Salboni, West Medinipur district	Bot, Akar	Grama Devi	Santal	Adra, Puruliya district	Sawra
Chullatala, Baram Thaan	Loha	Kushgeri village, Keshirya Block, West Medinipur district	Jalla	Grama Devi	Santal	Adra, Puruliya district	Monkurkur
Dakoitala	Santal	Gopiballavpur, West Medinipur district	Bot, Sheora Asathya	Gram Baba Thakur	Santal	Puruliya Municipality, Puruliya district	Abra

Egrakumari Puja	Loha	Manicdipa village, Garbeta, West Medinipur district	Sheora	Grama Devata	Santal	Cheta Sul village, Shimlapal Block, Bankura district	Khejur, Eucalyptus
Erosim	Santal	Talerbandh, Bankura district	Sal, Bhela	Grama Devata	Santal	Belpahari, West Medinipur district	
Erosim, Bamnaisala	Santal	Bamnaisala, Saltora, Bankura district	Ankra, Sheora, Kalikend	Grama Devata	Santal	Naya Basant, Dompura, Gopiballavpur, West Medinipur district	Karabi, Neem, Jalla
Erosim, Beldanga	Santal	Beldanga, Gangajalghati, Bankura district	Sal, Putla	Harihorsim, Erosim	Lodha	Shibkunda, Bankura district	Sal, Koen, Mohul
Erosim, Ox, son-in-law	Santal	Siberbandh, Bankura district	Sal, Sindha, Kurchi	Harihorsim,	Lodha	Nayagram, Jhargram P.O., West Medinipur district	Apang, Bael, Akarh, Kalmegh, Punamava, Latapalash, Thankuni, Churchuri, Kham Alu, Talmuli, Gurmar, Anantamul,
Jaher Thaan, Erosim	Santal, Koramudis	Gengari, Bankura district	Sal, Sindha	Manasa Thaan	Lodha	Lodhasola village, Keshirya Block, West Medinipur district	Bot

Jaher Thaan, Beldaburi	Santal	Hatibari village, Shimlapal Block, Bankura district	Sheora, Khejgur	Manasa	Santal	Choto Belun, Bardhaman district	Bael
Jaher Thaan, Bhadaspur	Santal	Bhadaspur, Saltora, Bankura district	Sheora, Ankra, Koitbael	Manasatala	Santal	Kurchidanga village, Bikrampur, Bankura district	Bamboo
Jaher Thaan,	Santal	Jaypur, Bankura district	Ankra, Challa, Koen, Mohul	Mahakal puja	Rabhas	Doars, Jalpaiguri district	Peepal, Kamala, Siris, Gamhar, Harra, Lychee
Jaher Meghna	Santal	Ranichok Gram, Amrakuchi, West Medinipur district	Pakur	Marang Buru	Santal	Soliwala, Bankura district	Asan, Koen, Mohul, Jaam
Jhar Boni	Santal	Baodi-Fatipursing, Garbeta, West Medinipur district	Tetul	Marang Buru	Santal	Majherdanga, Bankura district	Sal, Bahera
Kamar Mura	Mura	Jaipur, Puruliya district	Bot, Bael, Sal, Bamboo, Kolke	Marang Buru	Santal	Charidhagram, Baghmundi, Puruliya district	Sal, Kolke, Palash, Akar, Simul, Khejur
Kudratata	Majhi	Bel Sule village, Bishnupur, Bankura district	Sal	Marang Buru	Santal	Kulugora, Bankura district	Piasal, Simal, Aam
Latasini Thaan	Santal	Between Sorsai- Dantikka village, Lalgah, West Medinipur district	Challa	Marang Buru	Santal	Sarenga Block, Bankura district	Pakur

Lohatikri	Lodha	Lohatikri, Jhargram P.O., West Medinipur district	Kalmegh, Ishermul, Latakanchan, Punarnava, Latapalash, Thankuni, Churchuri, Talmuli, Parashu, Kham Alu, Bainchi, Gurmar, Anantamul, Bantulsi, Tulsi, Sheora, Kuchila	Salai	Lodha	Guptinani, Jhargram P.O., West Medinipur district	Kunch, Patari, Muktajhuri, Apang, Kalmegh, Kadam, Punarnava, Bandarlai, Churchuri, Parashu, Bainchi, Kurchi, Bherenda, Bantulsi, Tulsi
Maranburo	Santal	Digirtore, Khatra II, Bankura district	Lamk, Palash, Shishu	Marang Buru	Santal	Bamnisa, Saltora, Bankura district	Kend, Sal, Haritaki
Ma Ranan- giritala	Santal	Krishnanagar Barjara, Bankura district	Segun, Boric	Salai	Lodha	Muslo, Bankura district	Sal, Swet
Masad Bouni	Santal	Brahmandiha village, Bankura district		Salai	Lodha	Sarul, Natun Bandh, Bankura district	Sal, Koen, Mohul, Neem
Ox, Napitdanga	Santal	Napitdanga, Patrasaer, Bankura	Sal, Bahera	Salai Puja, Marang Buru	Santal	Khas Jangal Gram, Lalgah, West Medinipur district	Sal
Ox, Binodpur	Santal	Saltora, Bankura district	Sheora, Koit, Bael, Ankra	Salpuja	Lodha	Lodhasola village, Keshirya Block, West Medinipur	Sal

Ox, Son-in-law	Santal	Chalkdhava, Bankura district	Sal, Kurchi, Pial	Sarhul, Simalari	Munda	Bankura district	Koen, Mohul, Kend, Bainchi
Ox, Baishnab Bandh	Santal	Baishnab Bandh, Bankura district	Sal, Aam, Pial	Sarhul,	Munda	Siakuldaba, Bankura district	Lamk, Palash, Sal, Sheora
Rangini Thaan Kora		Khatra Block, Bankura district	Sal, Pakur	Sidhu-Kanu Hul Puja	Santal	Ramnagar P.O., Mura Gram, Lalgarg, West Medinipur district	Pakur
Raibagheshwari Thaan	Santal	Raibadhni Gram, Puruliya district	Peepal	Sidua	Santal	Satmahani village, Gopiballavpur, West Medinipur district	Bot, Sheora
Salai	Lodha	Krishnerdanga, Bankura district	Sal, Bahera	Son-in-law	Santal	Bamnisa, Saltora, Bankura district	Ankra, Sheora, Palash
Salai	Lodha	Dalangora, Taldangra, Taldanga block, Bankura district	Sal, Palash, Lamk	Son-in-law	Santal	Chandipur, Bankura district	Kend, Sal, Sheora
Salai	Lodha	Dhadkidanga, Bankura district	Sal, Chakalda, Neem				

Source: Field survey, 2010-2012.

B. Nourishment of Faunal diversity:

Table 3.1. : List of present faunal conservation through Sacred Jungles in West Bengal.

Birds	Animals	Reptiles
Baran Owl	Bat	Earthworm
Bengal Vulture	Buffalo	Lizard
Common Pariah Kite	Cat	Snail
Fowl	Cow	Tadpole
House Crow	Dog	Toad centipede
House Sparrow	Fox	Water snake
Indian Myna	Goat	Insects
Koel	Jackal	Black bee
Owl	Languor	Butterfly
Pied Crested Cuckoo	Mongoose	Fly
Pigeon	Monkey	Cockroach
Ring Dove	Mouse	Cricket
Roufus Woodpecker	Squirrel	Fly
Sarus Crane	Wolf	Lee Grasshopper
Tailor Bird		Scorpion
Veseringed Parakeet		Wasp mosquito
White Breasted Water Hen		White ant

Source: Field survey, 2010-2012.

C. Water Resource Management: "Sacred Jungles prevent the spread of deserts and has excellent water retention capacity" (Kumar, 1998, p.10, 13). That the Sacred Jungles with good canopy cover and litter layers in West Bengal have significant role in moisture retention as well as in maintaining hydrological regime is evident from perennial streams and higher ground water table. Long term monitoring is required to substantiate the linkages between ecology, biodiversity with hydrology at local and regional levels.

D. Soil Resource Management: According to official website of Kerala Forests and Wildlife Department, "Sacred Jungles that are situated in the middle of the human habitation are responsible for conserving water and soil" (Kerala Forest and Wildlife Department, 2009). This is evident

from the perennial nature of ponds, wells and tanks, which are situated within the Sacred Jungles. The fertility of the agro-ecosystems is very high due to the humus and nutrients generated in the Sacred Jungles. Sacred Jungles improve soil stability, prevent top-soil erosion, and provide irrigation for agriculture in drier climates. It helps in improving the soil fertility through efficient nutrient cycling, conserving soil moisture through building up humus in the soil and partly through a deeply penetration root-system which has root-biomass uniformly distributed through the soil profile. Sacred trees check the soil erosion and soil fertility at deeper level of soil horizon.

Relation between Tribal People, Sacred Jungle and Natural Resource

Management: In tribal society the per capita nourishment of Sacred Jungle is higher comparative to all religions because tribal society mainly practices the traditional worshipping methods and the result is like 1 tribal person are conserving 2 Sacred Jungle averagely in West Bengal (on the basis of my research, 2010-13). In tribal societies, religion began as conglomeration of ideas, attitudes, creeds and acts of super-naturalism, beyond the realm of the normal. In early tribal societies of the world, this rudimentary form of religion played an important part in the life of the community. They have their set of community activities to ensure safety, security and prosperity which is attached with their Sacred Jungle nourishing. Flora in the forests preserved on the basis of such religious beliefs is rich. “These Sacred Jungle in tribal areas are worshipped in different religious functions and plays an important role in social and cultural avenue. This tradition also helps to maintain ecological balance and support climax vegetation” (Kumbhojkar et al., 1996, p.349-351). Deb and Malhotra (1997, p.157-163) report that, among the tribals of south-west Bengal, social gatherings take place in these Jungle on the occasion of Salui and Karam festivals, as well as wedding ceremonies. On the basis of different folk-Gods tribal-folks arrange their Sacred Jungle. For example, the popular Gods of Santal tribe is: Marang Buru, Moreko, Jair era, Gosain era, Pargana, Manjhi. All the Gods have their allotted place in the Sacred Jungle, and are worshipped only in public place. Marang Buru alone is also worshipped privately in the family. Another example of folk-deity is attached with Sacred Jungle formation, i.e. Gramadevata. No temples existed in India during the Vedic period. They were not to be found in the Pre-Buddhist period except for some wooden ones. “The various Gods and Goddesses whom the indigenous population of West Bengal worshipped, was not accustomed to dwell in the secluded atmosphere of temples; they loved the open air. The deity may be in the shadow of a big tree. Generally they are lodged in small

shrines. The concept of the worship of the Gramadevata first became popular among the tribals” (Tiwari, 2002, p.109). In a good number of villages, no object is placed to represent the deity and the tree itself is regarded as the embodiment of the deity among tribal society. Sacred Jungle is the property of tribal community. In tribal Sacred Jungle, the anthropomorphic idols are very rare. Their deities are mountain, termite mound, trees, animals of the forest and rivers-untamed nature. According to tribal folklore, they don't venture into these forests alone. Traditional belief among tribal groups is that it is a sin to cut trees, break leaves and pluck flowers from there Sacred Jungle. Tribes are the integrated part of the nature oriented culture. Sacred Jungle are basically related with tribe and their life. From the whole survey more than 63 tribal Sacred Jungle have been observed. The basic characteristics of these Sacred Jungle are: the complete nature bourn, the core center of their culture and the identity of their tribal life.

Management of Natural Resource like Sacred Jungle: *“Belief systems are like whole boats in the water; it is extremely difficult to alter them all at once e.g. it may be too stressful, or people may maintain their biases without realizing it” (Glover, 2011).* Time and space always follow the dynamism and for this society and its cultural traditions like Sacred Jungle have been modified partially or in some cases totally from their material-identity. Human's unbounded demand-desire, modern aspiration, unmethodical land-use, altering perception about eco-environmentalism, and aggressive philosophy about environment is destroying the eco-thought of Sacred Jungle. And we are going to be quite incapable to find out our traditional wisdom, cultures, traditional rituals-rules-beliefs and perceptions from our social geography and the identity crisis has been evolved with the following diagram (no. 1) and figure (no. 1). *“Man does not have the right to destroy what he cannot create.” -Granth Sahib* (The religious text of Sikkim, Wikipedia, 2012). Sacred Jungle are declining at an alarming rate across the country due to population pressure, changing value and rapid economic growth. It is very important to identify and protect the “Sacred Jungle to save nature in its pristine form” (Khurana, 1998, p.34-38).

Women empowerment should be the concept as because they are believed to be conservative, deep thinker, perfectly ritualistic, eco-friendly minded, keen on religion, ardent religious minded, nature lover and good eco-planner(diagram 1). For example, India's largest Sacred Jungle is Mawphlang Sacred Jungle of East Khasi hill in Meghalaya, where worshipping is completely conducted by women group and the rank of



Plate 7: Erosim in Puruliya district.

this Sacred Jungle tells us how effective it would be if the planning and the maintenance is conducted by them. Other two examples such as Tea cultivation and *Tulsitala*/basil plant worshipping are mainly maintained by female group since a long time in India. In *Nabanna* festival of Hindu society, the court-yard painting by liquid dust rice is still maintained by female encouragement even in this globalised era. “Regarding the gender of the priest, it appears that without an exception the priesthood rests with males” (Godbole et al, 1998; p.233, p.365). “In West Bengal and Orissa practically no role of women can be traced out in the management of Sacred Jungle environment” (Deb et al., 1992). The data in terms to the access to Sacred Jungle by women are very rare and scanty (only 1 Sacred Jungle is being maintained in Chandrakona of West Medinipur). It appears that generally women are not permitted into the Sacred Jungle after attaining puberty as in the case of Marang Buru Sacred Jungle in Baghmundi of Purulia and Bagratata in Dhallaha of Birbhum (plate 8). Same as West Bengal, “the scenario of the whole of India is very poor. Roy (1912), while describing Sacred Jungle among the Oraon of Chhotanagpur mentioned that the main festival associated with Sarana is Sarhul; where women are not allowed but can take part in dance at the *akhara* which is located close to the Jungle”. Roy and Burman (1996) have reported similar phenomena among the *Mahadeo Koils* of Pune and among the *Kunbis* of Kolhapur district in Maharashtra. Malhotra (1990, p.439) observed taboo against entry of women in the Sacred Jungle among the tribes of south of West Bengal and among the tribes of Koraput district of Orissa. It will be of immense value to examine whether women are represented in numerous trust bodies that are managing Sacred Jungle, particularly in Maharashtra, Kerala, and Karnataka.

- “Participation of the local community and village councils is essential for the successful implementation of such proposal. This

type of activity has been implemented in Haryali Jungle of Garhwal and is managed by a temple committee consisting of members of three villages” (Sinha and Saxena, 1998. P. 289-300, p.277). Every individual can make a small, though significant effort in the race to save our planet and conserve biodiversity.

- Man is only yet another nature’s creatures and not an alien to other life-forms. *Man has no more right to destroy nature than any other being.* We should treat all animals and plants of Sacred Jungle with composition.
- The Gandhian line can be reminded that “*There is enough in the world for everybody’s need, but there cannot be enough for everybody’s greed*” (Datta and Sundharam, 1965, P. 258). In the middle of the 21st century, we would see the last of the primary tropical forests and the extinction of over half of the 1.4 million species.

Thus we have to track the Tagore’s line about relation between urbanization and tree-culture that is: “*Dao phire se aranya loha ei nagar*” (in regional language) *Bring back the forest and take this city centric civilization* [Tagore, 1895. Chaitali: poem Sabhyatar Prati, p.18]. So with the above line it can be said that due to urbanization the identity of Sacred Jungle are diminishing and in this situation again we have to move in the way of the *aranya* of traditional culture of Sacred Jungle.

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15

Homegardens: Traditional Systems for Maintenance of Biodiversity in Kolashib District of Mizoram, Northeast India

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Abstract

Forty five homegardens (size from 0.035ha to 2 ha) positioned in Kolashib district of Mizoram in North-East India was studied for their species composition, use in relation to livelihood support and garden size, energy input and output and role in maintenance of plant biodiversity. The methods employed for the study included semi-structured interviews, direct observation, vegetation inventory and process analysis on energy input and outputs. A total of 162 plant species (77 tree species, 18 shrubs and 62 herbs) belonging to 58 families was recorded with thirty families represented by a single species, of which thirty plant families were represented by a single species and 12 families represented by more than 5 species, was recorded. The size of home gardens and species richness was positively correlated ($r=0.29$, $p<0.001$). Shannon Weiner index ($H'=3.81$) revealed that large gardens had higher tree diversity than the medium and small homegardens. Species richness was observed to be higher (99 species) in large garden than medium (89 species) and small garden (68 species). Evenness index for trees, shrubs and herbs varied widely among the homegardens (for trees 0.748 (large homegardens, for shrubs 0.413 in small homegardens). The energy output and input ratio was highest (58) in large home garden and lowest (27) in small garden and the contribution of the large home gardens to household income was 52% while for small garden it was 27%. This study suggests that home

gardens are production system maintained purposively for harvesting diverse products and are important avenues for species conservation and food security at household level.

Key words: Agroecosystem, home garden energetics, plant diversity, species composition.

Introduction

Homegardens are traditional agroecosystems close to human dwellings in many tropical countries (Hamilton & Hamilton 2006; Peyre *et al.* 2006; Niñez 1987). They are usually characterized by high biodiversity of trees, shrubs, vines and herbaceous plants, with multiple functions and roles, complex structures, and ecological and socioeconomic sustainability (Lamont *et al.* 1999; Padoch & De Jong 1991; Rico *et al.* 1990; Sahoo *et al.* 2012; Zaldivar *et al.* 2002). These gardens are planted and maintained by members of the household and their products are intended primarily for household consumption. Because of their great contribution to indigenous people's livelihoods, biodiversity conservation, ecological and economic functions, and modern agrosience, homegardens have been receiving increasing attention from scientists, especially ethnobotanists, but are still under-researched (Pandey *et al.* 2006). Recognising these benefits many have sought to promote homegardening as part of efforts to improve food security and nutrition, strengthening livelihoods, and increase poor communities resilience to wide range of shocks including climate change impacts (Buchmann 2009). Many managed landscapes and tree-dominated habitats such as natural forest patches (Schelhas & Greenberg 1996) or agroforests (Mendez & Bacon 2005; Saikia *et al.* 2012) often have shown promising result for biodiversity conservation all over the world.

These systems are probably evolved through generations of gradual intensification of cropping in response to increasing human pressure and the corresponding shortage of arable lands (Kumar & Nair 2004) are as old as shifting cultivation practiced in most south Asian countries. According to Harlan (1975) plant domestication most likely began around the dwellings of human settlements. The increased availability of water, better soil fertility due to organic waste inputs, and easier protection of the crops against animals etc around the home compound must have facilitated the concept of home gardens from the early days and this process fairly continues till days, especially in parts of the world where there is still ample plant diversity available and where a 'natural' link between gardens and nature exist (Pandey *et al.* 2006; Singh 1987). Home gardens play an important role in food security and nutrition, especially when food supplies are inadequate or unreliable. In Mizoram context, while shifting cultivation

has been researched well for their socio-ecological bearings in Mizoram (Singh, 1996), very little attention is given to the homegardens (Sahoo 2009; Sahoo *et al.* 2010). Notwithstanding the homegardens are typical indigenous agroforestry systems in both rural and urban settings where people have been cultivating, managing, and conserving diverse plants in and around their houses for alternative sources of forest products and services, supporting the idea that these managed patches could be of significant conservation value. It is thus important to know to what extent these managed landscapes could hold biodiversity value and help meet the people their various needs.

The paper presents species composition, diversity, use of home garden plants and their role in biodiversity conservation and other functional aspects in relation to livelihood support of the people

Materials and Methods

Study site

Three villages viz Vairengte, Kolasib and Thingdawl located in Kolashib district were selected and a minimum of 15 homegardens (five each from small, medium and large category) were selected randomly from each of the three village totalling 45 homegardens (Fig. 1), for a detailed study on homegarden structural and functional characteristics. The physical and microclimatic variables of the study sites are given in Table 1.

Table 1. Physical and microclimatic characteristics of the home gardens of Kolashib district of Mizoram.

Parameters	Vairengate	Kolashib	Thingdawl
Latitude (Range)	24°07'45.9"-	24°08'34.6"-	24°10'37.3"-
	24°13'10.4" N	24°14'48.7" N	24°30'03.4" N
Longitude (Range)	92°40'29.5"-	92°41'01.4"-	92°34'35.2"-
	92°41'36.0" E	92°41'32.8" E	92°45'44.5" E
Mean altitude (m; asl)	710	617	307
Air temperature (°C)	25.0 ± 0.4	25.8 ± 0.4	26.4 ± 0.6
Soil temperature (°C)	32.0 ± 0.8	30.6 ± 0.4	31.2 ± 0.4
Light intensity (Lux)	12560± 8012	4873±752	12000±5123
Relative humidity (%)	77.07±3.10	75.36±1.30	76.03±2.80

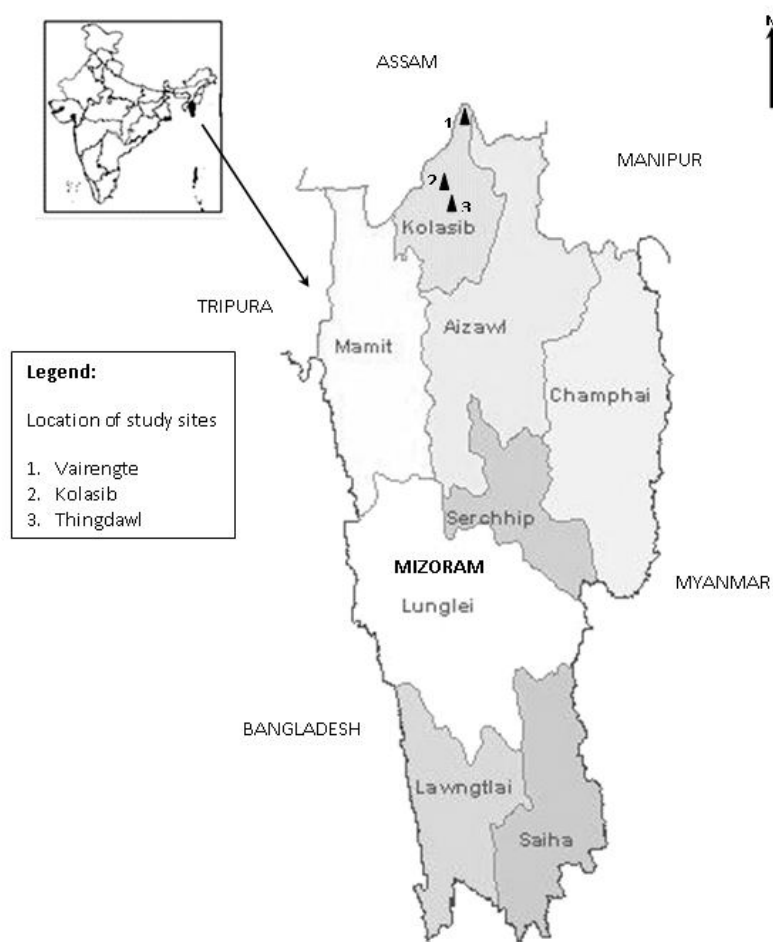


Fig. 1. Map showing the location of study sites in five districts of Mizoram (not to scale)

Vegetation analysis

In all the home gardens, density, frequency and basal area of different plant species were measured using 10 regularly placed quadrats (10m x 10m) for trees, randomly placed twenty-five quadrats for (5m x 5m) shrubs and herbaceous (1m x 1m) species. Nomenclature of the plant species followed Hooker (1875). Girth at breast height (above 1.37 m height) of all trees was measured. Basal diameter of shrubs and herbs was measured by vernier-calliper. The vegetational data were analysed for relative frequency, relative dominance and relative density (Phillips 1959). The sum of relative frequency, relative dominance and relative density was calculated as importance value index (IVI) of individual species (Curtis

1959). Species diversity (Margalef 1958) was calculated as: $H' = -\sum \{(n_i/N) \log_e (n_i/N)\}$, where H' =Shannon index of general diversity, n_i =IVI of a species, N = Total IVI of the community (i.e. 300) (Shannon & Weiner 1963). The dominance index (Simpson 1949) of the community was calculated as: $C = \sum \{(n_i/N)^2\}$, where C =dominance index, n_i and N are same as for Shannon's index. Pielou's (1966) evenness index (e) was calculated as: $e = H'/\log S$, where H' = Shannon's index of diversity, and S = Total number of species. Sorensen's similarity index (Sorensen 1948) was calculated as, $[2C/(A+B)] \times 100$, where, A and B are the total species content (trees, shrubs or herbs) in stand A and B respectively, while C is the number of species common to both stands. The ratio of abundance to frequency is a relative measure of degree of contagiousness of the distribution of species (Whitford 1949). According to Curtis & Cottam (1956), the ratio below 0.025 would indicate regular distribution; between 0.025-0.05 indicate random distribution and more than 0.05 contagious distributions and this is used to characterize the species distribution patterns. Physico-chemical properties of the soil of differently sized homegardens were analysed following Misra (1968).

