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The conservation status of laokhowa and burhachapori wildlife sanctuaries: An application of DPSIR framework

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Abstract
It is observed, of late, that the environment has been paid greater attention than ever in the history of mankind. This emphasis is the result of the realization that the environment holds fundamental but finite resources for economic and social development and should therefore be used sustainably. Despite such emphasis, the environment is degrading continuously as a result of the ever-growing demand of the human race. The anthropogenic pressures have a significant impact on the forests culminating in forest degradation. An improved, holistic approach is needed for the sustainable management of degraded forests. This paper examines the factors of forest degradation, its impact and the responses of the peripheral people of the forests by applying the DPSIR (Driver-Pressure-State-Impact-Response) framework taking Laokhowa and Burhachapori Wildlife Sanctuaries as a case. The participatory tools such as key informant interview, focus group discussion, participatory observation and questionnaire survey were administered to elicit the required data for analysing through the DPSIR assessment framework. The result shows significant degradation of the ecosystems of both the sanctuaries over the last three decades. However, realising the impact of such degradation, various stakeholders started responding positively and the sanctuaries' ecosystem has been witnessing a slow improvement.

Keywords: multi-cropping, mosquito net, mosaijal, intensive cultivation, deforestation, grazing, encroachment, overexploitation

Introduction

Protected areas are stocks of natural capital that support the livelihood and well-being of many. The PAs are also important tools for the conservation of biological diversity and thus an important cornerstone for sustainable development. Protected areas are water and food sources and help guard against environmental disturbance. However, over-exploitation of natural resources in PAs such as national parks and wildlife sanctuaries is a worldwide concern nowadays. This is particularly severe in developing countries that have been facing unprecedented environmental challenges despite a perception of abundance. Thus, environmental degradation has been identified as a high-impact problem in physical and financial terms that could result in human and environmental disasters (WCED, 1987) [37]. Human activities such as indiscriminate grazing, large- and small-scale mining, sand and stone mining, periodic bush burning, and firewood harvesting, have played an increasingly important role in driving the environment far beyond its carrying capacity, causing unprecedented degradation and depletion of natural resources (WECD, 1987; EEA, 1999).

Therefore, it has been observed that never in the history of mankind has greater attention been paid to the environment than in the present (WCED, 1987; Agyemang, *et al*., 2007) [37, 1]. This emphasis is also the result of the realization that the environment holds fundamental but finite resources for economic and social development and should therefore be used sustainably (WCED, 1987) [37].

Assessment of environmental degradation and natural resource depletion has become an essential tool for the long-term management of natural resources and the sustenance of livelihoods dependent on them (William, 1998). A key step in the assessment of human-driven environmental problems is to research the spatial and social determinants of such problems through the adoption of an appropriate environmental assessment tool (Turner, 1998). Thus, the Driver-Pressure-State-Impact-Response (DPSIR) model came up as a very effective way to structure environmental information concerning specific environmental problems and to reveal existing causes, consequences, and effective responses (EEA, 1999) [7].

In human-environmental systems, we can find a very high complexity of elements, connections and cause and effect relations. There are several attempts to bring some order into these complicated human-environmental interaction structures (Muller and Burkhard 2012) [17]. While validating the understanding of the interactions and inter-relationships that exist within an environmental system, and reinforcing the integration of its different elements the creation of new procedures for environmental studies became essential for the development of a more adequate approach to the exploitation of natural resources (Neto, *et al*. 2013) [21].

On the backdrop of this and in a recommendation to the European Environment Agency (EEA) on how they should proceed with the development of a strategy for Integrated Environmental Assessment, RIVM (National Institute of Public Health and Environment, Bilthoven, Netherlands) proposed the use of a framework, which distinguishes driving forces, pressures, states, impacts and responses, which became known as DPSIR framework (Kristensen, 2004) [15]. The framework is seen as giving a structure within which to present the indicators needed to enable feedback to policymakers on environmental quality and the resulting impact of the political choices made or to be made in the future. According to this framework, there is a chain

of causal links starting with 'driving forces' through 'pressures' to 'states' and 'impacts' on ecosystems, human health and functions, eventually leading to political 'responses'.

Thus, DPSIR plays a valuable role in terms of building the necessary knowledge, communication and awareness for integrated scientific, political and public input into effective decision-making processes for sustainability (Nebyou, 2010) [20]. DPSIR for integrated environmental reporting and assessment has since been widely adopted in the study of environmental problems (Carr, *et al*, 2007) [5]. This approach has proven to have utility in understanding the genesis and persistence of environmental problems from global to local scales. A presumed strength of the DPSIR model is that it captures, in a simple manner, the key relationships between factors in society and the environment, and, therefore, can be used as a communication tool between researchers, on the one hand, and the policymakers and stakeholders on the other (Svarstad, *et al*., 2007) [35].

Assam possesses considerable biodiversity, natural resources, and many endemic species. According to the Forest Survey of India report (2021), the total forest cover of the state is 28,312 sq. km. which has declined by 0.05 per cent in 2021 than in 2019. However, the startling fact is that the very dense forest cover of the state declined significantly between 1991 and 2021 from a staggering 15,842 sq. km. to 3,017 sq. km. only (FSI, 1991 and 2021) [9]. There are several reasons for such a dismal state. Ever increasing population along with their growing demand, implementation of various developmental plans, and large-scale diversion of forest lands for non-forestry purposes are the primary reasons for the loss of the forest in the state. Many of the reserve forests and wildlife sanctuaries have been degraded because of the growing anthropogenic pressures put by their surrounding people. Therefore, there is an utmost urgency to identify the driving factors of forest degradation and find out their remedies. The DPSIR framework can contribute to the analysis of the driving forces and their effects on the ecosystem to formulate coordinated conservation measures.

This paper is a humble attempt to identify the drivers, pressures and remedies of the degraded sanctuaries of Assam taking Laokhowa and Burhachapori Wildlife Sanctuaries as an example. An extensive field survey has been carried out and the outcome has been presented through the DPSIR framework. It, thus, tries to focus on the particular topic of protected area management and is anticipated to be extremely useful for PA managers and other stakeholders. The broad objectives of the paper are

1. To identify the driving forces of forest degradation and its resulting changes,
2. To develop a suitable management practice for the degraded sanctuaries of the state.

Materials and Methods

1. Study Area

1.1 Brief background of Laokhowa and Burhachapori