Energy, economic inputs and outputs

Observations of energy and economic input and output for all the homegarden activities and products were made over a 2-year period, only in twelve households, four in each of the three categories (small, medium and large) as these twelve households were enthusiastic and ready to co-operate for the study. Each homegarden system was considered as a functional unit. The inputs were human labour, seeds and manure while the output was the crop productivity. Questionnaires were filled in and sample weighing was done in the fields. Questionnaire also included a set of questions on the socio-economy, demography, sale of the garden products and management aspects of the garden. Cropping pattern in different seasons was noted.

A process analysis was used to measure energy flow (Fluck 1992) adding human work contributions (Odum 1996). Internal and external inputs were measured in Mega Joules (MJ). These were estimated by extrapolating standard energy values (Gopalan *et al*, 1982; Mitchell 1979; Mittal and Dhavan 1989). The input of energy through seeds was calculated on the basis of total energy expended to produce that fraction of the crop yield. The economic yield per hectare in all cases was calculated on the basis of the entire plot. For calculating the output of energy the total economic yield of various crops was converted into mega joules of energy by

multiplying with similar standard values. The energy efficiency of each system was calculated as the output/input ratio.

Input of household labour is a component that needs to be factored to an economic valuation. For the purpose of this study, opportunity cost of household labour is calculated as a function of time, $OC_{HL} = f(t * \text{labour rate})$, where t is the time spent in the garden. The opportunity costs of land have been assigned values equivalent to the rate at which farmers were able to lease out all or parts of their lands. This rent was calculated to be an average of Rs 9500 per hectare of the land per year. For monetary input/output analysis, labour charge was calculated on the basis of prevailing daily rates of Rs. 70. The monetary returns in terms of crops, feed, milk, egg and organic manure were calculated based on prevailing market price for each commodity.

Results and discussion

Homegardens in all the three villages surveyed irrespective of their sizes are excellent demonstrations of the importance of ecosystem diversity for the evolution and conservation of plant genetic resources. In the sampled area a wide variation in homegarden size was encountered and suitably grouped into small (0.10-0.20 ha), medium (0.20-0.50 ha) and large (0.50- $\geq$ 1.00 ha). Studies on homegarden systems from different ecological and geographical regions showed that the worldwide average size of homegarden units is around 0.10–0.50 ha. Soil pH was acidic in all gardens; soil organic carbon, Total keldahl nitrogen, ammonium-N, nitrate-N and available P registered lower values in the smaller garden and increasing values with increase in garden size (Table 2) are attributed to the difference in plant species composition.

Table 2. Soil physico-chemical properties of the home gardens of Kolashib district in Mizoram.

Parameters	HOME GARDENS					
	Large		Medium		Small	
	0-15	15-30	0-15	15-30	0-15	15-30
Moisture content (%)	27.9 $\pm$ 0.15	23.17 $\pm$ 0.78	25.93 $\pm$ 0.91	23.86 $\pm$ 2.94	21.96 $\pm$ 1.93	18.93 $\pm$ 0.53
WHC (%)	64.48 $\pm$ 2.03	57.03 $\pm$ 2.29	61.44 $\pm$ 2.95	57.63 $\pm$ 1.1	56.97 $\pm$ 1.42	55.86 $\pm$ 3.67
Soil texture						
Sand (%)	55.24 $\pm$ 3.12	53.84 $\pm$ 3.01	58.32 $\pm$ 2.54	58.13 $\pm$ 4.19	64.43 $\pm$ 3.98	63.19 $\pm$ 3.77
Silt (%)	33.84 $\pm$ 2.87	34.09 $\pm$ 2.84	28.86 $\pm$ 1.29	28.17 $\pm$ 1.48	27.69 $\pm$ 3.07	28.37 $\pm$ 2.65

Clay (%)	10.92±0.91	11.97±1.281	12.82±1.48	13.69±2.45	7.90±0.94	8.43±1.15
Textural class	Loamy sand	Loamy sand	Sandy loam	Sandy loam	Sandy loam	Sandy loam
pH	5.03±0.05	4.78±0.008	5.15±0.02	5.12±0.02	4.77±0.02	4.95±0.02
SOC (%)	2.09±0.15	1.07±0.11	1.81±0.08	1.25±0.02	1.26±0.1	1.01±0.04
SOM (%)	3.6±0.27	11.84±0.19	3.12±0.14	2.15±0.04	2.18±0.18	1.74±0.08
TKN (%)	0.58±0.06	0.43±0.03	0.40±0.02	0.33±0.02	0.23±0.02	0.16±0.01
C/N ratio	3.68±0.56	2.60±0.54	4.24±0.44	3.72±0.30	6.84±0.43	6.30±1.04
NO ₃ -N (µg g ⁻¹)	8.64±0.26	6.17±0.88	6.22±0.49	5.60±0.05	3.36±0.23	2.76±0.10
NH ₄ -N (µg g ⁻¹)	5.74±0.23	5.18±0.41	3.39±0.30	2.58±0.12	3.31±0.12	2.45±0.09
PO ₄ -P (µg g ⁻¹)	7.05±1.53	4.95±0.08	5.71±0.33	5.11±0.22	3.61±0.58	2.23±0.69

WHC-Water holding capacity, SOC-Soil organic carbon; SOM- Soil organic matter; TKN-Total Kjeldahl nitrogen.

Structural composition and dynamics of the homegardens

A total of 162 plant species (77 tree species, 18 shrubs and 62 herbs) belonging to 58 families were recorded from the sampled homegardens in the district (Fig. 2). Thirty families of plants were represented by a single species, while 12 families were represented by more than 5 species. Cucurbitaceae, Euphorbiaceae, Gramineae, Malvaceae, Moraceae, Myrtaceae, Palmae, Papilionaceae, Rosaceae, Rutaceae, Solanaceae and Verbenaceae were the most dominant families

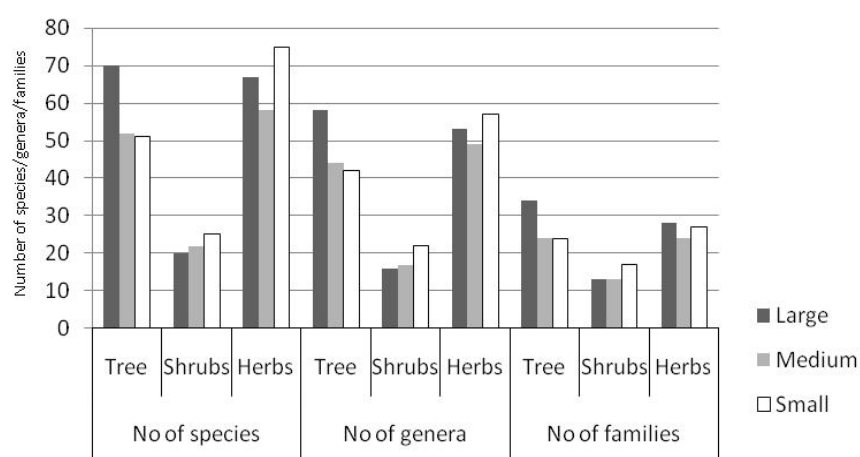


Fig. 2 Plant diversity in different homegarden size categories (large, medium and small) in Kolashib district of Mizoram.

in these home gardens (Fig. 3-5). From a total 58 plant families recorded, Euphorbiaceae had the highest species number (11) followed by Solanaceae, Cucurbitaceae and Gramineae (8 each). Forty nine tree species were distributed in 38 genera and 28 families in the large home garden, followed by 38 tree species belonging to 33 genera and 23 families in the medium size home garden and 35 tree species, 32 genera and 21 families in the small home garden respectively. Twelve tree species (16%) were common to all the homegardens types and *Carrica papaya*, *Musa paradisiaca* and *Clerodendrum colebrookianum* were found in the entire home garden

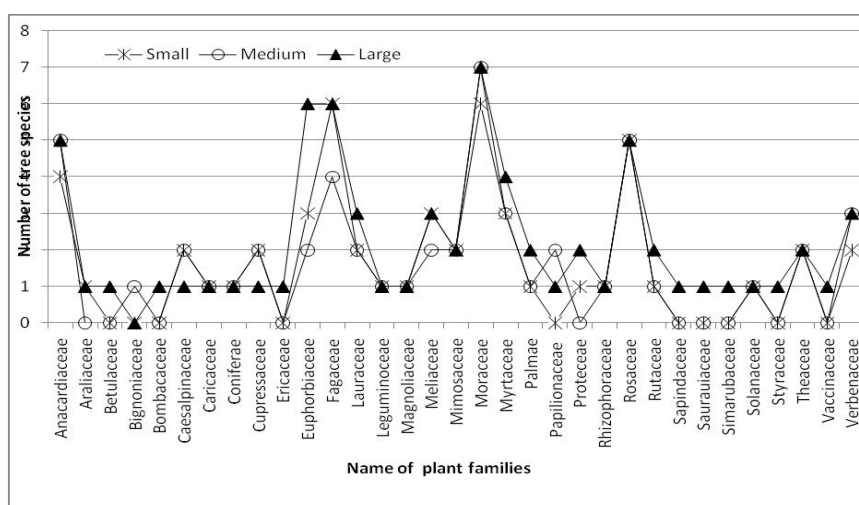


Fig. 3. Distribution of tree species under different families in different homegarden categories in Kolashib district of Mizoram

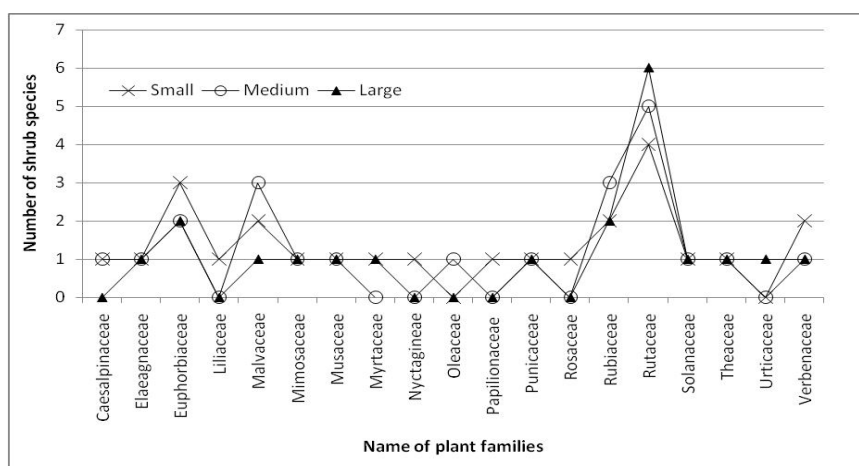


Fig. 4. Distribution of shrub species under different families in different homegarden categories in Kolashib district of Mizoram

sampled. Species like *Curcuma longa*, *Brassica juncea*, *Hibiscus sabdariffa*, *Eryngium foetida*, *Cocos nucifera*, *Colocasia esculenta*, *Trevesia palmata*, *Artocarpus heterophyllus* and *Cucurbita maxima* were recorded in more than 70% of the homegardens surveyed in the district.

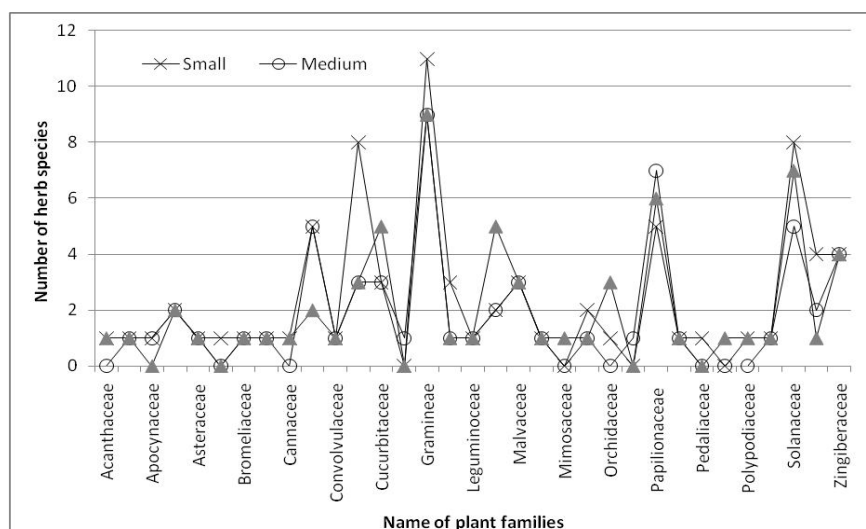


Fig. 5. Distribution of herb species under different families in different homegarden categories in Kolashib district of Mizoram.

Diversity index for trees was maximum in large homegardens (3.81) followed by small (3.51) and medium (3.49) homegardens (Table 3). Least species diversity was recorded for shrubs in small homegardens (2.03). Evenness index for trees, shrubs and herbs vary widely among the homegardens and it was maximum for trees (0.748) in large homegardens and minimum for shrubs in small homegardens (0.413) (Table 3). Similarity index for trees, shrubs and herbs among medium and large homegarden were comparatively higher than others (Table 4). The mean tree species in traditional home gardens of Mizoram is *ca.* 40; shrubs *ca.* 33 and herbs *ca.* 72 individual per home garden. Overall, the plants species (herbs, shrubs and trees) were distributed contagiously (100%). The distribution pattern of tree species is contagious in agroforestry home gardens ecosystem, revealing the absence of a regular and random distribution pattern. A contagious or clumped distribution of trees, shrubs and herbs is an indication of clusteredness of species throughout the indigenous home gardens and the contagious distribution has been accepted as more a characteristic pattern of plant occurrence in nature (Odum 1996). Thus, it is evident that the farmers have understood this natural concept through time and have adopted the strategy for introducing tree species into their home gardens.

The species diversity of trees was more in large home garden, followed by medium and small home garden and the similar trend was also recorded for shrubs and herbs species. Species diversity index values in the homegardens is high and the diversity index in the present study was higher than that of the index value of 3.93 in the homegardens of Sri Lanka, 1.9-2.7 in the homegardens of Thailand (Gajaseneni & Gajaseneni 1999) and the value of 3.21 in Karnataka (Shastri *et al.* 2002). The diversity increased with increase in holding size. Mendez *et al.* (2001) in their study of Nicaraguan homegardens also reported that higher number of species was found in the larger homegardens. Also the Evenness value in the present study is much higher than the recorded value of 0.282-0.705 in Kerala homegardens (Kumar *et al.* 1994). The high species richness index in the home gardens of Mizoram indicates that the number of species in the area is very high and also the distribution of individuals in all the species is significant with low dominance. Also the higher index value indicates that the system is more stable and mature and therefore self-sustaining and has the capacity to generate high production output under low input conditions. The high diversity in the homegardens is the result of selection of species by the owners with utility of the specific products as the main criterion. The diversity recorded by them was comparable to our results. Besides climatic and geographic location, the species diversity also depends on site representativeness; plot dimension, various attributes and the extent of human interaction in the past and present. Trees species diversity and richness was also closely related with soil fertility level, particularly the soil organic matter.

Table 3. Phytosociological analysis and community indices of large, medium and small home gardens in Kolasib district of Mizoram.

Parameters		Home gardens		
		Large	Medium	Small
Diversity index	Trees	3.81	3.49	3.51
	Shrubs	2.35	2.34	2.03
	Herbs	3.59	3.6	3.21
Dominance index	Trees	0.32	0.37	0.37
	Shrubs	0.52	0.52	0.53
	Herbs	0.36	0.36	0.41
Evenness index	Trees	0.748	0.686	0.688
	Shrubs	0.462	0.452	0.413
	Herbs	0.629	0.708	0.708

Table 4. Similarity indices between tree, shrub and herb components of two of the three different types of home gardens in Kolaship district of Mizoram

		Home Garden	
		Medium	Small
Large	Tree	52.874	42.857
	Shrubs	54.546	33.333
	Herbs	45.570	43.077
Medium	Tree		38.357
	Shrubs		44.444
	Herbs		48.485

Total tree density (Table 5) was higher in the large home garden (294 individual ha⁻¹) and followed by medium size home gardens (248 individual ha⁻¹) and small home garden (182 individual ha⁻¹). The density of tree species was greater in the large home gardens as compared to the other gardens. The shrub and herb layer were well represented in all the home gardens with a basal area contribution of 7.32% and 2.46% respectively in the large home gardens, 2.39% and 1.48% in the medium size home gardens and 0.72% and 0.88% in the small sized home gardens. In the large home gardens *Schima wallichii* (IVI 9.321 and density 5.8 individual ha⁻¹), *Melia azedaratchta* (IVI 9.125 and density 6.2 individual ha⁻¹), *Samania saman* (IVI 8.728 and density 2.7 individual ha⁻¹), *Saprosma ternatum* (IVI 7.980 and density 2.2 individual ha⁻¹), *Mimusops elengi* (IVI 7.564 and density 8.0 individual ha⁻¹), *Persea americana* (IVI 7.431 and density 9.3 individual ha⁻¹) and *Artocarpus heterophyllus* (IVI 5.703 and density 7.1 individual ha⁻¹) were the dominant tree species. In the medium home gardens species like *Areca cathechu* (IVI 10.485 and density 27.1 individual ha⁻¹), *Tamarindus indica* (IVI 10.238 and density 8.0 individual ha⁻¹), *Duabanga sonneratioides* (IVI 10.204 and density 4.0 individual ha⁻¹), *Mangifera indica* (IVI 9.568 and density 8.9 individual ha⁻¹); *Parkia timoriana* (IVI 8.742 and density 13.3 individual ha⁻¹), *Gmelina arborea* (IVI 7.848 and density 8.4 individual ha⁻¹), *Citrus anamensis* (IVI 7.234 and density 11.6 individual ha⁻¹), *Psidium guajava* (IVI 6.783 and density 11.6 individual ha⁻¹) were the dominant tree species and the small size home gardens species like *Mangifera indica* (IVI 15.067 and density 6.7 individual ha⁻¹), *Psidium guajava* (IVI 11.157 and density 8.9 individual ha⁻¹), *Artocarpus heterophyllus* (IVI 10.746 and density 7.6 individual ha⁻¹), *Schima wallichii* (IVI 10.699 and density 6.9 individual ha⁻¹), *Parkia timoriana* (IVI 10.475 and density 4.9 individual ha⁻¹), *Semecarpus*

Table 5. Importance value index (IVI), density (D, individual ha⁻¹) and basal area (BA, m² ha⁻¹) of herbaceous species in the three home gardens of Kolashib district of Mizoram.

Name of the species	Large home garden			Medium home garden			Small home garden		
	IVI	D	BA	IVI	D	BA	IVI	D	BA
<i>Abelmoschus esculentus</i> (L.) Moe.	3.736	1066.7	0.005	6.130	977.8	0.017	6.481	577.8	0.006
<i>Adiantum philippense</i> L.	-	-	-	4.676	711.1	0.012	-	-	-
<i>Ageratum conyzoides</i> L.	4.838	1555.6	0.005	6.677	1777.8	0.002	10.980	2088.9	0.002
<i>Allium cepa</i> L.	4.967	1644.4	0.001	6.185	1511.1	0.007	9.950	1911.1	0.007
<i>Allium hookerii</i> Thw.	5.831	2133.3	0.003	6.172	1555.6	0.004	12.767	2355.6	0.004
<i>Allium sativum</i> L.	3.160	977.8	0.000	-	-	-	-	-	-
<i>Annanas comosus</i> (L.) Merrill	2.332	533.3	0.001	-	-	-	59.609	533.3	0.291
<i>Arundina graminifolia</i>	3.462	888.9	0.006	-	-	-	-	-	-
<i>Asparagus racemosus</i> L.	1.841	444.4	0.001	-	-	-	-	-	-
<i>Bidens biternata</i> (Lour) Merr	2.895	800.0	0.001	-	-	-	-	-	-
<i>Blumea alata</i> D.Don.	3.256	977.8	0.006	-	-	-	-	-	-
<i>Boehmeria rugulosa</i> Wedd.	2.220	444.4	0.002	2.707	444.4	0.002	-	-	-
<i>Brasica juncea</i> L.	4.760	1644.4	0.001	10.264	1777.8	0.042	10.355	1466.7	0.007
<i>Brassica botrytis</i> L.	4.6551	644.4	0.002	-	-	-	8.991	1111.1	0.010
<i>Brassica campestris</i> L.	3.280	1155.6	0.001	6.828	1511.1	0.011	8.195	1111.1	0.008

<i>Brassica oleracea</i> L.	2.365	533.3	0.002	7.461	1777.8	0.010	12.401	1644.4	0.019
<i>Brassica rapa</i> L.	3.469	1022.2	0.001	10.747	1644.4	0.048	9.107	1111.1	0.015
<i>Calamus acanthospathus</i> Griff.	2.819	711.1	0.002	-	-	-	-	-	-
<i>Calamus erectus</i> Roxb	-	-	-	22.732	266.7	0.213	-	-	-
<i>Calamus gurbu</i> Buch.-Ham.	2.767	488.9	0.019	-	-	-	-	-	-
<i>Calamus tenuis</i> Roxb.	40.083	1200.0	0.756	-	-	-	-	-	-
<i>Canavalia ensiformis</i> (L.) DC.	-	-	-	1.787	88.9	0.011	-	-	-
<i>Canna orientalis</i> Roscoe	1.556	400.0	0.001	-	-	-	-	-	-
<i>Centella asiatica</i> (L.) Urban.	5.882	2622.2	0.003	7.467	2000.0	0.008	8.904	1600.0	0.001
<i>Chimnocalamus fimbriatus</i> Hsueh & T.P.Yi	1.422	355.6	0.003	-	-	-	-	-	-
<i>Colocasia affinis</i> L.	6.403	1866.7	0.027	-	-	-	-	-	-
<i>Colocasia esculenta</i> (L.) Schott	2.443	666.7	0.003	8.963	1511.1	0.035	7.592	1022.2	0.002
<i>Colocasia</i> sp.	1.411	266.7	0.006	-	-	-	-	-	-
<i>Coriander</i> sp.	4.529	1466.7	0.005	-	-	-	-	-	-
<i>Costus speciosus</i> Smith.	1.570	266.7	0.009	5.537	355.6	0.034	-	-	-
<i>Cucumis sativus</i> L.	3.142	711.1	0.012	4.738	666.7	0.018	-	-	-
<i>Cucurbita maxima</i> Duchense	3.865	933.3	0.001	7.748	888.9	0.033	-	-	-
<i>Cucurbita siceraria</i> Kobra	2.299	488.9	0.002	-	-	-	-	-	-

<i>Cumumis melo</i> L.	2.606	533.3	0.014	4.301	577.8	0.009	-	-	-
<i>Curcuma caesia</i> Roxb.	1.496	355.6	0.001	4.150	666.7	0.008	-	-	-
<i>Curcuma longa</i> Roxb.	14.334	1333.3	0.210	9.265	1466.7	0.039	6.481	711.1	0.004
<i>Curcumpha longiflora</i> Sm.	13.086	666.7	0.217	-	-	-	-	-	-
<i>Cyperus kyllingia</i> Endl.	3.589	1244.4	0.004	1.495	977.8	0.003	2.560	266.7	0.001
<i>Daucus carota</i> L.	3.905	1466.7	0.003	10.125	1200.0	0.052	10.434	755.6	0.032
<i>Dioscorea alata</i> L.	3.677	1155.6	0.005	5.812	844.4	0.023	-	-	-
<i>Dolichos tetragonobolus</i> (L) Kuntze	3.740	800.0	0.022	5.712	1200.0	0.018	6.844	400.0	0.021
<i>Elsholtzia communis</i> Coll.	1.682	266.7	0.015	-	-	-	-	-	-
<i>Glycine max</i> (L) Merr.	-	-	-	4.296	933.3	0.009	-	-	-
<i>Impatiens balsamina</i> L	2.541	711.1	0.003	1.410	311.1	0.001	-	-	-
<i>Imperata cilindrica</i> (L.) P.Beauv	2.172	266.7	0.025	4.446	1244.4	0.002	-	-	-
<i>Ipomea batata</i> L.(Lamb)	4.954	1155.6	0.020	5.134	1155.6	0.006	9.231	800.0	0.010
<i>Luffa cylindrica</i> Roem.	1.608	266.7	0.006	3.201	533.3	0.010	-	-	-
<i>Manihot esculanta</i> Krantz.	1.783	444.4	0.004	2.130	311.1	0.006	-	-	-
<i>Mentha viridis</i> L.	-	-	-	5.262	1244.4	0.006	-	-	-
<i>Mikania micrantha</i> Kunth.	3.256	977.8	0.006	5.815	1466.7	0.002	8.257	888.9	0.010
<i>Mimosa pudica</i> L.	3.647	755.6	0.025	6.893	1600.0	0.010	4.835	533.3	0.002

<i>Momordica charantia</i> L.	4.343	666.7	0.039	1.842	311.1	0.003	-	-	-
<i>Oxalis corniculata</i> L.	5.113	2088.9	0.001	7.472	2266.7	0.005	7.294	666.7	0.011
<i>Paderia foetida</i> L.	2.684	844.4	0.002	-	-	-	-	-	-
<i>Passiflora edulis</i> Sims.	5.094	1288.9	0.023	5.753	577.8	0.026	7.030	622.2	0.004
<i>Phaseolus vulgaris</i> L.	4.241	1244.4	0.010	10.918	1422.2	0.054	-	-	-
<i>Phrynium capitatum</i> Willd	-	-	-	2.946	400.0	0.008	-	-	-
<i>Piper betle</i> L.	-	-	-	3.520	666.7	0.002	-	-	-
<i>Piper boehmerifolia</i> (Micq.) DC.	1.923	488.9	0.005	-	-	-	-	-	-
<i>Psophocarpus teragonobulus</i> DC	0.576	133.3	0.001	-	-	-	-	-	-
<i>Pteris amoena</i> Bl.	3.314	488.9	0.031	4.024	844.4	0.005	-	-	-
<i>Pueraria montana</i> (Lour.)	2.348	355.6	0.022	-	-	-	-	-	-
<i>Raphanus sativa</i> L.	6.190	1333.3	0.040	10.523	1333.3	0.058	7.681	844.4	0.006
<i>Secchium eduli</i> (Jacq.) Sw	4.460	1022.2	0.014	9.956	711.1	0.058	9.166	800.0	0.012
<i>Spilenthos acmella</i> (L.) Murr.	6.768	2488.9	0.011	-	-	-	14.364	2488.9	0.010
<i>Spilenthos oleraceae</i> L.	6.967	2400.0	0.025	6.499	1866.7	0.001	12.769	1866.7	0.013
<i>Stevia rebaudiana</i> Roxb.	1.915	133.3	0.028	-	-	-	-	-	-
<i>Thladiantha calcarata</i> Roxb.	4.762	266.7	0.079	-	-	-	-	-	-
<i>Torenia peduncularis</i> Benth.ex Hoo.f.	1.969	44.4	0.036	-	-	-	-	-	-

<i>Trichosanthes anguina</i> L	3.263	577.8	0.012	2.920	622.2	0.001	-	-	-
<i>Urena lobota</i> L	4.607	1511.1	0.009	6.373	1911.1	0.001	8.399	933.3	0.006
<i>Vinga mungo</i> (L) Hepper	-	-	-	5.854	844.4	0.017	-	-	-
<i>Vinga unguiculata</i> (L.) Walp.	4.181	977.8	0.021	-	-	-	-	-	-
<i>Vitex negundo</i> L.	5.494	133.3	0.103	-	-	-	7.566	666.7	0.008
<i>Vitis vinifera</i> L	5.648	1111.1	0.048	4.131	666.7	0.012	4.060	355.6	0.004
<i>Zingiber officinalis</i> Roscoe	5.331	977.8	0.042	8.003	1288.9	0.025	7.697	666.7	0.005

anacardium (IVI 9.629 and density 8.9 individual ha⁻¹) *Tamarindus indica* (8.120 and density 5.8 individual ha⁻¹) were the dominant tree species. Shrub species like *Musa paradisiaca*, *Musa acuminata*, *Citrus limon*, *Thysanolaena maxima*, *Hibiscus macrophyllus* were dominant in the large home garden and *Musa paradisiaca*, *Musa velutina*, *Capsicum annum*, *Cajanus cajan*, *Clerodendron colebrokianum*, *Ocimum sanctum* were dominant in the medium size home gardens and in the small home garden *Musa paradisiaca*, *Zea mays*, *Clerodendron infortunatum*, *Carica papaya*, *Amaranthus caudatus*, *Bauhinia variegata* and *Hibiscus sabdaiffa* were the dominant shrubs species. Among the herbs, *Calamus tenuis*, *Curcumphera longiflora*, *Spilenthesis acmella*, *Colocasia affinis*, *Centella asiatica* and *Allium hookerii* in the large home gardens; *Phaseolus vulgaris*, *Brassica rapa*, *Sechium eduli*, *Curcuma longa*, *Colocasia esculenta* and *Cucurbita maxima* in the medium size home gardens; and species like *Annanas comosus*, *Spilenthesis acmella*, *Allium hookerii*, *Ageratum conyzoides* and *Ipomea batata* dominated the small home gardens (Table 5).

The importance value (IVI) distribution of tree species indicates that more than one tree species share the dominance in the community in all the home gardens. Nevertheless, the similarity indices determined for tree, shrubs and herbs showed maximum similarity indices between the large sized and medium sized home gardens. Least similarity of plant species were observed among large and small sized home gardens. The homegardens of the district were like other tropical homegardens for producing subsistence farming systems. The high diversity and complexity in the structure of homegardens fulfill a range of social, economic and ecological functions (Sahoo *et al* 2010). These indigenous homegardens also contribute to the *in situ* conservation of plant genetic resources including many rare and underutilized species besides reducing the pressure on nearby forest areas for the extraction of fuel wood and other non-timber forest products.

Homegarden plant use

All species encountered in the homegarden were found very useful for several purposes. The households cited most species as useful for food (45%) followed by medicine (13%) fuelwood (12%) ornamental (9%) and timber (7%). Of the 162 recorded plants 104 have only one indicated use, while 58 had more than one attributed utility. Amongst the different homegarden category large gardens have higher mean number of timber, fruit trees and vegetables as compared to small and medium (Figure 6). The mean number of species in each use plant category (Table 6) revealed

that spices and condiments were much higher in small gardens than the medium and large gardens.

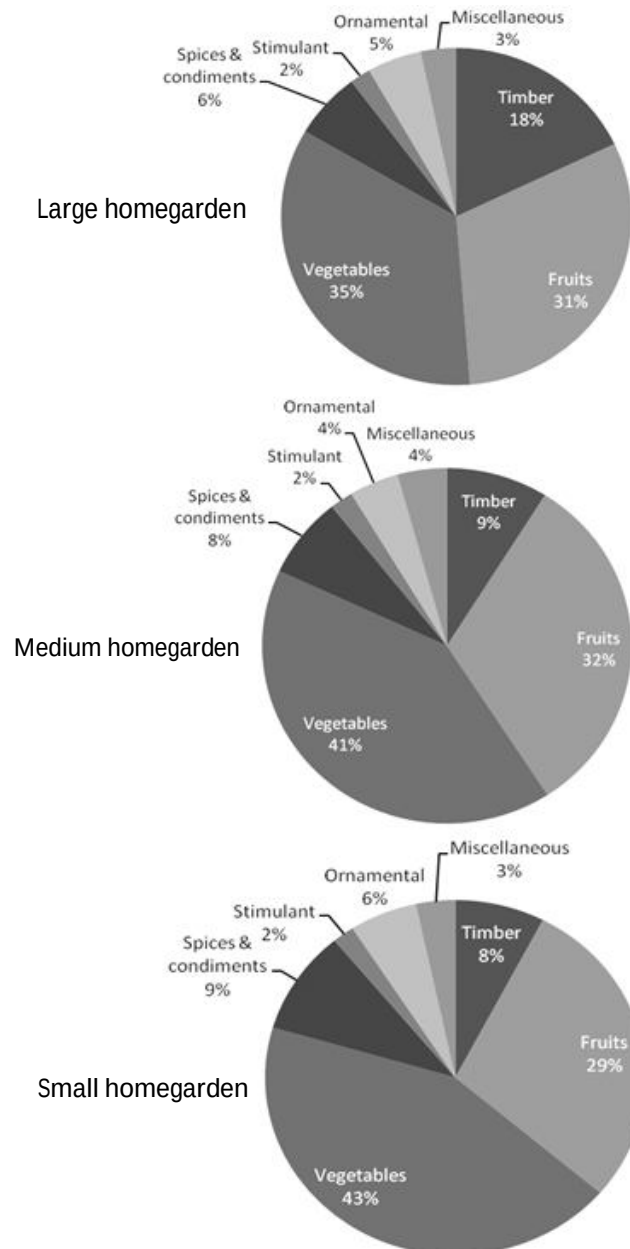


Fig. 6. Plant use categories in different homegardens in Kolashib district of Mizoram

Table 6. Mean number of species for each use category in the different homegardens categories of Kolashib district, Mizoram

Use	Small		Medium		Large	
Timber	2.85	(0-7)	3.89	(0-6)	9.3	(2-32)
Fruits	10.7	(4-15)	13.89	(7-20)	16	(13-21)
Vegetables	16.2	(10-24)	17.89	(10-23)	18	(12-23)
Spices & condiments	3.55	(0-7)	3.22	(2-5)	3.3	(0-7)
Stimulant	0.7	(0-3)	0.89	(0-2)	1	(0-2)
Ornamental	2.15	(0-7)	1.89	(0-5)	2.6	(1-7)
Miscellaneous	1.25	(0-3)	1.89	(0-6)	1.7	(0-3)

Values in parentheses are range.

Homegarden energetic

The yield of homegarden products varied between the gardens, and was directly related to the species diversity. The total yield was higher; the yield per unit area was more in small gardens and decreased with increase in garden size (Table 7). The yield in terms of gross income per unit area similarly was higher in small gardens compared to medium and large ones because of the lower labour costs associated in the former than the later. It was observed that the major energy input to the homegardens were labour and in the small gardens labour inputs were only from household members whereas in the large gardens external hired labours were used for the energy requirements especially during the harvesting and showing of crops. External labours were represented both by male and female workers with slightly higher participation from the female workers in the age group 22-35. One man-hour human labour was assigned 1.96 MJ energy and 1 woman-hour as 1.57 MJ and total energy input inclusive of seeds and manures/fertilizers worked out to be 125 MJ, 38 MJ and 31 MJ per 100 m² in small, medium and large gardens. Major output of the gardens was vegetables, rhizome, seeds, pods, and fruits etc which were usually for household consumption and sale of surplus after adequate savings of seeds for the following year. Total energy output was 3728 MJ, 1365 MJ and 1452 MJ in the small, medium and large homegarden respectively and the energy efficiency was found to significantly vary from 27 in small garden 54 in large garden ($P < 0.04$).

Table 7. Energy and monetary output and input (MJ/100m² year⁻¹) under different homegarden categories in Kolashib district, Mizoram

Production measure	Small	Medium	Large	F-test
Energy : Input (total)	125 (81)	38 (61)	31 (61)	
Output				
Fruits	605 (50)	685 (68)	798 (89)	
Vegetables (leaves, pods, seeds, etc.)	3049 (110)	497 (115)	626 (97)	
Tubers & rhizomes	74 (81)	83 (46)	27 (40)	
Total	3728 (93)	1365 (50)	1452 (75)	
Output/input ratio	27 ± 5.3	36 ± 7.4	54 ± 7.8	P < 0.04
Monetary:Input	928 (54)	315 (53)	228 (58)	P < 0.02
Output	2597 (73)	1297 (31)	1375 (81)	NS
Output/input ratio	2.6 ± 0.9	4.4 ± 0.6	6.6 ± 1.5	P < 0.05

Values in parentheses are CV%, ± SEm

Homegarden economics

Virtually all species in the homegarden have a multiple use. Higher number of species in the large homegardens obviously contributed to higher production resulting into availability of more products for sale after household consumption. Sale of surplus was much higher among the larger gardens which were with commercial motives and also among some of the medium size gardens with similar strategies while higher proportion of the products was consumed in the households in most of the smaller gardens. Major portion of the fruit species like *P. guajava*, *C. reticulata*, *Passiflora edulis*, rhizomes like *Zingiber officinalis* and pods of *P. timoriana* were sold out in the local market as the production are usually high and not all the products could be consumed within the household. The monetary input significantly vary from Rs 928 per 100 m² in small to Rs 228 per 100 m² in large gardens (P<0.02) while there is no significant difference for the monetary output and the output-input ratio significantly varies from 2.6 in small to 6.6 in large gardens (P<0.05) (Table 8).

The mean financial value of homegardens based on benefits and costs revealed higher net income in the large garden (Table 9) compared to the small and medium ones, however, since the intensity of production was greater in small gardens, the intensity of profit generation (mean profit/unit area) obviously was more in small garden. It was observed that a significant fraction of the profit was consumed by the farmers of small

Table 8 Mean financial value of homegardens for 2007-2008 (in Rupees) based on the benefits and costs of 12 gardens surveyed in Kolashib district, Mizoram

Category	Mean financial value (Rupees)	Mean financial value, including opportunity costs of land and household labour (Rupees)
Small (≤ 0.22 ha, n=4)	28,146	19,890
Medium (> 0.22 ha, ≤ 0.65 ha, n=4)	52,252	40,052
Large (> 0.65 ha, n=4)	1,58,161	1,31,476

Financial worth measured in Rupees (1.00 US\$ ~ Rs. 46, October 2008)

gardens in obtaining their daily requirements. Poorer households (small garden farmers) consumes proportionately less and sell more than the better off households (well developed gardens), therefore the profit generated was highest in small gardens and lowest in large gardens. The contribution of homegarden products to the total household income was higher from large garden (52%) while lower (29.0%) from the small garden (Table 9). This implies that the medium and large garden posses more liquid cash with which they may procure household products. However, the income generation from the garden irrespective of their size was subjected to market demand and quantum availability of a particular homegarden product. There was no fixed seasonality /time for harvest of homegarden products. Typically, the subsistence plants were harvested daily or according to the requirements. It was observed that when the products were used to supplement the dietary requirement as was the case with small gardens, they were sold for liquid cash. Although income generation was an important component of all homegardens for large gardens, it was given less importance by the smaller/poorer farmers who preferred more diversity and higher range of production and their contribution to livelihood of the households.

Table 9. Contribution to total household income from sale of homegarden products in Kolashib district, Mizoram

Category	Mean annual proceeds from sale of products (Rs.)	Percentage to total household income
Small (≤ 0.22 ha, n=4)	13,012	29.2
Medium (> 0.22 ha, ≤ 0.65 ha, n=4)	33,750	32.5
Large (> 0.65 ha, n=4)	78,875	52.1

However, we could not evaluate the various non-market benefits of the homegarden. It was told that such benefits were important to the farmers. It was observed that the management of these gardens was done using mostly the traditional indigenous knowledge. The management of trees and shrubs were done according to the farmers' requirements. For example, the small tree *Clerodendrum colebrookianum* is pollarded at a height not above 1.5 m. Bamboos are usually grown on the lower slopes of the garden. Tea is not pruned unlike in the conventional tea gardens and is planted among *Citrus maxima* and *Artocarpus heterophyllus* for shading. Seasonal vegetable growing areas are more open and located adjacent or nearest to the residential house. Mangoes are grown among/under other trees whereas guavas are grown in closer spacing in open areas.

Home gardens and conservation of genetic diversity

Home gardens are excellent examples of *in-situ* conservation where preservation of various indigenous species especially the rare and endangered species (Table 10). A large number of species reported to be threatened in the state (Lalramnghinglova 2003) found in the homegardens nevertheless contribute to the conservation of biodiversity at the ecosystem, species and within species levels (Saikia *et al.* 2012). As far as the species composition is concerned, all home gardens complex, multi-storeyed environments with very high species diversity and a wide range of very varied ecological micro-niches (Eyzaguirre & Linares 2001). These features provide a wide range of ecological benefits and services and a valuable set of products for the rural poor. They are also important in the conservation of useful plant species since they contain very large numbers of species which are often absent or disappearing from other production systems. In several countries, the homegardens are convenient sites for traditional plant experimentation and domestication and there are several reports which indicate that the germplasm brought from the wild been successfully introduced in the homegardens (Leiva *et al.* 2002) and subsequently being widely commercialized. Although conservation is rarely the actual objective of the farmers, the farmers maintained crop diversity because they find it very useful and each plant type meets the producers' needs. The pattern of diversity distribution among homegardens are usually different and related to three groups of interacting factors like the biological characteristics of the crops, the way in which the farmers manage the production and reproduction of the material and the way in which the environmental factors affect crop production (Leiva *et al.* 2002; Podoich and De Jong 1991).

Table 10. Rare and endangered species that are present in the homegardens of Kolashib district, Mizoram

Scientific name	Local Name	Family	Habit	Status
<i>Aegle marmelos</i>	Belthei	Rutaceae	T	EW/R
<i>Aeschynanthus sikkimensis</i>	Bawltehlantai	Gesneriaceae	E	LR
<i>Aquilaria malaccensis</i>	Thingrai	Thymeteaceae	T	CR
<i>Bombax ceiba</i>	Phunchawng	Bombaceae	T	Vu
<i>Cassia alata</i>	Tuihlo	Caesalpinaceae	S	Vu
<i>Cautleya gracillis</i>	Pa-le	Zingiberaceae	H	Ew/R
<i>Clerodendrum wallichii</i>	Phuihnamria	Verbenaceae	S	Vu/R
<i>Curcummorpha longiflora</i>	Aitur	Zingiberaceae	H	Ew/VR
<i>Elaeagnus pyrifomis</i>	Sarzukpui	Elaeagnaceae	T	Vu
<i>Garcinia lanceaefolia</i>	Pelh	Clusiaceae	S	EN/R
<i>Hydnocarpus kurzii</i>	Khawitur	Flacourtiaceae	T	EN/R
<i>Musa glauca</i>	Saisu	Musaceae	T	Vu
<i>Ocimum tenuiflorum</i>	Ramhmul dmdawi	Labiatae	H	Ew
<i>Picrasma javanica</i>	Thingdamdawi	Simaroubaceae	T	LR
<i>Ruellia suffructicosa</i>	Sa-vang-ma	Acanthaceae	H	CR/VR
<i>Zanonia indica</i>	Lalruanga-dawibur	Cucurbitaceae	H	CR/VR
<i>Zanthoxylum armatum</i>	Arhrikreh	Rutaceae	T	EN/VR

*Abbreviations used

EW: Extinct in the wild known only to survive in cultivation/naturalized.

CR: critically endangered, eat remedy high risk of extinction in the wild in the immediate future, EN: Endangered not CR, but very high risk of extinction in the wild in the near future.

VU: Vulnerable not CR or EN, but high risk of extinction in the wild in the medium-term future, R: Rare; VR: Very Rare; Tree; S: Shrub; H: Herb; LR : Lower Risk; E:Epiphytes;C:Climbers

We have noted that the farmers have been cultivating as many as 17 species (Table 10) which are very rare and on the verge of extinction from the state. Our interactions with the farmers also reveal that these species were drawn from the wild and are introduced in the homegardens and these species have now been used for several purposes. For an example, *Curcummorpha longiflora* is a very rare species but the farmers have

retained in the homegardens because its rhizome is an effective cure for diarrhoea and dysentery. *Musa glauca* is yet another species very rare to the state but is found in most homegardens because of use of its seeds and fibre, besides the spadix and convolute leaf sheath are used as vegetables. The various parts of the other rare plant species are used for several purpose like antidysentric, stomathic & digestive, against colic, hepatitis, bronchitis, diabetes etc. (Lalramnghinglova 2003) Since these species are unlikely to be maintained on any scale in *ex situ* collections, home gardens may be the only reasonable way of maintaining these plant diversity. Preliminary evidences also suggest that home gardens often maintain many more local cultivars of some crops that might also be found in larger scale production systems. A detailed inventory of the rare and endangered species, however, is necessary to understand whether homegardens can conserve biodiversity to a larger extent. Besides, it is also intriguing why specific local cultivars are grown in the gardens for a specific period by the farmers and need based studies must answer these questions

Conclusions

Home gardens are dynamic farming systems which promote *in-situ* biodiversity conservation while providing numerous direct benefits to the owners and to the users of home garden products. In view of the fact that they also provide numerous ecological, economical and social benefits to the rural poor, the policy makers should promote home gardens in Mizoram to wean away pressures on the ongoing *jhum* (shifting cultivation). Probably some targeted and well-planned interventions may further be undertaken to strengthen the importance of this production system. It is further envisaged that through a better understanding of the role of farmers and their families as the producers of garden products, it will be possible to improve the management of genetic diversity in home gardens which in turn may result in a better and more sustainable production.

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Natural Resource Management and its Preservation for Better Livelihood

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Abstract

Natural resource management refers to the management of natural resources such as land, water, soil, plants and animals, with a particular focus on how management affects the quality of life for both present and future generations. Some of the natural resources that are common resources are air, water and soil, biological resources - plants and animals, raw materials (like minerals) and solar energy. Natural resource management deals with managing the way in which people and natural landscapes interact. It brings together land use planning, water management, biodiversity conservation and the future sustainability of industries like agriculture, mining, tourism, fisheries and forestry. It recognises that people and their livelihoods rely on the health and productivity of our landscapes, and their actions as stewards of the land play a critical role in maintaining this health and productivity. Natural resource management is an interdisciplinary field of study that considers the physical, biological, economic and social aspects of handling natural resources. It involves putting resources to their best use for human purposes in addition to preserving natural systems. Natural resource managers' duties include overseeing workers, analyzing data, developing environmental plans and policies in accordance with state and federal laws and negotiating land and resource use contracts with landowners and governments. Within this field, there are various areas of concentration.

Introduction

Earth or physical sciences involve the chemical and physical properties of ecosystems. This may include the study of soils and the disciplines of geosciences and GIS (Geographic Information Systems). Science of biotic resources focuses on ecosystem management and biological principles. This would include the study of vegetation, wildlife and landscapes. It can include working with farmers in an effort to manage rangelands and protect wildlife, along with working with other agencies to oversee recreational land use. Social sciences look at how humans affect the environment or various ecosystems. This area of natural resources management may look to the disciplines of sociology, anthropology or emergency management. Pollution control examines how air, water and land pollution can be reduced and how quality of these resources can be restored. Environmental communication involves the use of mass media, public relations and journalism to highlight environmental and natural resources issues and concerns. Economics of natural resources encompasses policy making, regulation, administration and management of natural resources. It involves the combination of policy and economics to protect ecosystems, with the ultimate goal of sustainability.

The best way to conserve natural resources is to find ways to reduce dependency of natural resources in everyday life. Resources are products of the natural environment that humans use in some way or another. Oil, natural gas, water and coal are all natural resources that are used in energy and food production. Another way to conserve natural resources is reuse. We should continue the practice of using something over and over again before recycling, composting, or throwing it away.

In India, close to 275 million rural people depend largely on natural resources for their livelihoods. However, over the last few decades, the equilibrium between natural resources and livelihoods has been under increasing pressure, threatening both the ecological security of the country and increasing the vulnerability of rural communities. Rural populations are, therefore, the primary stakeholders in biodiversity conservation and sustainable use of natural resources. Through centuries of co-existence, communities living in the proximity of biodiversity rich areas have acquired invaluable traditional knowledge that has shaped their culture and livelihoods. Community-based natural resource management is a key approach to conserving biological diversity and supporting local livelihoods.

Environment and natural resources preservation is vital to the economic growth of any country or a region in many ways but also susceptible to the extent that their utilization, management and sustainability can be affected by performance and deeds of various actions within the society. Natural resources and environmental issues matters and apprehensions are cross-sectorial but also renders input in every sector in terms of reducing poverty and destitute conditions of people and therefore need to be accorded highest precedence within the overall framework of the Poverty Eradication Action Plan (PEAP) which intends at reducing the fraction of people living in unconditional poverty to a level below 10% by 2017. In view of the cross-cutting nature of environment and normal assets issues, actions to address them require involvement of all relevant sectors. It is from this background that during the PEAP revision in the year 2003, the environment and natural resources PEAP revision sub-committee under the auspices of the then Ministry of Water, Lands and Environment prepared principles for conventional environment and natural resources issues in the PEAP, and other government sectors and programs. The overall objective of these principles was to provide direction and leadership to different sectors on how they can integrate cross cutting environment and natural resources issues in their sectorial preparations and series. The purpose of this research therefore, was to assess the extent to which environment and natural resources issues have been integrated, and propose actions that can accelerate the mainstreaming of environment and natural resources issues in government sectors and programs [1]. There have been identification of different issues that cause harm to the earth and regular assets; they have been named rustic neediness, populace blast, deforestation, industrialization, uncalled for waste administration, catastrophes and characteristic dangers.

NRM refers to the processes and practices relating to the allocation and use of natural resources. Sustainable NRM optimizes the use of resources to meet current livelihood needs, while maintaining and improving the stock and quality of resources so that future generations will be able to meet their needs. NRM decisions are made at various levels—household, farm, community, national, and global. Agricultural production systems depend on natural resources- land (over 55 percent of nonforest land), water (about 80 percent of total fresh water), biodiversity, forests, pastures, and wildlife. Farm activities can also have major impacts on the quality and availability of these resources well beyond the boundaries of the production system (for example, downstream pollution and soil erosion). Although natural resources are critical to agricultural production, farm

households also frequently depend on them to meet other needs, such as fuel, construction materials, and supplemental foods. Thus rural livelihoods are intricately linked to the condition of natural resources, particularly for those 1.3 billion people living on fragile lands.

Sustainable NRM is critical to reducing poverty. If productive capacity continues to erode, the potential to satisfy future food needs will be seriously compromised. The poorest will suffer the most, through increased food costs and greater vulnerability to their livelihood. Further, increased agricultural production and productivity and increased incomes provide more resources in the long run for addressing environmental problems. There are an increasing number of threats to forest reserves across India and to the people living within them. India is rapidly industrializing and de-forestation is increasing to make way for factories, roads and reservoirs.. There are often legal disputes over forest ownership because many communities have been living within or nearby forests for years but do not have legal documentation to support this. Furthermore, many people living within forests are very poor, have a little or no education, and have limited livelihood options available to them in an increasingly market-driven world. There have been five extensive results of greening rural development.

Improved resource conservation - Rural development schemes especially MGNREGS and IWDP focus on restoration of natural resources. Conserving and regenerating land and water resources enhances their productivity, leading to increased agricultural outputs and improved livelihoods derived from agriculture, forests and pastures. These schemes can assist in reducing run-off and soil losses, recharge groundwater, increase vegetative cover and improve biodiversity, and thereby, expand the productivity of natural resources and ecosystems.

Improved resource efficiency – Rural development schemes aims to improve the efficiency of natural resources in rural livelihoods and essential services. Under IWDP, there is an opportunity to support farmers and agricultural workers to adopt practices to support irrigation water. This can be implemented by adopting appropriate crops, farming techniques, irrigation systems and improved field irrigation methods.

Reduced negative environmental impacts – Greening rural development schemes can potentially reduce the negative environmental impacts of economic development such as pollution, waste generation etc. Solid and liquid waste management under the Nirmal Bharat Abhiyan scheme improves local sanitation and hygiene and in this manner the well-

being and health of local residents.

Strengthened climatic resilience of communities – The resilience of local population can be enhanced by reducing the risk of climatic variations such as droughts, cyclones and floods. Afforestation, plantations, fodder management and vegetation belts in the coastal areas lead to livelihood resilience and enable the communities to cope with the climatic changes.

Contribution to climate change mitigation – Large scale forestry and soil conservation measures can seize carbon and greenhouse gas emissions.

Economic Growth and Environmental Sustainability

India has been committed to economic growth and environmental sustainability. The first five year plan (1951-1956) aimed at economic stabilization and investment in the agrarian sector. The plan supported community development taking into consideration the social and economic welfare of the rural sector. The second five year plan aimed at structural transformation with an emphasis on heavy industrialization. The first two plans laid the foundation for development planning in India. The development strategy of the country has mainly emphasized upon economic development. With the increase of velocity of economic growth, the works and the pressures to bring about changes and improvements began to strengthen and therefore the need to pay greater attention to the management of water, forests and land began to enlarge. These are largely associated with the development of the rural sectors not only in India but in other countries of the world as well .

Environmental degradation has been expressed as loss of fertile soils, desertification, unsustainable forest management, reduction of freshwater availability and an extreme biodiversity loss rate. There has been a high correlation between economic growth, rural development and environmental sustainability. Sustainable use of environmental resources can contribute to augmentation and steadiness. It is essential to contribute to the environmental resources to increasing the productivity of investment in agriculture, infrastructure and natural capital. Success in achieving the conservation of the environment will contribute effectively towards rural development, water supply, land management and agricultural activities will be fulfilled effectively. The Schemes of the Ministry of Rural Development are well organized to deliver green endings i.e., to restoring and enhancing the ecosystem services and natural capital .

Natural capital is often esteemed and understood most excellent at the local level, and local knowledge is essential for useful solutions. Communities and societies need to be active supporters of the conversion to sustainable development, alleging their rights and also fulfilling their responsibilities in terms of sustainable management of natural resources. Rural development schemes provide a strong opportunity to cumulative small inventiveness in several locations to improve natural capital on a comprehensive scale. These self-governing institutions and their capacities will be answers to greater effectiveness of regulatory and market instruments in ecosystem rejuvenation and perfection of natural capital .

Discussion and Conclusion

The depletion of natural resources and environmental degradation are common and are prevalent worldwide, in India, there have been many reasons that lead to the depletion of natural resources and environmental degradation, these are effects of natural calamities and disasters, population explosion, deforestation, increase in transportation, eversion of fumes and poisonous gases from the industries as well as vehicles cause air pollution, throwing of waste into the rivers and lakes cause water pollution and conditions of poverty; with the impact of urbanization and migration of rural individuals into the urban areas in search for better livelihood has led to an increase in all kinds of pollution and deforestation, in urban cities especially in the national capital of Delhi, trees and plantations have been cut down in order to construct residential areas for the urban dwellers and this has been the major source of environmental degradation. Delhi has been considered to be the most populous as well as the most polluted city in the world. Other dire consequences have been that as a result of environmental degradation and depletion of natural resources there has been an increase in the levels of paucity, individuals are getting more prone to living in destitute conditions in rural as well as urban areas.

Deforestation has resulted in calamitous consequences, the rural people who are mostly dependent upon forests for their livelihood, when the forests and trees get chopped down their agricultural occupation suffers, they depend upon forests for their food and to obtain wood, hence undergo tough conditions as a result of deforestation. Natural calamities and disasters are natural as well as man-made; when they occur unexpectedly, they cause threatening consequences upon the lives of the individuals as well as plants and animals, the effects can be environmental, health, economic, social, political, administrative and managerial. In order to investigate the measures that would lead to preservation and safeguarding of the environment and

the natural resources, it is necessary to assess the risks, impacts and the opportunities that are available from these two main aspects, how the life of the individuals would suffer threats, perils and be at jeopardy, what would be the impacts and what are the opportunities available have to be analyzed.

For the environment, sustainability and green development, the specific suggestions have been concerning the climate and energy considerations, natural cycles and their connected social processes, the urban-rural nexus, urban infrastructure and the transport systems, and the green development in future and its economic impacts. The spread of greenery has been considered to be a crucial factor in order to curb weakening of natural resources and environmental degradation, there have been number of activities that are as a result of greening of rural development, improved resource conservation, improved resource efficiency, reduction in the negativities of environmental impacts, strengthening of the climatic resilience of communities and contribution to climate change mitigation. India is a developing nation, with the increase in industrialization and development of technology, innovation and other advancement, it is essential that measures and procedures should be implemented in order to curb all kinds of pollution, plant more trees, in other words, encourage greenery and follow particular waste management procedures; in order to preserve and safeguard natural resources, it is mandatory to follow appropriate measures and steps, as it is up to the human beings to curb man-made disasters such as industrial explosions to safeguard their lives.

- Set up/strengthened decentralized people's institutions to sustainably manage natural resources. These include Biodiversity Management Committees in Arunachal Pradesh and Jharkhand, Joint Forest Management Committees and Forest Protection Committees in Chhattisgarh and Village Cluster Committees in Odisha
- Traditional knowledge on biological resources preserved through documentation of value and use of biological resources in 122 villages through various micro-planning approaches
- About 327 plant species in the Community Conserved Areas documented through ethno-botanical surveys
- Biodiversity conservation needs in Arunachal Pradesh and Chhattisgarh better understood through a baseline mapping of natural resources and biodiversity surveys

- One hundred hectares of cane plants is now protected from over-extraction in Khurda and Sambalpur–South divisions in Odisha. Three hundred hectares of these forest areas are also being conserved through aided-natural regeneration
- Improved biodiversity through in-situ and ex-situ conservation measures. For example, 83,000 saplings of rare species (*taxus wallichiana* and *swertia chirayata*) are now grown in nurseries across project states; 5,000 hectares of land is designated as Community Conserved Areas and two sacred groves regenerated in Arunachal Pradesh
- Forest protection squads strengthened which has further resulted in legal action against tree felling and trade in timber
- Six hundred tribal farmers benefited from micro-water harvesting structures in three forest divisions
- Habitats of rare plants regenerated through soil and moisture conservation activities
- Forty-five tribal SHGs benefited from livelihood support provided by integrating agro-forestry, pisciculture, poultry and goatry
- Revival of traditional medicinal practices through Herbal Health Care Centres in Chhattisgarh
- Improved access to community infrastructure including health and sanitation facilities for tribal communities in Arunachal Pradesh, Jharkhand and Odisha

We should consider the following activities in order to development NRM

- 1) Promoting and piloting community-based and gender-equal forest management practices
- 2) Facilitating the integration of land-soil-water-agriculture management into forest governance and management
- 3) Enabling and facilitating forest dwelling communities' legitimate rights over forest and allied resources by improving their capacities, unity and demonstrated models of success
- 4) Increasing the income of forest dwelling communities Conducting high quality research, analysis and dissemination – including media advocacy – to further CFM and the sustainability of forest resources

- 5) Monitoring, analyzing and responding government programmes, schemes and actions .
- 6) Exploring and enable community capacity to earn from their resource management efforts through emerging sources

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Need of Effective Public Policies on Conservation of Forest for Sustainable Development: A Case Study of North East India

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Abstract

The higher percentages of population of northeast India are still living in rural areas and they are depending on resources which are locally and naturally available. But the unsystematic practices and poor vision of cultivation and other economic activities devastated large areas. This studied is carried out to find out need of effective policies in which participation of grassroot level is active. Data on population and forest are gathered and examined comparatively. Proposal for formulation of policies have been drawn out.

Introduction

The importance of natural forest resources to the life of the people of north east India is incomparable; especially people living in rural areas are directly dependent to the available forest resources. Though every state has their own forest policies which are practised and implemented through ages, policies which sensitise the rural poor and to impart the importance of conservation of forest resources to them is meagre and nominal till date.

Most of the regulations against the conservation of forest resources in the north eastern states are about penalty to those did against the rules and regulations. In fact, there are only few lines which dealt with the

importance of availability of the resources and the need of the conservation. Although there are several policies/legislations/regulations relating to natural resource management, only a few of these really link livelihood issue with the NRM (Barik 2003). There is a need to develop natural resource-specific policies, giving strong focus for addressing the livelihood issues of the rural poor, particularly for those natural resources, which have high potential to address such issues (Barik, S.K. & Darlong, V.T. Natural Resource Management Policy Environment in Meghalaya Impacting Livelihood of Forest Poor). The natural resources of the North East are also subjected to degradation and loss due to constant deforestation, unsustainable shifting cultivation practices, fragmentation and degradation which ultimately impact the biodiversity as well as forest biomass production. Increase in human and livestock population, increased extraction of fuel wood, lack of land ownership rights, shortening of jhum cycle, conversion of natural forests into plantations for horticultural crops, mining, overgrazing, and forest fire are the major causes of deforestation in North East India (Bhatt, B.P. and Sachan, M.S., Firewood consumption pattern of tribal communities in North East India, Energy Policy, 2004, 32, 1-6). Therefore, this paper examined the existing policies and proposes capacity building programmes which will be implemented to the people of north east India.

Methods and Materials

Data are collected to understand how much the people of north east India especially the rural people are depending on the forest resources. Rules and Regulations of Forest department of north eastern states are collected and examined. Moreover, the pattern of deforestation and afforestation practices in the area is monitored through available reports to understand the effectiveness of those regulations. Map is prepared to show the area of forest cover in the region and data are shown with table and bar graph for better understanding. Capacity building and sensitization programmes are formulated which will be implemented to the grassroots.

Result and Discussion

The north eastern part of India has about 143,360 sq.km of forests and it is around 61% of the entire north eastern states and is rich in fauna and flora. Much of these dense forests of Assam, Nagaland and Arunachal Pradesh are part of the Himalayan biodiversity hotspot, as defined by Conservation International (Conservation International Himalayan Hotspot Data, 2010; also available at <http://www.biodiversityhotspot.org/xp/hotspot/himlaya/pages/default.aspx>).

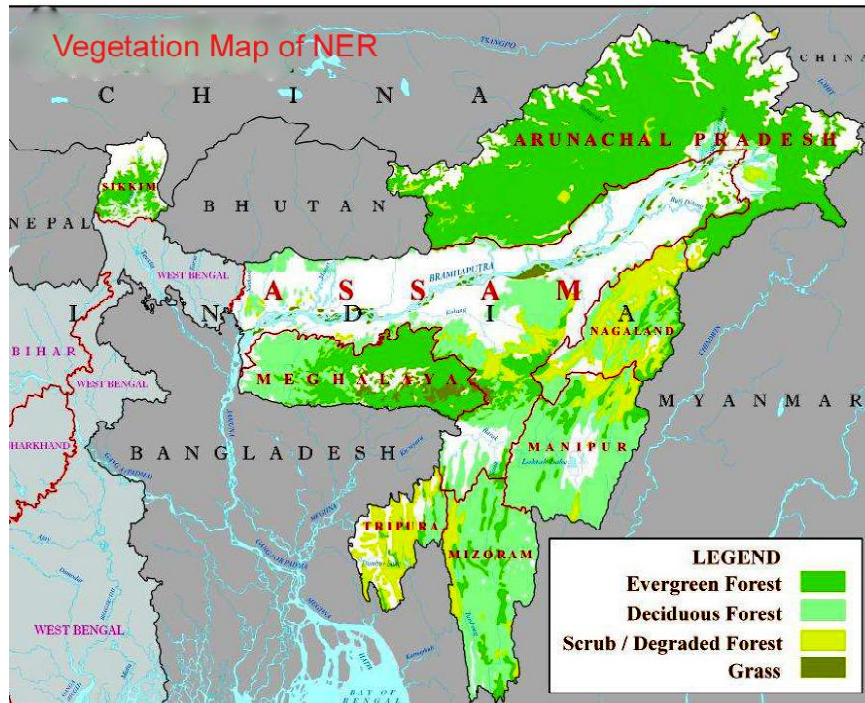


Figure 1. Vegetation Map of NER in 2011.

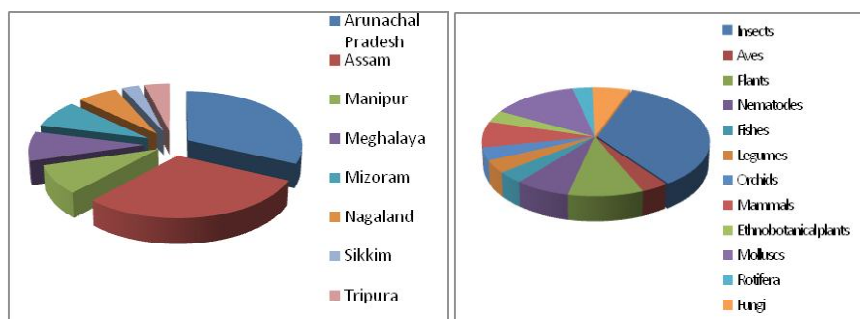


Figure 2. State-wise Space in NER

Figure 3. Biodiversity in NER 2010

Indian State of Forest Report 2015 mentioned that as much as 3775 sq.km of forest area is increase in India as a whole whereas the NER loss 638 sq.km of forest cover since 2013. For instance, Mizoram, with the highest percentage of forest cover i.e. 88.9 %, loss 306 sq.km out of the total forest area. These results are due to constant degradation led by the ever increasing in human population. About 0.5 million families in NER annually cultivate 10000 sq.km forests whereas total areas affected by jhuming is believed to be 44000 sq.km. (Singh 1990). According to Basic

Statistics 2015 published by NEC around 79% out of the total population of northeast India are engaging in Cultivations and allied agricultural activities for their livelihood. Therefore, keeping rich forest resources is seriously important in NER region to sustain livelihood of around 45.5 lakhs of its population.

Table 1. State-wise area and Forest Areas

State	Geographical areas	Forest Area 2001	Forest Area 2003	Forest Area 2011
Arunachal Pradesh	83743	68045	68019	67410
Assam	78438	27714	27826	27673
Manipur	22327	16926	17219	17090
Meghalaya	22429	15584	16839	17275
Mizoram	21081	12494	18430	19117
Nagaland	16579	13345	13609	13318
Sikkim	7096	3193	3262	3359
Tripura	10486	7065	8093	7977

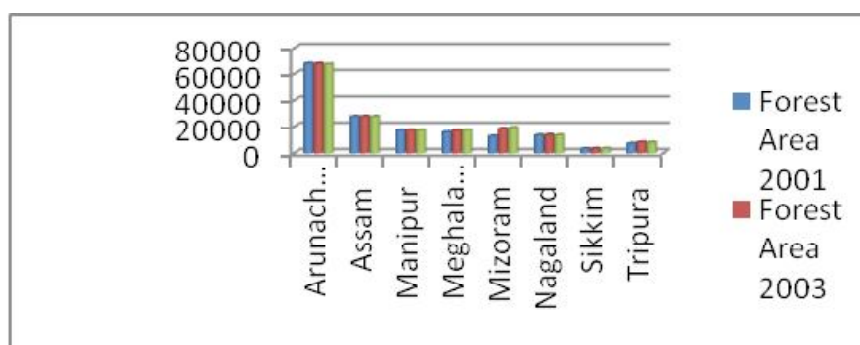


Figure 4. Bargraph comparing Population and Forest Area

Meghalaya, Mizoram and Sikkim witnessed increase in the size of forest area while Assam, Nagaland, Manipur, Arunachal Pradesh and Tripura experienced loss in their forest area from the above table. Each and every state has its own Forest policy but the supply of forest resources is insufficient to support the ever increasing population in NER. Though, bar graph shows that the forest covers area is improving in some states; the quantum of resources is insufficient to support the life of people living in 44666 villages and to urban dwellers who are depending on the supply of primary goods from the their surrounding rural areas. Moreover, it is

interesting to note that according to NEC's Basic Statistics 2015 all the NER states are experiencing Net deficit in their revenue and expenditure from or on forest resources.

Table 2. State-wise total and rural population with Forest areas

State	Total Population	Rural population	Forest Area 2011
Arunachal	1383727	1066358	67410
Assam	31205576	26807034	27673
Manipur	2570390	1736236	17090
Meghalaya	2966889	2371439	17275
Mizoram	1097206	525435	19117
Nagaland	1979502	1407536	13318
Sikkim	610577	456999	3359
Tripura	3673917	2712464	7977

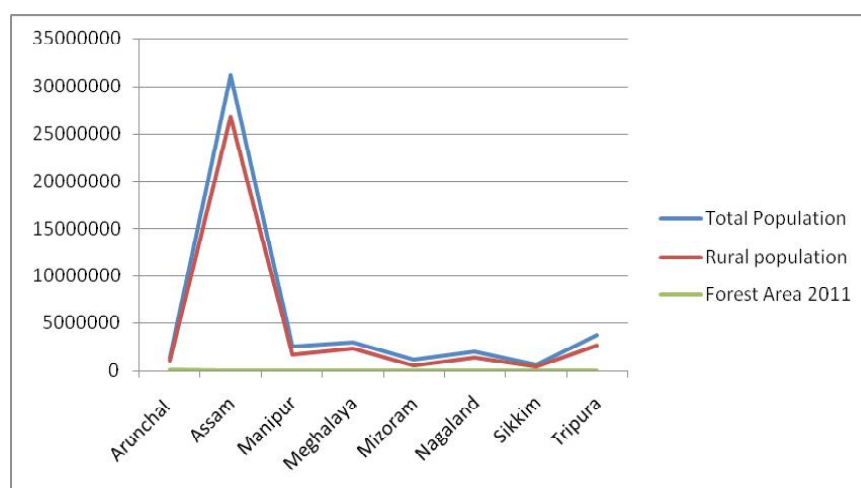


Figure 5. Comparison of Total and Rural Population with Forest Areas.

With some efforts made by the governments and JFM Committees and local people in NER the forest sources are the sources of livelihood to many families. But the rapid increase in number of population and the constant degradation processes lead to insufficiency of supply of natural forest resources to the people.

Conclusion

Therefore, this study agreed that the existing policies to check the

rapid rate of decline in the forest covers are assumed ineffective without involvement and participation of grassroot population. As very high percentages of population of northeast India are depending their livelihood to the natural forest resources, it is verily important to conserve and manage forest area and its quality in the NE region. Hence, the following action plans are proposed to be included in each Forest policies of states –

1. All year round Sensitization Programme where the grassroot population will be gathered and study the importance of conservation and management of forest resources for sustainable livelihood should be planned. Budget may be allocated for the successful implementation of this sensitization programme by the states.
2. Joint Forest Management Committee (in India 22 states have joined) with active participation of villagers (users) is required.
3. Earmarked budget allocation for conservation of forests resources under the purview of local panchayat is required.
4. Afforestation programmes in which grassroot could be involved as a main stakeholders should be planned and implemented.
5. Identification of woods which are commonly used by the particular people in particular places is required and means of recovering the loss should be planned.
6. Reserve forest should be kept by each state government, and effective monitoring and evaluation processes is required (to find out causes of degradation and solutions for the same).
7. In state like Mizoram many people in rural areas practise jhum cultivation in public forest area where they cut down huge natural forest resources. The government need to formulate means to recover the loss. Again, many households in rural areas who practised jhum cultivation handle the plot of land as their own property later on, which is a loss of public property to private. Therefore, an urgent formulation of regulations against this practise is required.

18

Forest Resources, Traditional Medicines and Sustainable Livelihood of Tribal Population of North East India

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Abstract

About 4 billion hectares, or about 31 percent of the world's land area is covered with forests. The sustainable management of this forest estate is critical for three reasons. First, forests are home to, and sustenance for, hundreds of millions of people, including some of the world's poorest. Second, deforestation results in severe local and global environmental damage. Third, controlled/sustainable commercial exploitation of forest products could contribute to economic growth.

However, the intrinsic characteristics of forests make sustainable management a challenge. Deforestation and degradation continue without much compensating gain for economic development or poverty reduction. While afforestation and re-growth have added eight million hectares (mostly plantations) to the global forest estate, the loss of natural forests continues at an unsustainable rate. The scenario of forest cover in the North Eastern Region of India is not much different from the global scenario.

In this present paper the author has studied the trend of forest cover in North East India since independence, critically analysed the present forest policy of the Government in the context of tribal right and health care of the people and suggested suitable forest management policy

for sustainable development of the people. The method of research is descriptive and analytical and data sources are secondary.

Keywords: Global Environmental Damage, Economic Growth, Sustainable Commercial Exploitation, Tribal Right, Natural Forests.

Introduction

The total forest area of the different countries of the world and also the per capita forest area have been declining more particularly since 20th century as a result of rapid growth of population and increasing demand for forest products. The world's total forest area is just over 4 billion hectares, which corresponds to an average of 0.6 ha per capita in 2010. The five most forest-rich countries (the Russian Federation, Brazil, Canada, the United States of America and China) account for more than half of the total forest area. Ten countries or areas have no forest at all and an additional 54 have forest on less than 10 percent of their total land area (Global Forest Resources Assessment 2010). The results of Global Forest Resources Assessment 2015 (FAO, 2015) indicated that forest covered 3999 M ha globally. This is equivalent to 31% of global land area or 0.6 ha for every person on the planet. The total forest area of the world has declined by 3%, from 4128 M ha in 1990 to 3999 M ha in 2015. The rate of net loss of global forest area has slowed by more than 50 percent between the periods 1990- 2000 and 2010-2015 (FAO, GFRA, 2015 P 25). The area of natural forests has been decreasing but planted forest area has been increasing. Natural forest area declined from 3961 M ha to 3721 M ha between 1990 and 2015, while planted forest (including rubber plantations) increased from 168 M ha to 278 M ha. (Rodney J. et al 2015).

In India, in 1951, 71.80 million ha ie 21.84 percent of geographical area was recorded as forest which has been reduced to 20.98 percent in 1961, but again increased to 22.76 percent in 1971 and 22.82 percent in 1981 (ISFR, 2003). As compared to global scenario during the period 1991-2015, the situation of India was much better as the total area of forest has increased from 639,364 square km. in 1991 to 701,673 sq. Km. in 2015. In 2015, 21.34 percent of the geographical area of the country was recorded as forest. As per World Bank data, in 2015, the percentage of land area covered by forest was 33.9 in the U.S.A., 68.9 in Sweden, 49.8 in Russian Federation, 16.2 in Australia, 59.0 in Brazil and 38.2 in Canada against 30.8 percent for the world as a whole (<http://data.worldbank.org/indicator/AG.LND.FRST.ZS>). In 2015 per capita forest area of India has increased to 0.066 ha from only 0.064 ha in 1988 but the world average forest area has declined from 0.64 ha in 1988 to 0.6 ha in 2015

(FAO,2015). But considering world average forest area, our forest area is much less ie 21.54 percent. In India, per capita forest area is only 0.064 ha against the world average of 0.64 ha. (FRA, 2015 and Planning Commission, India, 1988).

In this context the main objectives of the present paper are as follow:

1. To discuss the trend of forest cover in North East since independence.
2. To critically analyse the present forest policy of the Government in the context of tribal right and health care of the people.
3. To suggest suitable forest management policy for sustainable development of the people.

The descriptive and analytical method of study are made in this present paper and data are collected mainly from secondary sources.

The first two objectives are included in section-1 and section-2 respectively. Section 3 covers conclusion and suggest suitable forest management policy for sustainable development of the people.

Section-1

The North Eastern Region of India lies between 22°N and 29°5'N latitude and 88°00'E and 97°30'E longitudes comprising the eight states viz Mizoram, Arunachal Pradesh, Sikkim, Assam, Manipur, Nagaland, Meghalaya and Tripura and shares international border with Bhutan, Nepal, China, Myanmar and Bangladesh. The closeness of the region so many international borders have left the region much unexplored due to its sensitivity. The total geographical area of the region is 263179 square km. As per 2011 census the total population of the region was 4,55,33,982. Thus the region covers 8.0 percent area of the country where 3.77 percent of the total population is residing. The literacy rate of all states of NER except Arunachal Pradesh and Assam are higher than that of national average of 74.04 percent. This is also true for ST literacy rate. Except Arunachal Pradesh, ST literacy rate in other states also ranges in between 72.58 percent to 91.51 percent. The Percentage of Land area covered by forest is much higher in all states of NER as per SFR 2015.

Table 1: Forest Cover of North East States 1987- 2015 (Area in Sq. Km.)

States	1987		1995		2003		2011		2015	
	Area	percent	area	percent	Area	percent	area	percent	area	Percent
A.RUNA	64132	76.5	68621	81.9	68,019	81.22	67410	80.5	67248	80.3
ASSAM	25160	32.0	24061	30.6	27,826	35.24	27673	35.3	27623	35.22
MANIPUR	17475	78.2	17558	78.6	17,219	76.53	17090	76.5	16994	76.11
MEGHALAYA	16466	73.4	15714	70.0	16,839	75.74	17275	77.0	17217	76.17
MIZORAM	19084	86.4	18576	84.1	18,430	84.62	19117	90.7	18748	88.93
NAGALAND	14394	86.8	14291	86.1	13,609	82.75	13318	80.3	12966	78.21
SIKKIM	2756	38.8	3127	44.0	3,262	45.97	3359	47.3	3357	47.31
TRIPURA	5953	56.7	5538	52.8	8,093	77.77	7977	76.1	7811	74.49
NORTH EAST	1,65,420	25.81	1,67,486	26.2	1,65,204	24.35	1,73,219	25.03	171964	24.5
INDIA	640,819	19.49	638,879	19.43	678,333	20.63	692027	21.05	701,673	21.34

Source: SFR 1987- 2015 .Note: The Percentage of Forest Cover is calculated with respect to total area of the state/ region

Table – 1 shows the trend of absolute area of forest in the states of NER since 1987. The table reveals that in spite of slight up and down, the forest cover of North East India has increased over the period and the percentage of land area covered by forest much above the national average. Since 2003, Forest cover is shown in three density classes viz, very dense forest (VDF) with more than 70% canopy density, moderately dense forests (MDF) with canopy density between 40% and 70% and open forests (OF) with canopy density between 10% and 40%. The total forest cover of the country as per 2003 assessment is 678,333 km² and this constitutes 20.64 percent of the geographical area of the country. Of this, 51,285 km² (1.56 percent) was very dense forest, 339,279 km² (10.32 percent) is moderately dense forest while 287,769 km² (8.76 percent) is open forest cover. The area of very dense forest (VDF), moderately dense forests (MDF) and open forests in terms of percent of geographical area became 2.54, 9.71 and 8.77 respectively in 2007 and stood at 2.61, 9.59 and 9.14 in 2015.

Let us look into the scenario of North Eastern States during the period 2003-2015. During that period very dense forest area of this region has increased from 6.5 percent to 9.56 percent of total geographical area, moderately dense forest has decreased from 31.5 percent to 27.2 percent and unclassified forest area has increased from 27.8 percent to 29 percent in the North eastern region as a whole though there is state wise variations. The very dense forest area has increased in the states of Arunachal Pradesh, Nagaland and Tripura. The protected forest area has increased only in Sikkim and the unclassified forest area has increased only in Mizoram (SFR 2003 and 2005).

Again let us see as per government record, the state of reserved forest, protected forest and unclassified forest area in NER. The data relating to the year 2003 and 2015 reveal that during this period all types of forest area has declined in all states of NER. Unclassified forest area drastically reduced in Manipur (7629 Sq Km) and Mizoram (4082 sq km). The protected area has also reduced drastically in these two states (Table-2).

Table 2: Change in reserved, projected and open forest 2003-2015

STATES	RF	PF	UF	TOTAL RECORDED FOREST AREA IN SQ KM
AP	+401	+243	-787	-143
ASS	-196	0	+10	-186
MAN	0	-2704	-7609	-10313
MEGH	+1	0	-1	0

MIZ	-3426	-3568	-4082	-11076
NAG	-222	0	+815	+593
SIK	0	0	0	0
TRI	+587	-662	+76	+1
NORTH EAST	-2855	-6691	-11578	-21124

ISFR 2003, 2015

The remarkable variation noticed in these two states may be due to conversion of forest land in to agricultural land, settlement of pattas to the forest dwellers, encroachment, jhum cultivation, illegal felling of trees. The highest incidence of forest fire in India take place in Mizoram (Manhas RK et al, 2006). Due to Shifting cultivation 0.05 M ha of forest area is cleared every year in NER and totally 17-22 wood biomass and 10.69 Mt c was removed (Manhas RK et al,2006). More than 200 fascinating tribes lives in this culturally diverse region and have been practising jhum since time immemorial . Though the alternative of Jhum viz terrace cultivation was evolved by the scientists, it is not going to be popular among the tribes in the region. Some prominent tribes living in NER are Garo, Khasi, Jaintia, Adi, Nyishi, Angami, Bhutia, Kuki, Rengma, Bodo and Deori., Mizo, Reang etc . 4,43,336 families in Northeastern region annually cultivate 14680 square km forests where as total area affected by 'jhumming' one time or other is 14660 sq km (Basic Statistics of NER 2006). These figures have not changed in 2014 also (Basic Statistics of NER 2015). Further, the problem has been getting worse through the indiscriminate felling of trees to satisfy the ever-growing hunger of industries surviving on forest products such as paper and pulp, plywood, match stick, etc. So, in spite of the order of Supreme court ban of wood cutting in NER, due to the growing demand of forest products, wood cutting is still going on illegally in some states. As per one estimate, 386900 ha of land was in shifting cultivation in NER except Sikkim in 2008 (Basic Statistics of NER, 2015). That area has been increasing over the time due to growth of tribal population. Again National Remote Sensing Agency, however, indicated that actual forest cover in India has decreased to 14.10 percent in 1980-82 from 16.89 percent in 1980-82(SFR 2013). A large area of forests lands are diverted to non forest uses like agriculture, industries and towns, roads etc. (Govindaru V, 1994). In spite of this the forest of North East region has been identified as one of the 18 biodiversity hot spots of the world.

Section 2

Since times immemorial, the tribal communities of India have had an integral and close knit relationship with the forests and have been dependent on the forests for livelihoods and existence.

The relationship was mutually beneficial and not one sided. Forest policy of India announced in the year 1865, 1878, 1894, 1927 during the colonial period and in 1952, 1976, 1988 ie during post colonial period considered the tribals as destructor of the forests and wildlife. These laws always regulated tribals rights over the forest produce and forest lands. The British has triggered the commercialisation of forest product in a disguised 'National Interest' and confiscated most of the rights over the forests. The tribals who were enjoyed the forests from time immemorial had no clue but to surrender against the mighty powers. This forced them to alienate the forest and come out from their ancestral home. (Tripathi, Prakash, 2016). Thus these policies and acts did not consider the right of the forest people. The latest one ie 2006 considers their rights for the first time. "The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006" included in section 3(1) of the Act, rights of the forest dwellers.

These right can be summarised as:

- Title rights - i.e. ownership - to land that is being farmed by tribals or forest dwellers as on 13 December 2005, subject to a maximum of 4 hectares; ownership is only for land that is actually being cultivated by the concerned family as on that date, meaning that no new lands are granted.
- Use rights - to minor forest produce (also including ownership), to grazing areas, to pastoralist routes, etc.
- Relief and development rights - to rehabilitation in case of illegal eviction or forced displacement; and to basic amenities, subject to restrictions for forest protection.
- Forest management rights - to protect forests and wildlife.

Section 4(2) of the Act lays out a procedure by which people can be resettled.

Forests are the main source of subsistence for the tribals mainly who are residing in the hills. They collect their food from the jungles; use the timber or bamboo to construct their houses; collect firewood for cooking

and in winter to keep warm; use grass for fodder, brooms and mats; collect leaves for leaf plates; and use harre behra for dyeing and tanning.

Forest and Medicinal Herb

A large number of people in the world earn their livelihood from forest. The in-forest employment in the world in 2010 was 12.7 million persons and the gross value added from in-forest activities in 2015 was 116 billion USD (FAO, 2015). Forest flora and fauna are also used by many people for curing different diseases. Many healers and collectors of medicinal herbs, living in the forest also maintain their livelihood from forest.

According to WHO's (World Health Organisation) report, over 80% of world population relies on traditional medicines, largely plant based, for their primary health care needs. Due to the awareness of use of safe medicines, the demand of medicinal herb is increasing. Approx 85% to 90% of these herbs come from the wild. Department of ISM&H, Ministry of Health & Family Welfare, Government. of India, has identified 1500 medicinal plants of which 500 are commonly used in the preparation of herbal drugs. 150 species have been categorized as endangered. About thousand researchers in India have documented the uses of forest products in curing different illness. For example documentation of medicinal herb used by Maddugga tribe of South India was done by Soudalumini, et al (2005), on the tribes of Rajgarh by Jain and Singh (2010) , on Warli tribes of Thane by Manthi, C et al(2011) and so on. In North East India we can mention the works of some of the distinguished researchers like. Nath, Subhan C, (2011) Ramashankar, Deb, S and Sharma, BK(2015) Rama Shankar and Rawat MS (2013), Sharma, M, Sharma, C.L. and Marak, P.N(2014), Jamir, N.S.(1990,1997), Jamir, N.S. & Rao, R.R(1990)., Lalramnghinglova, H(1996) . In addition to the above mentioned research work, many other researchers also documented indigenous uses of medicinal plants for curing different diseases like stomach problems, cold, cough and fever, jaundice, skin diseases, blood pressure etc. The destruction of flora and fauna is a irrecoverable loss to the mankind. Thus there is a need for protection and conservation of forests. The North East region, one of 25 global biodiversity hotspots recognized, has been facing threat of biodiversity due to over-exploitation, habitat loss and fragmentation. (Chatterjee, Sudipto et al, 2006). Though some documentation of traditional medicinal plants are going on, but scientific validation and recognition of traditional healing medicines are not being made. In this day of deforestation, protection, preservation, team based research is urgently

required for revitalizing this loosing traditional knowledge.

Section-3

The sustainable management of this forest estate is critical for three reasons. First, forests are home to and sustenance for, hundreds of millions of people, including some of the world's poorest. Second, deforestation results in severe local and global environmental damage. Third, controlled/sustainable commercial exploitation of forest products could contribute to economic growth.

However, the intrinsic characteristics of forests make sustainable management a challenge. Deforestation and degradation continue without much compensating gain for economic development or poverty reduction. While afforestation and regrowth have added eight million hectares (mostly plantations) to the global forest estate, the loss of natural forests continues at an unsustainable rate. This loss, mainly due to the conversion of tropical forests to agricultural land, is intricately linked to commodity prices. There have been major changes in the ownership and management of forests.

The scenario of forest in North East India is not much different from that of the global scenario as mentioned above. The deforestation in the North East has added a question mark to the lives of many indigenous and poor people who have been using many forest products as food, shelter and health care.

Different models of forest management fail to check misuse of forest resources. That is why, the govt in 2016 uploaded draft forest policy (later on it was withdrawn) which emphasised management by local people with community forest management. But in Many sixth schedule areas like BTAD and Rabha Hasong Autnomous Council areas where forest department is looked by autonomous district council, deforestation is much more than that of afforestation. (Angshuman Sarma, a researcher angshumansarma13@gmail.com from web). In these days we can not ignore the role of markets, the importance of forest products as inputs in the industries, use of forest land for agricultural purposes by the forest dwellers, duties of human being to protect the diversity of flora and fauna. Keeping in mind above mentioned issues the forest management must be drafted.

For maintaining the sustainable livelihood and protect the endangered medicinal plants, National Medicinal Plants Board, Department of AYUSH, Ministry OF Health & FW, Government of India through its various regional centres in Itanagar, Shillong etc has taken various

measures for medicinal plants exploration in the forests of North Eastern India. Various attempts have also been made for the acclimatisation through cultivation of medicinal plants from one zone to another in the Region.

We can not ignore the use of forest products in our lives. The responsibility of sustaining forest based industries can be handed over to industries so that they can make afforestation programme in order to supply input. Due to mismanagement and shortage of forest products due to lack of afforestation, the production of Cachar Paper Mill at Panchgram and Nagaon Paper Mill at Jagiroad managed by HPC are suspended.

The Government of Assam recently conditioned the exemption of tuition and other fees of the poor students of the higher educational institutions by planting and nurturing a tree plant during his/ her study period. This is an innovative idea to make the state greener.

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19

Flowering and Regeneration of Bamboo (*Dendrocalamus longispathus* Kurz.) in Natural Forests of Mizoram

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Abstract

Bamboo distributes throughout the sub-tropical forest of Mizoram. Out of about 25 indigenous bamboo species growing under natural forests in Mizoram 5 species have flowered during the past 10 years, these are *Melocanna baccifera* (Mautak), *Dendrocalamus hamiltonii* (Phulrua), *Schizostachyum dulloa* (Rawthla), *Dendrocalamus longispathus* Kurz. (Rawnal) and *Bambusa mizorameana* (Talan). A study was carried out on the important ecological parameters such as seeds production, soil seed bank, seed viability, seed germination and seedling establishment of *Dendrocalamus longispathus* Kurz. The study can be used for theoretical modeling of bamboo regeneration after gregarious flowering which occurs after long intervals, as well as for resource management of *Dendrocalamus longispathus* Kurz. which is one of the most common and widely used bamboos in north-east India and Mizoram in particular.

Key word: Bamboo flowering, *Dendrocalamus longispathus*, seed germination, seedling growth.

Introduction

Bamboos are the world's greatest natural and renewable resources and are aptly called the poor man's timber and are found in great abundance.

Their strength, straightness and lightness combined with extraordinary hardness, range in sizes, abundance, easy propagation and the short period in which they attain maturity make them suitable for a variety of purposes. The people of Northeast India with their mongoloid features are endowed with rich bamboo culture and the plants are inseparable part of several diverse traditions and religious beliefs of many ethnic people residing at both hilly and plain areas. Role of bamboo in rural economy varies as food source which is an edible bamboo species. Consumption of bamboo shoots as food in India is mainly confined to the Northeast states where they are taken either fresh at the time of harvesting season or dried, fermented or pickled forms during offseason (Nirmala *et al.*, 2008).

Dendrocalamus longispathus Kurz. is a large caespitose bamboo; culms 20 m tall, up to 10 cm in diameter; nodes swollen; internode swollen, 25–60 cm long. It occurs in moist hill slopes and along streams in the moist fertile loamy soil and particularly shaded fringes of the forest cover. It is distributed in India (Assam, Manipur, Mizoram and Tripura), Bangladesh and Myanmar. *Dendrocalamus longispathus* is an edible bamboo species and is also used for thatching, basket making, fuel, chicks for doors, house posts and mat making, floats for timber and rafts. According to Gamble (1896), *Dendrocalamus longispathus* flowered during 1876, 1879–80 in Chittagong (Bangladesh) and during 1871 & 1891 in Myanmar. Gupta (1972) reported it in flowering from Assam in 1968 and in Mizoram during 1966–67.

During the past decades, research work has been expedited in the field of its biology, ecology, silviculture, utilization and improvement both nationally (Banik, 1987; Shanmughavel & Francis, 1996; Lalramnghinglova, 1997) and internationally (Liese, 1985; Wen & Chou, 1987; Liese, 1992). An unusual characteristic of some perennial bamboos is their habit of flowering at long intervals (3–120 years), dying back, and then regenerating from seed or rhizomes (Numata *et al.*, 1974; Janzen, 1976.). Most Bamboos are anemophilous (wind-pollinated) and have reductive features typical of wind pollinated plants including: high flower production, large anthers, high pollen production and plumose stigmas (Soderstorm and Calderon, 1971). Fruit and seed setting are the two important indicators of the reproductive success of plants and therefore, these two components can be expected to be under intense selection (Ganeshaiah & Uma Shanker, 1988).

Methodology

The study was carried out within Mamit District of Mizoram.

Natural stands of *Dendrocalamus longispathus* Kurz. was selected to study the various parameters. The proposed study area Lengte village falls on undisturbed area of latitude N 23.90063° & longitude E 092.65548° and the disturbed area of latitude N 23.7720034° & longitude E 092.5997035° which is moist sub-tropical and are modified by its physiography.

(1) Phenological characteristics:

The study was carried out in the natural populations of *Dendrocalamus longispathus* Kurz. Detailed phenological observation was carried out on; (i) General floral morphology (ii) Clump and culm characteristic, (iii) Anthesis and pollination and (iv) Fruit and seed formation. Five branches of bamboo was randomly selected in fruit and seed formation analysis, the number of branches and number of spikelets present was counted from the study site of disturbed area and undisturbed area.

(2) Seeds production and soil seed bank:

The quantity of seed produced was estimated by counting the number of randomly selected five individuals of seeds producing *Dendrocalamus longispathus* Kurz. from the study site of disturbed area and undisturbed area. Soil seed bank analysis of *Dendrocalamus longispathus* Kurz. was estimated during the seed drop period (February to July) by Sieving method (Bernhardt & Hurka, 1989).

(3) Seed viability, seed germination and seedling establishment:

Seed viability was tested by using five replicates each having 300 selected seeds from the study site of disturbed area and undisturbed area, which was analyzed by moist tissue inside petriplates and 1% solution of 2,3,5-triphenyltetrazolium chloride (Radford *et al.*, 1974).

Seed germination along with monthly variation in seedling variation from the study site of disturbed area and undisturbed area bamboo forests was established by maintaining as many as 6 (Six) parameter plot of size 10m x 10m (3 each for disturbed and undisturbed sides). Data was collected at every month for one year. The impact of thinning on the survival and growth of bamboo seedlings was maintained by plotting total of 6 quadrats (1.5m x 1.5m), 3 quadrats for bamboo seedlings subjected to thinning operation and another 3 quadrats for seedling for which there is no thinning operation.

Result

1. Phenological characteristics

(i) Floral morphology: The detail Inflorescence in *Dendrocalamus longispathus* Kurz. general floral morphology during March 2015 are presented on table 1 and figure 1.

Table 1: Details of spike, spikelets and florets in *Dendrocalamus longispathus* Kurz.

Characters	Mean
Flowering period	December- March
Flower type	Large panicle
Flower colour	Pale green Palea with Yellow Anther
The number of spikelets per branch	60000 - 80000
Spikelets with exposed stigma per head	Most of the florets
Spikelet with exposed anthers per head	Most of the florets
Width of spike (cm)	1.83 ± 0.18
Number of spikelets per head	25.5 ± 5.74
Length and width of the spikelets (cm)	0.67 ± 0.06 , 0.39 ± 0.07
Number of florets per spikelets	One
Number of glumes	5 ± 7
Length and width of lemma (cm)	0.36 ± 0.04 , 0.19 ± 0.04
Length and width of Palea (cm)	0.35 ± 0.02 , 0.15 ± 0.04
Anther dehiscence mode	Longitudinal.
Length of the stigma + style (cm)	0.56 ± 0.05
Stigma type	Wet and papillate
Length of ovary (cm)	0.1
Number of stigma	One
No. of anthers	6
Pollen shape	Round and circular/spherical

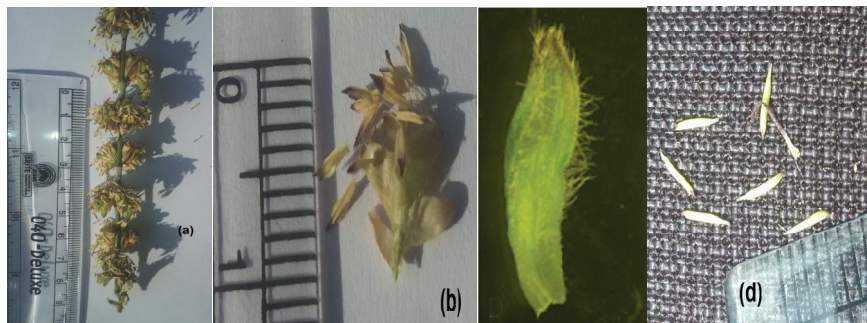


Figure 1: Inflorescence in *Dendrocalamus longispathus* Kurz. (a) Inflorescence, (b) Spikelets, (c) Lemma (d) Palea.

(ii) Clump and culm characteristics

The flowering clumps of *Dendrocalamus longispathus* Kurz. were selected from Lengte, Mamit District. The clumps and culms attributes such as clump diameter, total number of culms /clump, no of culms flowered and the height, girth (mostly at fifth node), number of nodes and intermodal length of the culms within the clump were recorded during March 2015 are presented in the Table 2.

Table 2: clump and culm attributes of *Dendrocalamus longispathus* Kurz.

Clump attributes	Mean
Diameter (m)	9.50 ± 5.50
No. of culms	46.75 ± 12.75
Flowering culms	All
Culm attributes	
Height (m)	21.01 ± 3.71
Girth at fifth node (cm)	25.66 ± 7.26
No. of nodes	34.50 ± 5.50
Internodal length (cm)	46.66 ± 10.11

(iii) Anthesis and pollination

Time of anthesis varied from early morning till noon. Stigma of the flowers emerged out four to five days prior to anther emergence. The stigma became receptive and the receptivity was indicated by the viscous fluid secretion. Just after half an hour of anthesis happened the yellow anthers emerged out and they were in the peeping out stage. They exerted out completely after that and linearly dehisced to disperse yellow pollens

within an hour. It was the peak time of pollen dispersal. Gentle breeze shook the anthers to liberate dusty pollen grains in the air. Majority of the anthers curled out in the afternoon. Like many other bamboo species, *Dendrocalamus longispathus* Kurz. is anemophilous (wind pollinated).

(iv) Fruit and seed formation: Five flowering bamboos were randomly selected for fruit and seed formation analysis which are shown on Figure 1.

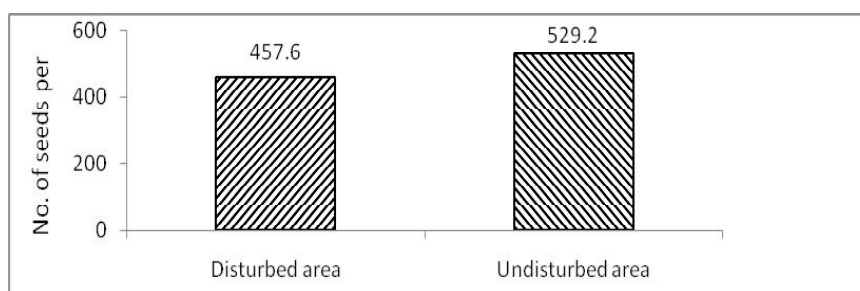


Figure 1: Fruit and seed formation of *Dendrocalamus longispathus* Kurz. flowering disturbed area (DA) and undisturbed area (UDA).

2. Seeds production and soil seed bank

The average number of seeds per branch and flowering culm are given on Table 3.

Table 3: No. of seeds produced b flowering culums of *Dendrocalamus longispathus* Kurz.

Bamboo stand	No. of seeds in one branch						No. of seeds produced in one culm					
	R1	R2	R3	R4	R5	Mean	R1	R2	R3	R4	R5	Mean
Disturbed area bamboo stand	2444	3687	2317	3987	2900	3067	46453	70059	46359	75771	58013	59331
Undisturbed area bamboo stand	4247	3545	2784	4906	3537	3803	80706	70908	55691	93229	70745	74255

Soil seed bank analysis results are given on Table 4 which shows significant variation between Disturbed area and Undisturbed area of flowering in *Dendrocalamus longispathus* Kurz.

Table 4: ANOVA Table on Soil seed bank of *Dendrocalamus longispathus* Kurz.

Disturbed area (DA) X Undisturbed area (UDA)	Sum of Squares	df	Mean Square	F-value	P-value
Between DA X UDA	51268.148	1	51268.148	42.843	.003*
Within DA & UDA	4786.615	4	1196.654		
Total	56054.763	5			

(P > 0.05 *significant)

3. Seed viability, seed germination and seedling establishment

Dendrocalamus longispathus Kurz. has been studied and data of one year analysis has been given for disturbed area (DA) and undisturbed area (UDA) from the study site. Three important analysis has been made on the basis of seed viability, seed germination and seed establishment.

Seed viability using moist tissue inside petriplates are shown on table 5 and figure 2.1.

Table 5: Total number of viability seeds per 300 seeds using petriplates and moist tissue paper.

Replication	No of viable seeds per 300 seeds	
	Disturbed area	Undisturbed area
R 1	145	156
R 2	162	169
R 3	144	153
R 4	152	154
R 5	156	152
Mean	151.8	156.8

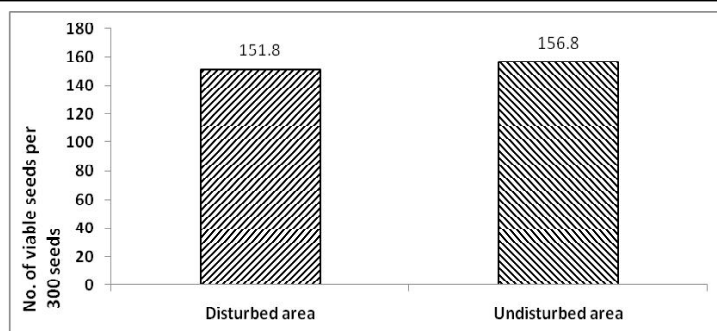


Figure 2.1: Total number of viability seeds per 300 seeds using petriplates and moist tissue paper.

The second method test viability using a 1% solution of 2,3,5-triphenyltetrazolium chloride indicate that 55% of the seed collected from study site give viability which are shown on Figure 2.2.

Table 6: Total number of viability seeds per 300 seeds using Tetrazolium.

Tetrazolium test Replication	No of viable seeds per 300 seeds	
	Disturbed area	Undisturbed area
R 1	168	171
R 2	170	169
R 3	162	160
Mean	166.66	166.66

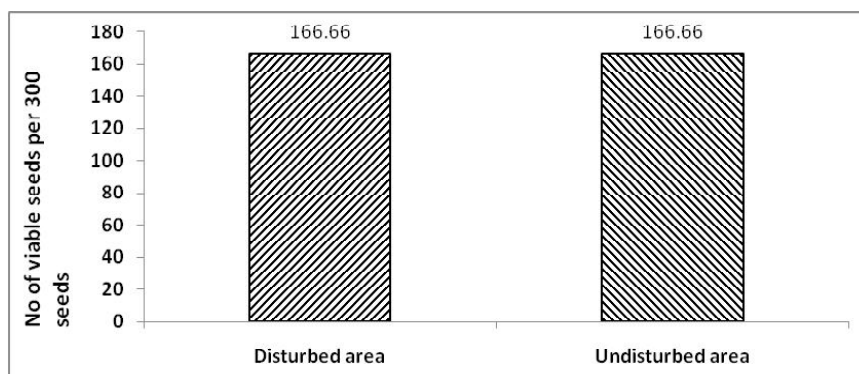


Figure 2.2: Total number of seed viability using 1% solution of 2,3,5-triphenyltetrazolium chloride.

Seed germination from the study site of disturbed area and undisturbed area are studied in terms of their monthly variation in seedling density for one year as on Figure 2.3.

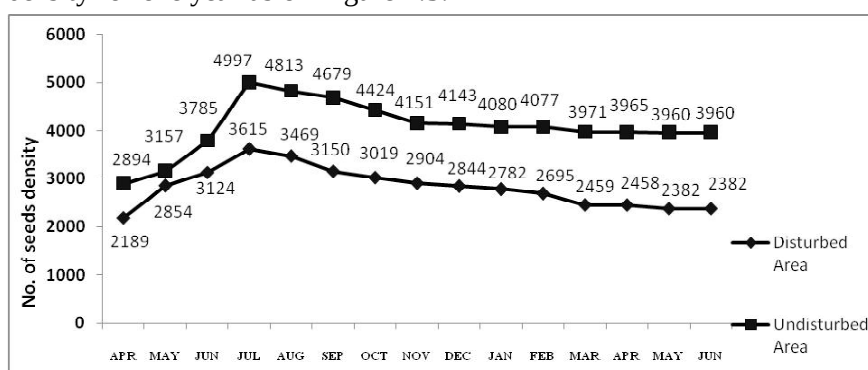


Figure 2.3: Monthly variation in seedling density of *Dendrocalamus longispatus* Kurz.

Seed establishment on *Dendrocalamus longispathus* Kurz. made on the impact of thinning on the survival and growth of bamboo seedlings are shown on Figure 2.4 & Figure 2.5.

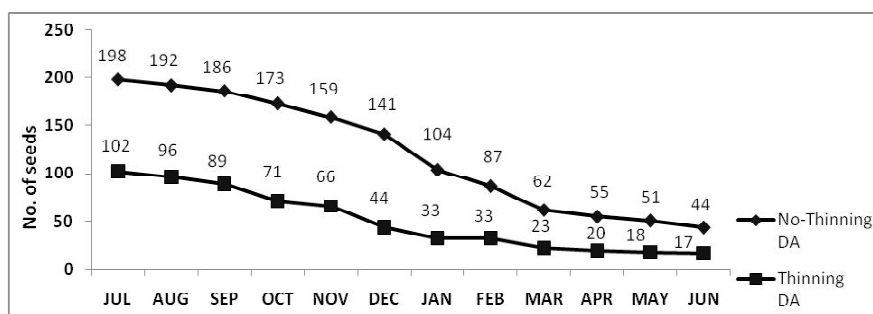


Figure 2.4: Seed establishment of *Dendrocalamus longispathus* Kurz. under Disturbed area.

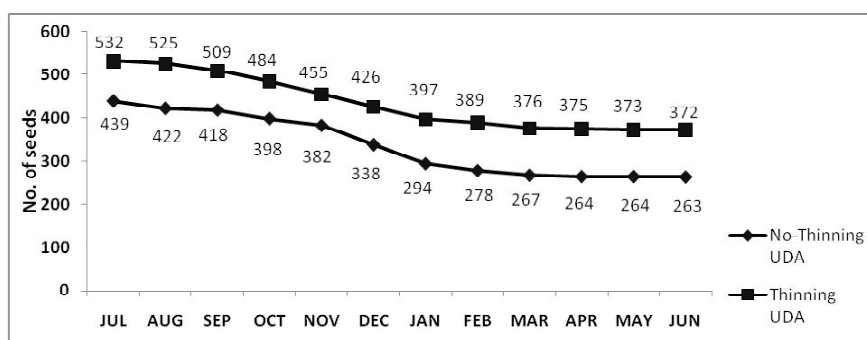


Figure 2.5: Seed establishment of *Dendrocalamus longispathus* Kurz. under Undisturbed area.

Discussion

Flowering of *Dendrocalamus longispathus* Kurz. occurs during the month of December to March. Flowering cycle is short and the order of opening flower even on the same spikelets shows irregular opening. It took four weeks to complete flowering followed by seed formation where early flowering were found to have form mature seeds already. The study shows that there was a significant fruit and seed formation over flowering bamboo of undisturbed area than flowering bamboo of disturbed area. Other workers have also shown the phenology of *Dendrocalamus longispathus* Kurz. (Banik 1998, Seethalakshmi *et al.*, 2010).

The number of seeds produced on branches and flowering culm on undisturbed area are greater as compared to disturbed area of *Dendrocalamus longispathus* Kurz. which is in accordance with the

observation of Banik (1987). Soil seed bank was tested which shows significant variation between flowering bamboo of undisturbed area and flowering bamboo of disturbed area. Seed viability test give no significant impact among the seeds tested through Moist tissue using petriplates and also 1% solution of 2,3,5-triphenyltetrazolium chloride test indicate that 55% of the seed collected from study site give viability. Therefore there is no significant difference on seed viability in comparisons to flowering bamboo of undisturbed area and flowering bamboo of disturbed area.

Seed germination start to occur during the month of late April and end of germination was observed to happen till late June within the flowering year. The germination rate happen to increased possibly due to the irregular flowering, data was taken during the early April when seed germination was first spotted on the study site. Flowering site of undisturbed area was observed to be higher in seedling germination as compared to disturbed area. Germinated seeds were found to decline in terms of mortality during winter and dry season on both the study site. Seed establishment by the process of thinning and no-thinning operation indicate that mortality rate was less on undisturbed area. The reason could be due to the surrounding impact where seedlings of *Dendrocalamus longispathus* Kurz. required shades and proper supply of nutrients for nourishment and survival.

It was observed in the present study that naturally regenerating seedlings of *Dendrocalamus longispathus* requires proper management for the successful establishment under natural forests. The present study would be useful in understanding the ecology and resource management of regenerating seedlings of *Dendrocalamus longispathus* Kurz. which is one of the most common and widely used bamboos in north-east India and Mizoram in particular.

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Tree Species Diversity and Composition in Naturally Regenerating Forest Stands of Tripura

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Abstract

Regeneration in the forest reflects the well-being of the forest. The structural and functional pattern of plant communities are important factors for understanding the mechanism of co-existence of species and to know the long term ecological processes of natural forests. The present study for tree species diversity and composition was carried out in naturally regenerating forest stands of Tripura. In total, 86 tree species were recorded from 8 study sites and belonged to 60 genera and 36 families. Overall *Ficus* is the dominant genera with four species followed by *Artocarpus* with three species. Moraceae was found to be the dominant family with 7 species. The total number of individuals recorded from different forests was 1890 individuals including seedling, saplings and trees with 656.25 individuals ha⁻¹. The forest with highest diversity was recorded in South Tripura (121.66 individuals ha⁻¹). The Shannon-Weiner diversity index ranged from 1.39 to 3.10. The Simpson's dominance index value ranged from 0.03 - 0.09. The Sorensen similarity index was also performed to understand the similarity of species in different forest sites. The tree density, and IVI was found to be highest for *Tectona grandis*. *Tectona grandis* and

Microcos paniculata were common in all forest types. Some of the species which did not show regeneration are *Aegle marmelos*, *Areca catechu*, *Borassus flabellifer* and *Butea monosperma*.

Keywords: Natural regeneration, species composition; stand structure, biodiversity index, stand density

Introduction

Regeneration in the forest reflects the well-being of the forest (Murthy *et al.*, 2016). Regeneration is driven by small scale disturbance such as canopy gaps and natural succession. It infers that regeneration of dominant species and seedling diversity under the gap disturbance is majorly affected by soil characteristics and topographic features. It is because the canopy gaps are occupied by new arrivals and does not get suppressed by understory seedlings and saplings. The size of the canopy gap in fact is a measure for the rate of new germination and survival of seedlings and sprouts (Yang *et al.*, 2009). The canopy gaps enhance the new growths through better light interceptions, which provide favourable microclimatic conditions. This condition is more suitable for less shade tolerant species and show an overwhelming development (Runkle, 1985). The variations along physiographic and ecological gradients creates potential for species heterogeneity in establishment and regeneration (Peterson *et al.*, 2002). The adequate number of seedlings, saplings and young trees in a community represents the successful germination and establishment in that community (Henle *et al.*, 2004).

The structural and functional pattern of plant communities are an important factors for understanding the mechanism of co-existence of species and to know the long term ecological processes of natural forests (Miura *et al.*, 2001). It reflects the dominance status of the species and its development within community; defines the niche requirement of species, examines temporal and spatial heterogeneity of regenerations (Long and Smith, 1992; Chen *et al.*, 1993). This structural pattern is influenced by competitive interactions between trees and can be inferred from differences in the spatial distribution of adult and juvenile trees (Hubbel and Foster, 1987). A dominant species in the forest may not have a good future due to lack of seed bearing species which brings danger to its existence. However, a species with equal distribution of seedling, saplings and trees are ensured with dominant populating in the near future (Bhuyan *et al.*, 2003; Goirola *et al.*, 2012). Thus regeneration of a species is dependent on endogenic ecological processes as well as exogenic disturbances (Barker and Patrik, 1994).

In particular quantitative information is lacking on regeneration status of Tripura but Majumdar *et al.*, (2012 & 2016) have carried out some works on species diversity and stand structure but these studies were limited to Trishna wildlife sanctuary and deciduous forest of Tripura. Quantifying the potential colonization rates of individual species is crucial for predicting how the forest ecosystem can responds to the rapid changes in the climate that have been forecasted. Therefore, the present research focuses on tree bio-diversity and its composition pattern and status of natural regeneration pattern in different forests of Tripura.

Methodology

Study area

The study was carried out in different forest types of Tripura which are mainly tropical evergreen, semi evergreen, and moist deciduous as mentioned in Table 1. The topography is undulating and plain in some parts with altitude ranging from 50 ft to 3080 ft above mean sea level. The climate is humid tropical, with a distinct dry season from November to March and having temperature ranging from 10°-35°C. The soil is laterite in the hills and alluvial in the plains. The soil is moderately acidic soil with pH of 6-7 and generally red or reddish brown appearance.

Table 1: Details of the study sites.

Name of site/s	Districts	Latitude (N)	Longitude (E)	Altitude (m)
Barmura / Naireng (BAR)	West Tripura	23°48' 55.9" to 23°48' 55.0"	91°35'05.0" to 91°34'17.1"	75-327
Bagafa/ Birchandra Manu/ Patichari (BCM)	South Tripura	23°24'10.4" to 23°19'31.0"	91°30'36.4" to 91°29'32.6"	11-794
Jampui Jala/Takarjala/ Charilam (SEP)	Sepahijala	23°13'53.6" to 23° 39'18.6"	91°36'47.3" to 91°18'05.7"	21-58
Kanchanpur/ Satnala & Jampui hill (KAN)	North Tripura	24°30' 31.9" to 23°57'16.5"	91°31'02.3" to 92°16'53.1"	315-645
Karbook/ Khwrwi/ Gonachandra (KAR)	Gomati	23°20' 51" to 23°20' 40.6"	91°42'08" to 91°43'52.0"	79-126
Khowai/Khengra/ Gongkhor (KHO)	Khowai	24°03'3" to 24°03' 09.9"	91°31'02.4" to 91°33'23.5"	63-112
Kumarghat/Dwarchwi/ Chidongchara (KUM)	Unakoti	24°10'36.7" to 24°07' 44.3"	92°20'15.1" to 92°04'08.8"	49-71
Mandai/Mohontisikari/ Dinabandu para (MAN)	West Tripura	23°45' 48.4" to 23°51'37.0"	91°15'48.3" to 91°29'14.9"	66-131

Collection and Analysis of data

Tree species diversity

In different forest types, mixed and monoculture plantations, 3 quadrats of 20 m × 20 m size was laid on ground to study the tree species diversity. The important quantitative values such as density, frequency and abundance were calculated as per Curtis and McIntosh, (1950). The basal cover of woody species was calculated following Ralhan *et al.*, (1991). The relative dominance was determined following (Pandey and Sukhla, 2001). The index was estimated to determine the overall importance of each species in a habitat. In calculating this index, the percentage value of relative density, relative frequency and relative abundance were summed up and this value was designated as important value index (IVI). Species Richness was calculated using Shannon-Wiener Diversity Shannon (1963) and Simpson (1949).

A similarity index was calculated using formula given by Sorensen (1948). Regeneration pattern of the study sites was done to predict the future changes of the vegetation. A total of 72 quadrats of 10 m × 10 m were laid down randomly in each range of forest area. The regeneration survey was carried out in linear strips where the intensity was 2%. A base line was drawn on the base of the map and parallel survey lines were drawn at right angles to the base line 200m apart by selecting the position of the first line by random sample.

Individuals were classified into trees, seedlings and saplings as per procedure of Knight, 1963. The regeneration status of phytosociological data was categorized as good, Fair, poor, no and new as per Shankar, 2001.

Result and Discussion

Tree biodiversity and its composition pattern

In total, 86 species were recorded from the 8 study sites including 15 unidentified tree species and the identified plants belonged to 60 genera and 36 families. The list of species with vernacular name and family name is shown in Table 2.

The total species recorded represent 36 families. Overall Moraceae family is the dominant family with 7 species followed by Euphorbiaceae with 5 species whereas Anacardiaceae, Apocynaceae, Bignonaceae, Dipterocarpaceae, Myrtaceae and Verbenaceae families with two species each and the rest of the families with only single species. However, the recorded family excludes unidentified species.

Table 2: List of species recorded along with vernacular and family name.

Species	Vernacular name	Family	Density ha ⁻¹	Basal area m ² ha ⁻¹	IVI
<i>Acacia auriculiformis</i> Benth.	Acacia	Mimosaceae	0.005	0.028	1.13
<i>Aegle marmelos</i> (L.) Correa.	Bel	Rutaceae	0.024	0.048	2.35
<i>Albizia lebbek</i> (L.)Benth.	Khwrwi	Mimosaceae	0.039	0.024	2.65
<i>Albizia procera</i> (Roxb.) Benth.	Khwrwi	Mimosaceae	0.029	0.053	2.48
<i>Alstonia scholaris</i> L.R.Br.	chethuwang	Apocynaceae	0.010	0.025	1.17
<i>Anogeissus latifolia</i> (Roxb. ex DC.) Wall. ex Guill. & Perr.	Borsroi	Combretaceae	0.231	0.025	8.53
<i>Areca catechu</i> L.	kuwai	Arecaceae	0.068	0.005	4.05
<i>Artocarpus chaplasi</i> J.R. Forster & G.Forster	Gwram	Moraceae	0.333	0.055	11.07
<i>Artocarpus heterophyllus</i> Lam.	Thaipung	Moraceae	0.145	0.039	6.35
<i>Artocarpus lakoocha</i> Roxb.	Lakoocha	Moraceae	0.014	0.065	1.57
<i>Bauhinia acuminata</i> L.	Kaya	Cesalpiniaceae	0.039	0.010	2.80
<i>Bombax ceiba</i> Burm.f.	Borchuk	Bombacaceae	0.024	0.035	2.35
<i>Borassus flabellifer</i> L.	Tal	Palmae	0.014	0.100	1.57
<i>Butea monosperma</i> Kuntze.	Palash	Papilionaceae	0.029	0.009	2.18
<i>Caryota urens</i> L.	Swmal	Arecaceae	0.029	0.013	2.18
<i>Cassia fistula</i> L.	Swka thuri	Cesalpiniaceae	0.024	0.008	2.08
<i>Cassia siamea</i> Lam.	Cassia	Cesalpiniaceae	0.178	0.013	7.09
<i>Citrus maxima</i> (Burm.) Merr.	Jamura	Rutaceae	0.019	0.010	1.96
<i>Crateva nurvala</i> (Lour.) DC	Borna	Capparaceae	0.010	0.007	1.17
<i>Croton</i> spp	Omokhwi	Euphorbiaceae	0.019	0.012	1.72
<i>Delonix regia</i> (Bojer) Raf.	Krishnachura	Cesalpiniaceae	0.039	0.022	2.65
<i>Dillenia indica</i> L	Thaiplok	Dilleniaceae	0.005	0.012	0.78
<i>Dillenia pentagyna</i> Roxb.	Bolong Thaiplok	Dilleniaceae	0.043	0.016	3.20
<i>Diospyros</i> spp L.	Bolphantok	Ebenaceae	0.072	0.019	4.27
<i>Dipterocarpus turbinatus</i> C.F.Gaertn.	Garjan	Dipterocarpaceae	0.405	0.025	12.88
<i>Elaeocarpus floribundus</i> L.f.	Jalpui	Elaeocarpaceae	0.029	0.015	2.18

<i>Emblica officinalis</i> Gaertn.	Amla	Euphorbiaceae	0.024	0.003	1.95
<i>Erythrina stricta</i> Roxb.	Mandar	Papilionaceae	0.039	0.018	2.62
<i>Erythrina variegata</i> L.	Mandar	Papilionaceae	0.014	0.012	1.57
<i>Eucalyptus grandis</i> Hill & ex Maiden.	Eucalyptus	Myrtaceae	0.005	0.030	0.78
<i>Ficus benghalensis</i> Linn. var.krishnae		Moraceae	0.005	0.003	0.78
<i>Ficus hispida</i> L.f.	Dumur	Moraceae	0.024	0.009	2.08
<i>Ficus racemosa</i> Wall.	Khwichang	Moraceae	0.068	0.004	3.89
<i>Ficus religiosa</i> Forssk.	Bwrwiphang	Moraceae	0.019	0.094	1.72
<i>Flacourtia jangomas</i> (Lour.) Raeusch.	Supra	Salicaceae	0.010	0.021	1.17
<i>Garcinia spp</i> Dunn.	Kok	Clusiaceae	0.039	0.010	2.80
<i>Gmelina arborea</i> Roxb.	Gamai	Verbenaceae	0.092	0.037	4.50
<i>Grevellia robusta</i> A. Cunn.ex R.Br.	Silver oak	Proteaceae	0.014	0.011	1.57
<i>Holarrhena antidysentrica</i> (Roxb.ex Fleming) Wall.ex A.DC.)	Kuichima	Apocynaceae	0.188	0.010	7.83
<i>Jatropha curcus</i> L.	Karan	Euphorbiaceae	0.024	0.003	1.95
<i>Litchi chinensis</i> Sonn.	Lichu	Sapindaceae	0.034	0.011	3.14
<i>Mallotus philippensis</i> (Lam.) Muell.Arg.	Kamala	Euphorbiaceae	0.053	0.010	3.16
<i>Mangifera indica</i> L.	Thaichuk	Anacardiaceae	0.063	0.036	4.01
<i>Melia azedarach</i> L.	Bolong neem	Meliaceae	0.029	0.021	2.18
<i>Mesua ferrea</i> L.	Nageshwar	Calophyllaceae	0.019	0.004	1.96
<i>Michelia champaca</i> L	Sampari	Magnoliaceae	0.034	0.020	2.64
<i>Microcos paniculata</i> L.	Pesla	Malvaceae	0.309	0.008	10.49
<i>Mitragyna rotundifolia</i> Korth.	Omokhwi	Rubiaceae	0.092	0.011	4.78
<i>Moringa oleifera</i> Lam.	Sajana	Moringaceae	0.029	0.013	2.26
<i>Murraya Paniculata</i> (L.) Jack.	Kamini	Rutaceae	0.010	0.004	1.25
<i>Oroxylum indicum</i> (L.) Benth. Ex Kurz	Tokharung	Bignoniaceae	0.024	0.013	2.08
<i>Phoenix dactylifera</i> L.	Khejur	Arecaceae	0.010	0.027	1.17

<i>Psidium guajava</i>	Goyam	Myrtaceae	0.024	0.022	2.35
<i>Polyalthia longifolia</i> (Sonn.) Hook.f.& Thomson.	Ashok	Annonaceae	0.005	0.005	0.78
<i>Schima wallichii</i> (DC.) Korth.	Madhuga	Theaceae	0.612	0.019	17.74
<i>Shorea robusta</i> C.F.Gaertn.	Sal	Dipterocarpaceae	0.256	0.031	9.14
<i>Spondias pinnata</i> L.	Thestwi	Anacardiaceae	0.063	0.043	3.57
<i>Sterculia villosa</i> L.	Lambak	Sterculiaceae	0.082	0.036	2.08
<i>Stereopermum personatum</i> (Hassk.) Chatterjee	Silai	Bignoniaceae	0.024	0.009	4.52
<i>Streblus asper</i> Lour.	Saruwa	Urticaceae	0.024	0.012	2.35
<i>Swietenia mahagoni</i> (L.) Lam.	Mahagoni	Meliaceae	0.024	0.064	2.08
<i>Syzygium cumini</i> (L.) Skeels.	Jam	Myrtaceae	0.444	0.022	13.70
<i>Tamarindus indica</i> Linn.	Thentrwi	Papilionaceae	0.010	0.193	1.17
<i>Tectona grandis</i> L.f.	Sejun	Verbenaceae	0.916	0.016	24.55
<i>Terminalia arjuna</i> W & A	Arjun	Combretaceae	0.024	0.012	2.35
<i>Terminalia bellerica</i> (Gaertn.) Roxb.	Boira	Combretaceae	0.140	0.015	6.23
<i>Toona ciliata</i> M. Roem.	Ronggin	Meliaceae	0.212	0.018	8.05
<i>Trema orientalis</i> (L.) Blume		Cannabaceae	0.019	0.018	1.72
<i>Trewia nudifolia</i> Benth.	Mentha	Euphorbiaceae	0.024	0.010	2.35
<i>Vitex peduncularis</i> Wall.		Lamiaceae	0.029	0.040	2.18
<i>Ziziphus jujuba</i> Lam.		Rhamnaceae	0.039	0.012	2.62
Unidentified -1-15					

The total number of individuals recorded from different forests was 1890 individuals including seedling (SE), saplings (SA) and trees (TR) with 656.25 individuals ha⁻¹. The forest wise total individuals according to decreasing order is highlighted in Fig. 1. The distribution pattern of plant species indicates its adaptability to various environment factors and forest communities mainly depends on characteristics of sites and regeneration status (Wang *et al.*, 2004). The species recorded in the present study is much higher than other reports (Hossain *et al.*, 2004; Pala *et al.*, 2013). Furthermore Majumdar *et al.*, (2012) recorded higher species in Sal dominated forest and *Tectona grandis* dominated forest of Tripura. In the present study Moraceae was the dominant family, similarly Majumdar *et al.*, (2012) also found the same family as dominant one from lowland

primary and secondary moist deciduous forest of Tripura. While Wale *et al.*, (2012) reported dominance of Fabaceae family in Western Ethiopia.

The species density, basal area and important value index (IVI) of tree species as recorded from study sites are mentioned in Table 2.

The Shannon-Weiner diversity index was estimated to know the diversity status of an area. The values ranged from 2.88 (MAN) to 3.81 (SEP) in 8 different forest sites. Whereas, Simpson's dominance index value ranged from 0.03 (SEP) - 0.09 (KAN) (Table 3). The Sorenson similarity index was performed to understand the similarity of species in different forest sites. The similarity index value was recorded maximum between BCM and SEP with 57.8 % while the lowest value was 28.1% between MAN and SEP (Table 4).

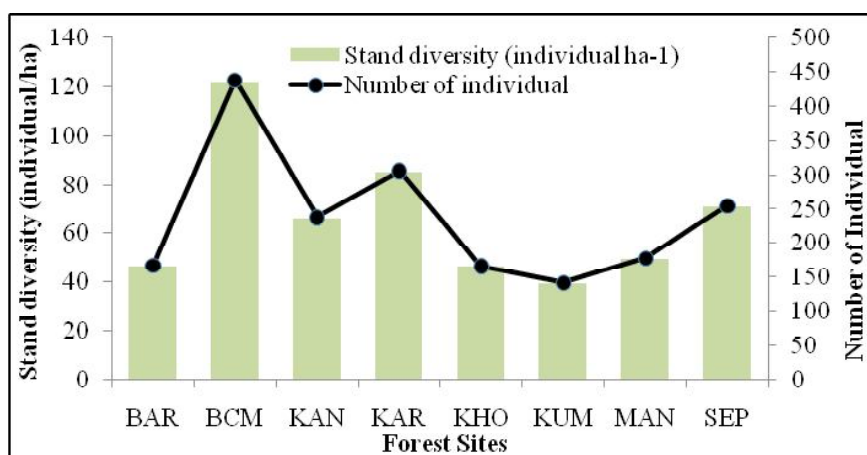


Fig 1: Trend of stand density (individual ha⁻¹) and number of individual in the studied forest sites.

Table 3. Summary of species inventory from the study sites

Variables	BAR	BCM	KAN	KAR	KHO	KUM	MAN	SEP
Species richness	28	39	29	27	38	25	20	44
Number of genera	23(5)	31(4)	22(7)	21(7)	36(2)	24(6)	18(2)	39(5)
Number of families	18	23	18	15	23	11	16	23
Number of individual	167	438	238	306	166	142	178	255
Stand diversity (individual ha ⁻¹)	46.38	121.66	66.11	85	46.11	39.44	49.44	70.83
Shannon Weiner index	3.38	3.60	2.91	3.40	3.77	3.31	2.88	3.81
Simpson's index	0.06	0.04	0.09	0.06	0.04	0.05	0.08	0.03

Values in parenthesis includes the unidentified species

Table 4. Similarity index values between different forest sites.

Sites	BAR	BCM	KAN	KAR	KHO	KUM	MAN	SEP
BAR	*	38.8	31.5	36.3	45.4	41.5	41.6	36.1
BCM	*	*	47.0	48.4	44.1	34.3	37.2	57.8
KAN	*	*	*	35.7	38.8	48.1	40.8	38.3
KAR	*	*	*	*	30.7	38.4	42.5	42.2
KHO	*	*	*	*	*	31.7	34.4	41.4
KUM	*	*	*	*	*	*	35.5	34.7
MAN	*	*	*	*	*	*	*	28.1
SEP	*	*	*	*	*	*	*	*

Status of Natural Regeneration Pattern

A total of 882 seedlings (SE), 283 sapling (SA) and 725 trees (TR) were recorded from overall forest sites (Table 5 & Fig. 2). The Shannon-Weiner diversity index ranged between 1.39 to 3.10 in seedlings, sapling and trees. The Simpson's dominance index ranged between 0.07 to 0.35. The Shannon's diversity index was higher in the study area which is greater than recorded for old Sal plantations in Gorakhpur (Pandey and Shukla 1999), for sal forests in Eastern Himalaya (Shankar, 2001), for Western Ghats (Arunachalam, 2002), and a tropical dry evergreen forest of South India (Parthasarathy and Sethi, 1997). In the present study, the Simpson dominance value are comparable with the value for natural forest and for planted forest (Chauhan *et al.*, 2008). The calculated similarity index was almost similar to that recorded by Khan *et al.*, 1987 disturbed and protected subtropical forest of north-east India, Meghalaya. Furthermore, Majila *et al.*, (2010) reported 100% similarity between west and north aspect of middle altitude, and least similarity between east aspect of lower altitude and south aspects of higher altitude in Binsar Wildlife Sanctuary.

In the study, greater number of individuals in the seedling stage was observed and a sharp decline in sapling but there is an increase in tree individuals, which indicates fair development of all the forest sites. It also suggests that if the current recruitment of sapling does not improve, the population may decline in the long run. On the contrary, forest structure of Sarkot van Panchayat in Garhwal Himalaya is expanding in nature with more number of tree species than sapling and seedling (Pala *et al.*, 2012). Others have also reported either fair or good regeneration in seven species and 17 species showed poor or no regeneration status in Garhwal Himalaya (Pala *et al.*, 2013).

Table 7. Summary of seedling, sapling and trees of various study sites

Variables		BAR	BCM	KAN	KAR	KHO	KUM	MAN	SEP
Species richness	SE	19	28	18	20	19	15	11	22
	SA	13	18	8	17	14	7	8	13
	TR	17	25	15	15	29	18	15	36
Number of genera	SE	15(4)	22(6)	12(5)	16(4)	17(2)	12(3)	11	18(4)
	SA	11(2)	18	7(1)	12(5)	14	4(3)	7(1)	12(1)
	TR	15(2)	23	11(4)	11(4)	28(1)	13(4)	13(2)	32(4)
Number of individuals	SE	77	218	158	157	44	68	55	105
	SA	31	58	12	64	27	18	46	27
	TR	59	162	68	85	95	56	77	123
Shannon diversity index	SE	2.40	2.76	2.02	2.48	2.70	2.37	1.78	2.77
	SA	2.36	2.15	1.91	2.59	2.49	1.46	1.39	2.31
	TR	2.32	2.66	2.21	1.84	2.95	2.55	2.01	3.10
Simpson index	SE	0.20	0.09	0.17	0.12	0.09	0.12	0.23	0.08
	SA	0.11	0.19	0.18	0.09	0.09	0.35	0.24	0.13
	TR	0.14	0.09	0.15	0.29	0.08	0.10	0.19	0.07

Values in parenthesis includes the unidentified species

The regeneration status varied from place to place and from species to species (Fig 3). The overall status of forest indicates that BCM in South Tripura district has the highest number of individual (438 individuals) and stand diversity (121.66 individuals ha⁻¹), whereas, KHO and KUM comparatively constituted with less individuals and less stand diversity. This indicates that BCM is less disturbed as compared to KHO and KUM, where settlement areas are nearby the forest sites. This increases the anthropogenic activities, thereby affecting the species diversity and forest population. In the disturbed forest sites, *jhum* cultivation in MAN and KAR and forest fires were also observed in KUM. In KAR, forest clearance was observed due to increasing rubber plantation and bamboo cultivation. The forest stands characterized with only adults species and low population of seedling and saplings are expected to face local extinction. In the present study, high forest fire sites were observed, this form the reason why the seedlings are higher in number but sapling number is low and increases in tree number. Same has been reported by Murthy *et al.*, (2002) and Sukumar *et al.*, (1997).

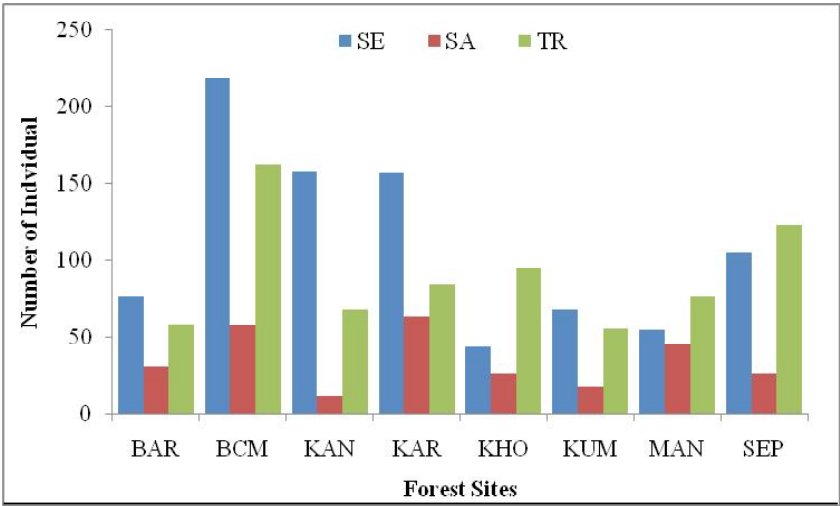


Fig 2: Number of individuals in different forest sites.

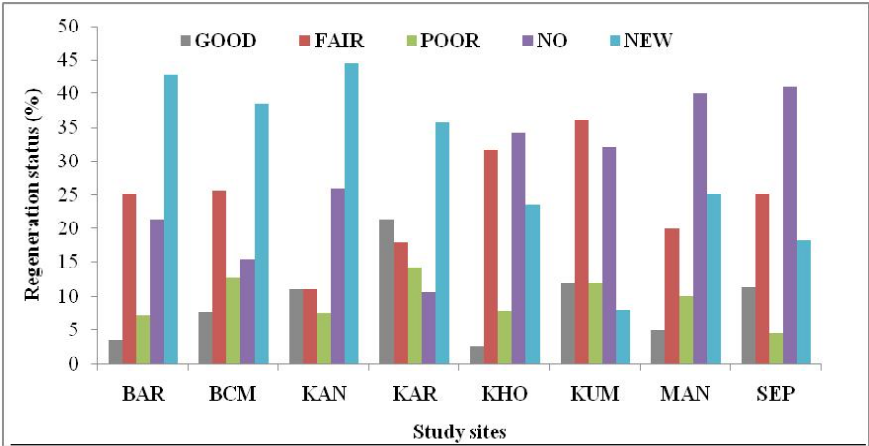


Fig 3. Regeneration status of study sites

The study finally concludes that a proper protection from human interferences and scientific management of natural regeneration of the study areas may lead a biodiversity rich site in the state.

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21

Soil Erosion: A Lose of Natural Resource

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Abstract

Soil is valuable; it is a natural resource. It is important for food production. Such soil is lost through wind and water which are called wind erosion and water erosion. There are various types of erosion. In all types of erosion top fertile soil is washed down or blown away. For formation of 1 cm of soil layer, it may take 1000 years; this information adequately shows the significance of soil erosion. North eastern hill region is comprised of the states Assam, Nagaland, Manipur, Mizoram, Meghalaya, Arunachal Pradesh, Tripura and Sikkim. Mostly the terrain is hilly and the steep slopes are very common and hence the quantum of soil eroded is relatively higher. In this paper the alarming soil loss in the North Eastern Hill Region is discussed.

Keywords: Soil erosion, Wind erosion, Water erosion, North Eastern Hill Region.

Introduction

Soil loss through soil erosion is occurring throughout the world. Soil is a natural resource. Natural resources are very valuable to the mankind. In this research article, it is an attempt to highlight the loss of natural resource in India with an emphasis on North Eastern hill region. Few things, which are salient to this region, are mentioned here. NER Hill region is consisting of high hills, good amount of forest cover, inherent soil and climate suitability to horticultural crops with high productivity. Agricultural crops are next to only horticultural crops because of topography.

If the soil particles are detached and carried by water it is called water erosion. If the soil particles are carried by wind and blown it is called wind erosion. Be it water erosion or wind erosion the ultimate damaging effect falls on soil fertility. Soil fertility is an important factor for forestry, Agriculture, horticulture in NEH region as is elsewhere in the world.

Discussion

Active soil erosion through wind and water is seen in more than 140 million hectares resulting in 6000 million tones of fertile soil, which consist of nearly 5.53 million tones of nitrogen, phosphorus and potash nutrients. In a developing country like India, the price in terms of rupees the country has to bear is very much understandable by these figures. It may not be wrong to say that soil loss from NEH India is quite significant, which is due to hilly nature and slopy topography.

Water erosion may express soil loss in the form of sheet erosion, rill erosion, gully erosion, ravines and landslides.

Sheet erosion: In sheet erosion a thin layer of soil is removed uniformly from the top layers of the soil. It is the first phase of soil erosion.



Figure 1. Sheet erosion



Figure 2. Rill Erosion

Rill erosion: It is characterized by channelization and non-uniformity of runoff. Incisions are formed on the surface. This is more prominent than sheet erosion. This the second phase of soil erosion.

Gully erosion: Uncontrolled rills turn into enhanced channelization of runoff. In this erosion deep and wide channels are formed due to channelized runoff from large slopes. The runoff water is having enough volume and velocity. Gullies are most prominent features of gully erosion. If gullies are not controlled crop production is a challenge.



Figure 3. Gully formation

Ravines: They are advanced phase of gully erosion with deep and wide gullies.



Figure 4. Ravine formation

Landslides: Slide down of large quantity of soil from steep slopes is called as landslides.



Figure 5. Landslide in hilly terrain

Available soil loss data for the states of Assam and Tripura are given in the Table No. 1 and 2.

Table 1: Soil loss Status in Assam

Class	Range of soil loss (t/ha/yr)	Area (%)	Area ('000 ha)
1	<5	16.44	1289.52
2	5-10	11.26	883.21
3	10-15	4.58	359.26
4	15-20	18.08	1418.16
5	20-40	14.83	1163.23
6	>40	28.30	2219.79

(Source: Sen *et al.* 2005)

Table 2: Soil loss from Tripura and its extent

Class	soil loss (t/ha/yr)	Area	
		Hectares	Percentage
Slight	<5	430131	41
Moderate	5-10	216115	21
Moderate-severe	10-20	147923	14
Severe	20-40	68192	6
Very Severe	40-80	90223	9
Extremely Severe	>80	96517	9

(Source: Bhattacharya *et al.*, 2007)

Conclusion

Soil loss data through erosion in terms of tones/ha for states like Sikkim, Nagaland, Manipur, Arunachal Pradesh, Meghalaya and Mizoram is scanty.. Since the data is scanty, soil erosion related work may be taken up in future.

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22

Spatio-Temporal Changes in Pichavaram and Sundarbans Mangrove Forest: A Geographical Analysis

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Abstract

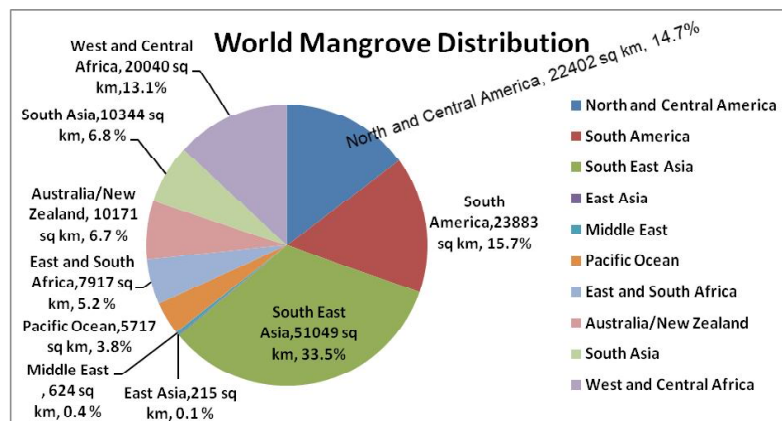
The mangrove wetland forms a dynamic ecotone between land and sea. It is the dominant feature of the tropical ecosystem and influx of freshwater, salinity and sediments act as the regulator of the spatial extension of the forest. The mangrove wetland is a multiple use ecosystem that provides protective, productive and economic benefits to coastal communities. Mangroves require high humidity, high tidal amplitude along with high rainfall throughout the year. Mangrove forest and associated wetlands are naturally resilient and have withstood severe storms and changing tides for many millennia, but now they are being destroyed on a large-scale due to human greed. The paper attempts to understanding the spatio- temporal changes and its impact on socio- economic conditions of both the area and to compare it. The ecosystem of mangrove wetland is rich in biodiversity, locals depends directly and indirectly for livelihood. In recent decade, spatial extension of the Sundarbans mangrove forest is shrinking and on the other hand spatial extension of the Pichavaram mangrove forest is increasing in recent decade. The Sundarbans Mangrove receives rainfall from South-west monsoon during summer but on the other hand Pichavaram receive rainfall from South-west monsoon during winter.

Keywords: Mangrove, Forest, Monsoon, Ecosystem, Livelihood, Wetland, Coastal Communities.

Introduction

Mangrove forest is the very unique ecosystem of the tropical and subtropical region of the world. It grows in between 32 degrees north latitude and 38-degree south latitude; mostly in the eastern coast of continent and forms the dynamic ecotone between the land and sea (Selvam et al., 2002). It needs the special ecosystem and criteria such as brackish water, mixing of fresh river water and saline sea water, high tidal amplitude, high humidity and high rainfall evenly distributed for its luxuriant growth. The mangrove plants are able to survive in brackish water due to its god gifted natural adaptation characteristic such as stilt roots, viviparous seed, salt glands, salt- excluding mechanisms, thick cuticles, leathery leaves and pneumatophores (Rahaman et al., 2014). Mangroves are vital to coastal communities as they act as some multiple use ecosystems by providing the protection and resource to the coastal communities; protect them from damage caused calamities such as tsunami waves, erosion and storms. They have an ability to sink carbon from the atmosphere, and serve as both a source and nursery grounds for a number of commercially important fish and sediments for other inshore marine habitats. It provides wood products and non-wood product.”However, owing to both anthropogenic and climatic factors, mangroves the world over are severely threatened, and, with current global annual loss rates of 1 per cent–2 per cent, no such forests may be left by the end of the 21st century, if the current trend continues” (Ghosh, et al. 2015).

Mangrove wetlands are predominant in the tropical region with Asia and Australia having the greatest diversity at present (Figure: 1).



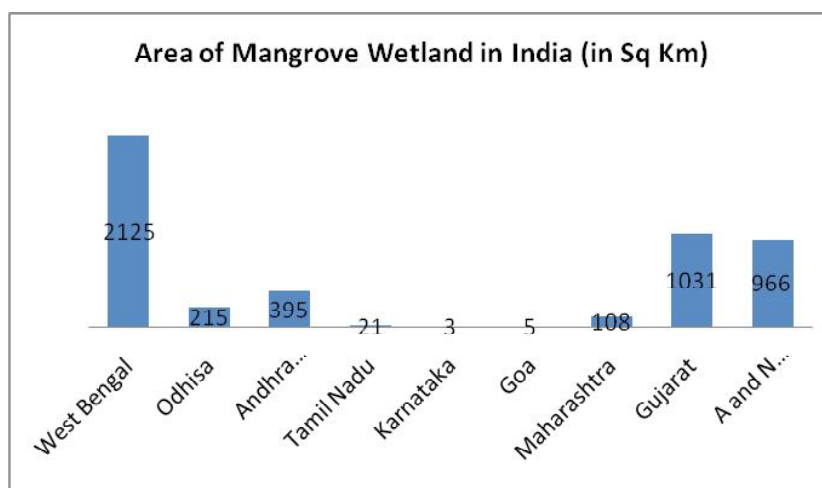
Source: Prepared by Authors based on the data from World Atlas of Mangrove, 2010

Figure 1: World distribution of mangrove

Out of 18 million hectares of mangrove forests, more than 40 per cent are found along the Asian coast (Figure 1). The mangrove forest can be divided into eastern and western groups. The eastern group covers the region from the west and central Pacific to the southern end of Africa (Ravishankar, et al. 2004).. The western group covers the American and African coast of the Atlantic Ocean, the Caribbean Sea and Gulf of Mexico as well as the west coast of Africa and the coastal regions of North and South America. “The eastern group have five times more mangrove species than the western group” (Ravishankar, et al. 2004).

Mangrove Forest in India

Inter alia Forest Survey of India stated that within the 7500 km coastline, India supports 487100 ha of mangrove wetlands, in that nearly 56.7 percent, i.e. 275800 ha is spread along the east coast region and 23.5 percent (1, 14,700 ha) in the west coast region and the remaining 19.8 percent (96,600 ha) is found in Andaman and Nicobar Islands (Sandilyan, 2014). The eastern coast has more mangrove than western because former coastal slope is gentle and later has steep slope towards the sea (Kathiresan and Rajendran, 2005). Along the east coast of India, the extension of mangrove wetland decreases from the Sundarbans in the north to the Pichavaram in the south and this is due to the decrease in the tidal amplitude and inflow of fresh water from the north to south (Krishnamurthy and Jeyabeelan, 1984).



Source: Prepared by Authors based on the data of Mangrove Wetland of India, Part 1: Tamil Nadu, 2002)

Figure 2: Area of different mangrove wetland in India (2002)

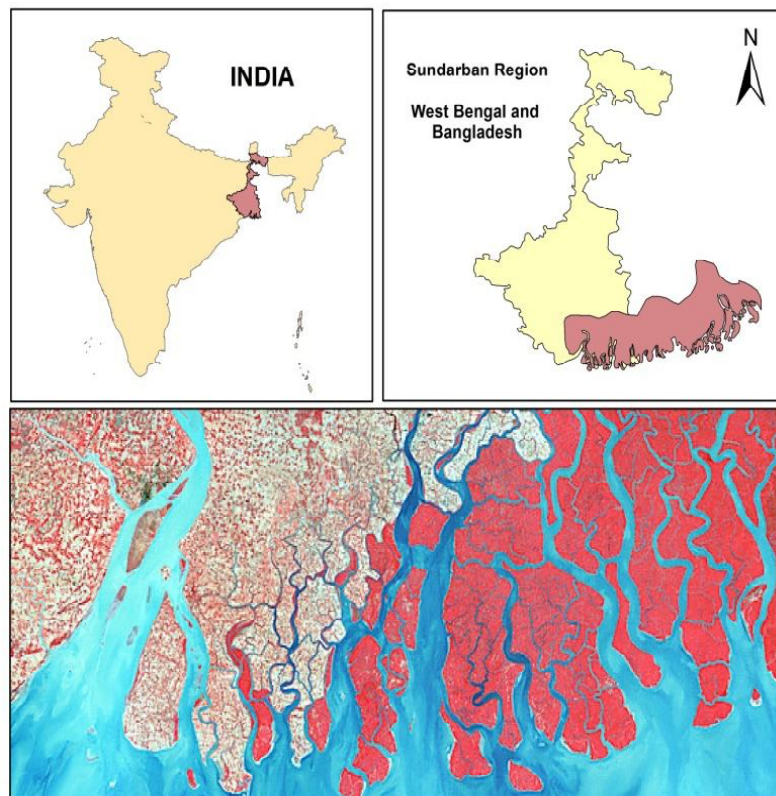
Study Area

The Pichavaram Mangrove wetland is located in the Cuddalore district of eastern Tamilnadu in South India, in the Killai backwater in between the Vellar River from north side to Coleroon River south side (Figure: 3). It slopes gently towards the Bay of Bengal and is drained by the tributaries of Cauvery River i.e., Uppanar and Coleroon. The beach, estuary, mud flats, barrier dunes, 51 islets, waterways, channels, gullies and rivulets are the major landforms. The mangrove wetland is consisting of 3 Reserve Forest (RF) viz., Killai RF, Pichavaram RF and Pichavaram Extension Area (Selvam et al, 2002). It is located at about 225 km south of Chennai and 5 km north east of Chidambaram, Cuddalore district, Tamil Nadu, between latitude 11°20' to 11°30' north and longitudes 79°45' to 79°55' east.

This ecosystem is well known for its luxuriant growth of mangrove plants with high productivity and diversity of flora and fauna. The Pichavaram mangrove is characterized by the presence of the 13 exclusive mangrove species (Ramanathan et al., 1999). The soil is generally dry, clayey and rich in alkaline and alkaline earth element. Most of the area has the depth of 0.63 to 1.63 m except in the mouth region at Chinnavaikal where the depth ranges are from 3.63 to 5.63m. The freshwater inflow is during the northeast monsoon season (October-January) through the Coleroon and Uppanar rivers. The average rainfall is 85.5 cm. The Coleroon estuary is the main source of tidal water for the mangrove wetland. The characteristic of the tide is of semi-diurnal type with slight inequality. The major crop cultivated in the village situated around is Groundnut and Paddy. Around 2 sq. km area of the mangrove are utilized for the aquaculture practice. Local residents mostly depends on the mangrove for Grazing, Firewood collection and Fishing (Selvam et al, 2004).

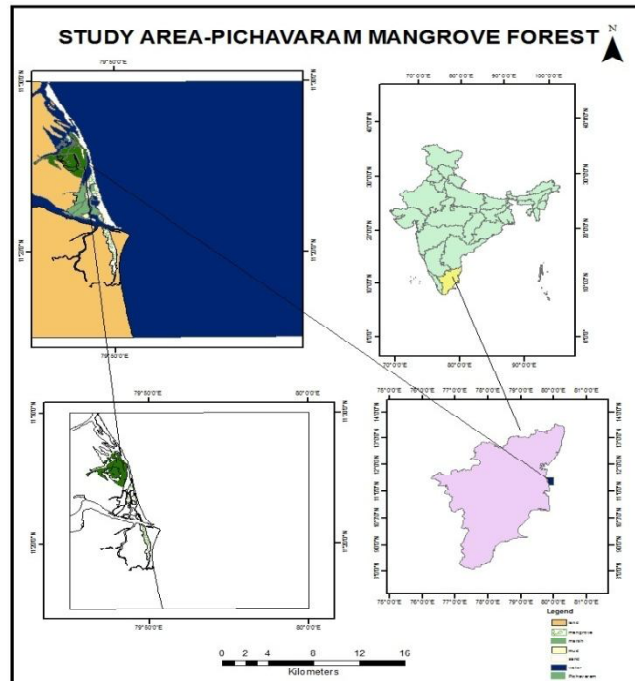
The Sundarbans mangrove forest is located on the delta region of the Ganges, Brahmaputra and Meghna rivers in the Bay of Bengal covering a total area of approximately 26600 sq. km of which 62 per cent is in Bangladesh and rest 38 per cent lies within India (and Islam, 2004). Indian Sunderban is found within 21°32'22" to 22°40'2" N latitude and 88°05'2" to 89°51'2" E longitude (Ghosh et al, 2015) and comprise an approximate area of 10000 sq. km (Figure: 4). This deltaic ecosystem is the largest continuous mangrove forest in the world. The total area below the Dampier-Hodge line is 9630 sq. km; round 5366 sq. km were reclaimed for cultivation and human habitation. About 4264 sq. km including water areas are covered by forest which contains the core area, the tiger project and bird sanctuary.

It experiences a humid tropical climate and receives the rainfall from South West Monsoon from June to September with annual rainfall ranging from 2500 to 3000mm and dry season between November and April. Seasonal mean minimum and maximum temperatures vary from 12°C to 24°C and 25°C to 35°C, respectively. Depending upon the season the tidal level varies from 5 to 7 m and the pH of the water ranges from 7.2 to 7.9. It is consisting of a network of mudflats and islands created by accumulated sediment loads brought down by the Himalayan Rivers and tidal waterways (Ghosh, et al 2015).



Source: Prepared by Authors based on data from (GLCF, 2017)

Figure 3: Pichavaram Mangrove Forest



Source: Prepared by Authors based on GLCF, 2017

Figure 4: Sundarbans Mangrove Forest

Objectives of the Study

The main Objectives of the study are:

1. To assess the Spatio- Temporal changes in both the Pichavaram and the Sundarbans mangrove forest.
2. To analysis the reason behind the change in area of the mangrove forest and to find out the impact of the mangrove forest in their respective coastal communities and vice versa.

Data sources and Methodology

Both primary and secondary data has been taken; primary data are satellite and top sheet map and secondary data was taken from various sources of literature review and website. It has been found through extensive review of literature and digitization of satellite map through various sources that the Sundarbans mangrove forest are shrinking in area and on the other hand the Pichavaram mangrove forest are expanding in its area. Assessment of mangrove forest has been done from 1972 to 2017. The growth

characteristic of the mangrove forest that is during monsoon season due to fresh water availability forest growth and area extension is maximum and during dry season due to absence of fresh water inflow salinity is high and the forest growth and area extension is minimum. So, owing to this growth characteristic it is taken great care that satellite map is taken in the particular season of the year. Pichavaram mangrove forest is in the Cuddalore district of Tamil Nadu which is the South east of South India (Saini et al., 2012). Tamil Nadu receive rainfall from North east monsoon during October to December and during this season the growth is maximum but on the other hand for Sundarbans mangrove forest is located in the eastern part of India it receives rainfall from South west monsoon during the June to August season so the growth is maximum during this season (Biswas, et al., 2010). The satellite map has been taken during the peak growth season of the mangrove forest for both the study area. Satellite map of resolution 23.5 to 30m was taken and merging of satellite map resolution has been done for the better accessing of study area and nearby buffer area.

Results and Discussion

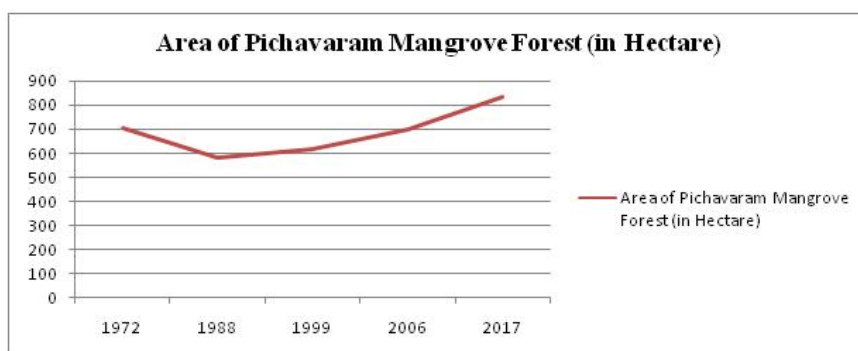
Mangrove forest globally is in verge of extinction due to coastal development, climate change, logging and agriculture. This forest is important subtropical and tropical habitats of many species and their loss will affect marine and terrestrial biodiversity widely. More than 80 percent of mangrove forest is lost in India and Southeast Asia in 60 years. This loss will result into the devastation of economic and environment of the coastal area. This forest is important to fight climate change, protect vulnerable communities from disaster and provide them resources and habitats. Mangrove forest are depleting at rate of four to six times faster than overall global forest area. Some countries have lost more than 45 per cent of their mangrove forest over a period of 25 years. The main driver behind this loss is the conversion of mangrove forest for aquaculture followed by urban, coastal and agriculture development. If the mangrove will continue to loss at that rate it will have serious ecological and socioeconomic impacts.

As per the above statement that there is loss in the mangrove forest in India and South-East Asia, the Sundarbans mangrove forest in West Bengal is decreasing. From figure 2 the mangrove forest of West Bengal in 2002 according to the atlas of mangrove wetland of India was 2125 sq. km but in 2010 according to global Journal of environmental research is 2118 sq. km, this clearly indicate that there is loss of 7 sq. km. On the other case, the mangrove forest of Tamil Nadu in 2002 was 21 sq. km but in 2010 it

increased to 35 sq. km i.e. increase of 14 sq. km. Mangrove forest all over the world is decreasing but its increasing in the Tamil Nadu. So, the aim of the paper is to conduct the comparative analysis of the Pichavarm mangrove forest of Tamil Nadu which is increasing in areas, to the Sundarbans mangrove forest which is decreasing and find out the reason behind its degradation and extension (Biswas et al., 2010).

Change in Pichavaram Mangrove Forest

The extension of the Pichavaram mangrove forest decrease from 1972 to 1988 by 1.25 sq. km then it keeps on increasing up to 2017. The Spatio-temporal changes in the extension of the mangrove forest during four decades i.e. from 1972 to 2017 are shown in the following figure 5.



Source: Prepared by Authors, based on Spatio-temporal analysis from the satellite map of GLCF

Figure 5: Decadal change of mangrove forest cover (1972 to 2017)

Between 1972 and 1988 the mangrove forest cover had reduced from 7.07 sq. km to 5.82 sq. km i.e. about 17.7 per cent reduction (Figure 6 and 7). This change is mainly because of change in topography due to the couple felling system of management followed by various government management agencies since 1911. For the revenue generation, the mangrove forest was cleared in 16 to 20 years rotation under this management. That clearance of forest misbalances the ecosystem and biophysical condition of the mangrove wetlands leading to development of hyper saline condition and prevented natural regeneration of mangrove species (Jagtap et al. 1993).

Remote sensing data from 1988 to 2017 showed that the mangrove forest cover has increased by about 43 per cent that is about 2.50 sq. km compared to the area in 1988. This positive change is mainly due to the restoration effort taken collaboratively by the Tamil Nadu Forest Department and **The M. S. Swaminathan Research Foundation (MSSRF)**

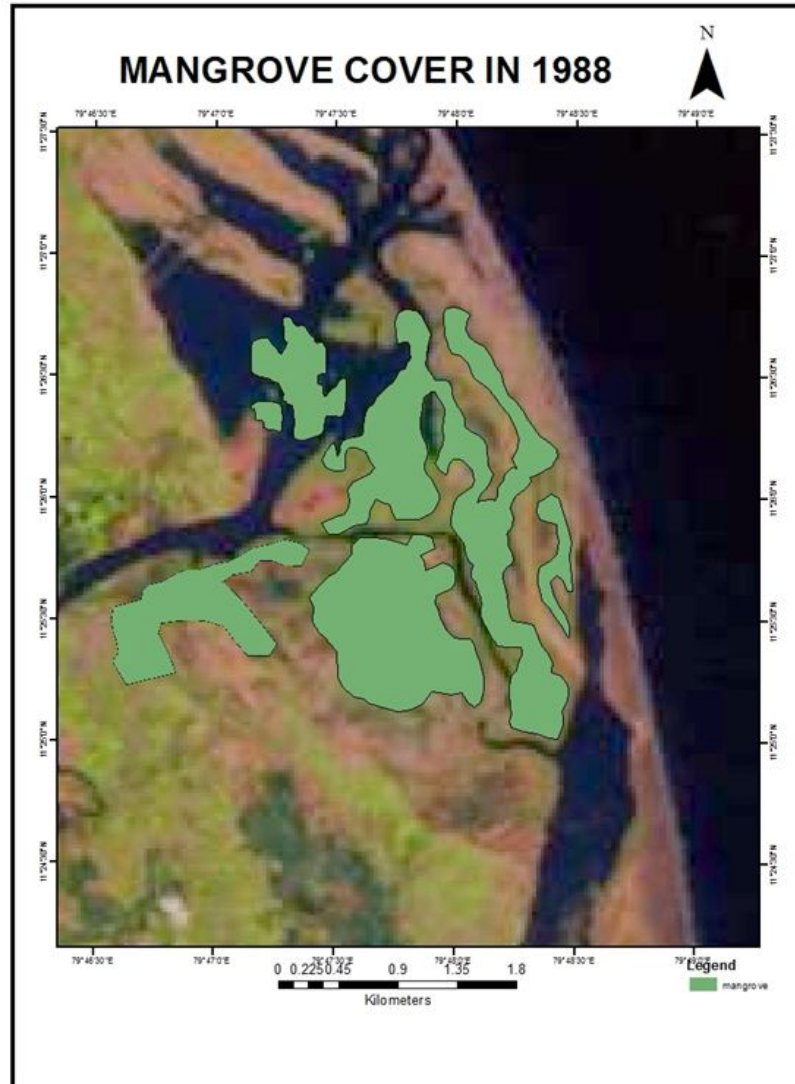
with the participation of the locals.

Analysis of the remote sensing data from 1988 to 2017 showed that the mangrove forest cover has increased by about 43 per cent that is about 2.50 sq. km compared to the area in 1988 (Figure 6 and 7). This positive change is mainly due to the restoration effort taken collaboratively by the Tamil Nadu Forest Department and **The M. S. Swaminathan Research Foundation** (MSSRF) with the participation of the locals. The main reason for the degradation of the mangrove wetland i.e. development of hyper saline condition due to changes in the topography has been sorted out and on the basis of this observation, MSSRF developed a method which involves construction of large canals between the trough shaped degraded areas and nearby natural waterways for the restoration of degraded area. Through this facility tidal water can move freely in and out of the degraded area during high tide and low tide. For complete flushing of the entire degraded areas this method is supported by the feeder canals. Soil salinity is reduced and soil moisture is also maintained for the desirable healthy growth of mangrove due to free movement of tidal water. This demonstration of the restoration technique which started in 1994 was replicated in 1998 by Tamil Nadu Forest Department to restore about 1.25 sq. km of degraded mangroves. The factor responsible for degradation of the forest was overgrazing by about 3000 cattle in during the monsoon season when regeneration and growth of the mangrove seedling reach the peak. Another important feature is that the beach that separates the mangrove wetland and the Bay of Bengal is getting eroded at the rate of 12 m per year.

If the erosion continues at this rate, the Pichavaram mangrove wetland may directly exposed to the sea in future (Srinivasa et al., 2012). Aquaculture farms were not found in 1987 and limited were found in 1994. According to the 1996 remote sensing data brackish water aquaculture is being practiced in about 6.85 sq. km in the area spreading from Vellar estuary in the north to Coleroon estuary in the south. Around the Pichavaram mangrove wetland aquaculture is being practiced in about 2 sq. km.

Change in Sundarbans Mangrove Forest:

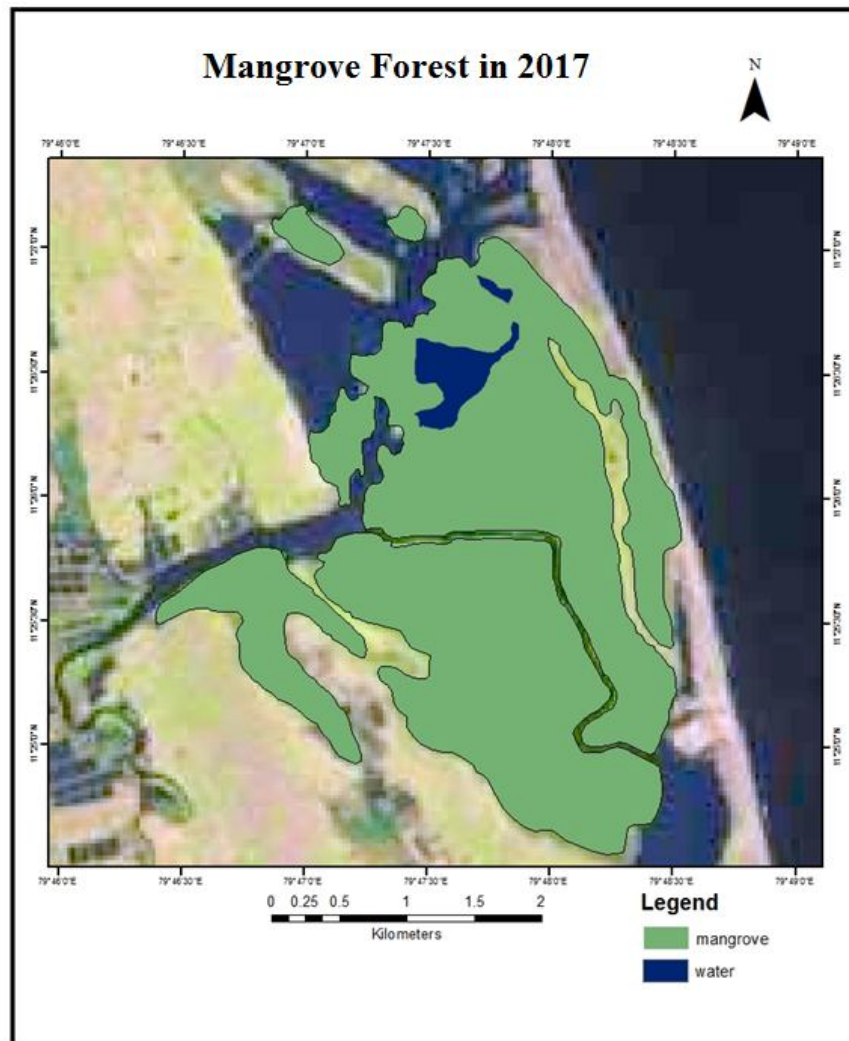
The surroundings of the Sundarbans mangroves both in India and Bangladesh are the absolute most thickly populated zones on the planet (Ahmed and Troell, 2010). The greater part of the populace is ruined on the Indian side and depends intensely on the products and ventures that the forest provides. Mangrove trees are utilized for timber and development material and also for fuel and charcoal generation (Hait and Behling, 2009.



Source: Prepared by Authors based on Satellite Map from GLCF, 2017

Figure6: Situation of Pichavaram Mangrove Forest in 1988

Apiculture is broad inside the Sundarbans mangrove backwoods and gives nectar and wax. Around 2000 individuals are occupied with beekeeping in the Indian Sundarbans, delivering roughly 90 per cent of the aggregate normal nectar creation in India (Figure 8). Likewise, mangrove plants give tannins to cowhide creation and a wide exhibit of



Source: Prepared by Authors based on Satellite Map from GLCF and Nandy et al., (2011)

Figure 7 : Extension of Pichavaram Mangrove Forest in 2017

therapeutic employments. While crabs, molluscs, shrimps and fish are gotten in the sea and the salty waters encompassing the mangrove backwoods, the mangrove forests are the most imperative hotspot for shrimp hatchlings providing the aquacultures. Furthermore, the mangroves are the nursery ground for some monetarily critical fish species (Siddiqi, 1995). Aberrant (administrative) advantages of mangroves for beach front populace incorporate disintegration control and also assurance from

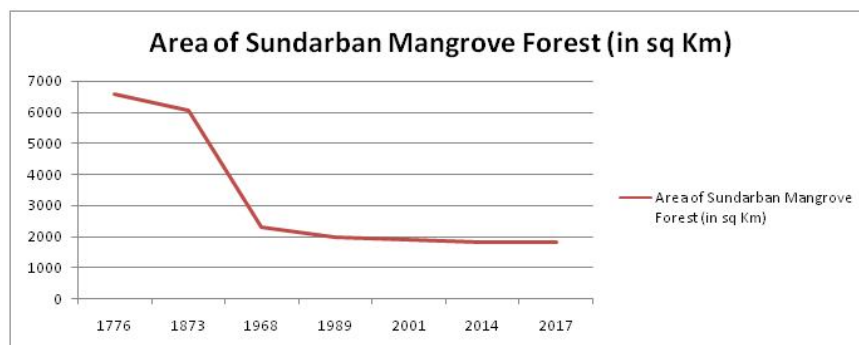
hurricanes and torrents. For example, the generally low quantities of casualties in the Sundarbans zone taking after the 2004 tidal wave are identified with the buffering limit of the timberlands.



Source: Compiled by Authors from USGS data

Figure 8: SundarbansMangrove extent and cover (1990 to 2017)

Besides, in May 2009, a significant part of the force of violent wind Aila was consumed by the mangroves, sparing the city of Kolkata and other urban sprawls in close vicinity. The Dampier-Hodges-Line denote the limit of tidal impact and generally denote the previous degree of mangrove woods (Figure: 9).



Source: Prepared by Author based on the data based on Ghosh, et al. 2015) Data of 2017 is calculated by Authors by Interpolation method from previous year's data.

Figure 9: Change statistics of mangrove extent and cover for the last two-and-a-half centuries

In the above graph X axis represent the time period in the year and spatial extension of the Mangrove forest is represented by the Y axis in sq. km (Figure 9). From the given graph, the total area of the Sundarbans Mangrove forest back in 1776 was approximately 6588 sq. km and its spatial extension get reduced to 6068 sq. km in 1873 (Biswas, et al., 2004). In 1771, British collector general permitted the clearance of the mangrove forest in lease. He bought the workers from the neighboring states to clear up the forest. This action resulted in the great destruction of the forest because after clearance of the forest the workers started settling in the region. With the rise of their population the intensity of clearance of the forest for settlement and agriculture also rose. The consequence leads to the sharp degradation of the forest from 6068 sq. km in 1873 to just 2307 sq. km in 1968 (Rainey, 1891). Its destruction was also followed by the partition of the India in 1947 in post-colonial era. Dampier-Hodges drew a demarcation line from Kulpi on the stream Hooghly in the west to Basirhat on the waterway Khhamati in the east in 1831-32 which is known as Dampier Hodges line. South of this demarcation line lies the Sundarbans mangrove forest (Siddiqi, 1995). But this line could not show much impact on the regulation of the destruction of the forest because the partition of India into East Pakistan and West Pakistan leads to the flow of huge amount of population into this area. However, in 1984 the part of Sundarbans in India has been recognized for the conservation of tiger and demarcated as the National Park and assigned as the UNESCO world heritage site in 1987. This leads to the great impacts towards the control of destruction of the mangrove forest. This impact can be clearly seen from the above graph, prior to 1968 that is from 1873 to 1968 there is loss of 62 percent of forest but during 1968 to 1989 there was only loss of 14 percent of the forest. From 1989 onwards there is the sharp decline in the loss of forest till date. However, in statistic still there is the loss of forest till now due to indirect or direct human interference but on the other hand the extension of the Pichavaram mangrove forest is increasing (Ravindran et al., 2005).

There is a high turnover rate of aggradation and disintegration, which was pretty much adjusted before. Today, be that as it may, disintegration rates are significantly higher than aggradations, which are undoubtedly the consequence of simulated silt traps upstream by dams and blasts specifically in ranges (e.g. the Farakka Barrage) and higher release through water redirection in different parts of the waste bowl. Another worry is the higher measure of soften water from Himalayan ice sheets, which builds disintegration along the estuaries and in this manner, conveys a higher measure of silt. Change recognition investigation

demonstrates that the new sedimentary stores along little tidal channels are colonized inside two or three years by light requesting pioneer plant groups which are later supplanted by various succession groups because of land rise and altered immersion and saltiness conditions. Because of hydrological alterations, with modified flooding and soil saltiness conditions, floristic changes can be accepted, which impact the whole evolved way of life inside the Sundarbans forest (Bandyopadhyay, 2000). Moreover, the expanded spillover from the Himalayas diminishes soil saltiness and inferable from higher disintegration, high siltation causes bring down straightforwardness. In this way, brings down photosynthetic movement of the phytoplankton with unfavorable results on natural ways of life and oxygen generation.

Conclusion

By contrasting the Pichavaram Mangrove Forest and the Sundarbans, it has been found the range of the previous is little than the later. The Pichavaram is situated in the South India and its territory is constrained inside the limit of India not at all like the Sundarbans which zone reach out from west Bengal in India to Bangladesh. Pichavaram get North-east storm amid winter and does not nourish common freshwater stream on the grounds that the waterway in South India is not lasting but rather than again Sundarbans. Sundarbans get the South West rainstorm amid summer season and get the freshwater during the time in light of the fact that the range is sustain by the enduring stream spilling out of the ice sheet of the Himalayan Mountain (Iftekhar, 2008). It is additionally found that however mangrove backwoods of the Pichavaram was expiring in 1980's. Now at present it is expanding yet then again Sundarbans mangrove woodland is diminishing just at present too (Ghosh et al., 2015). Both the mangrove has been meddled by the human residence and backings different beach front tenants. Both has been demonstrating to safeguard and spared the seaside groups amid the characteristic disasters like cyclone and tidal wave. The hurtful impacts of sewage and modern contamination in addition to proceeding with deforestation undermine the uprightness of the Sundarbans.

The issue of the mangrove is impact of extending farming because of which mangrove forest are cleared and water system channels are developed in their place, additionally there is substantial weight on the fisheries including angling along riverside tracts. The dangers from seaward oil slicks are additionally genuine one. While mangroves characteristically have a high versatility to regular unsettling influences. For example,

hurricanes or tidal waves, the impacts of anthropogenic corruption are frequently irreversible. This is the reason it is imperative to reconfigure advancement arranges by including neighborhood necessities and to approach the issue through a multiscale and polycentric way, rather than taking a gander at preservation and environmental change adjustment independently. The mangrove woodland this requires an interdisciplinary coordinated effort amongst regular and social researchers to create arrangements tending to protection and environmental change adjustment. The Tamil Nadu and West Bengal government as of late reported various advancement measures for the mangrove including ecotourism foundation. Such improvements, if acknowledged, may irreversibly endanger the biological community, without first tending to the center issues, i.e. modern Contamination, upstream redirection plans, backwoods clearing, and imperatively nearby employment needs.

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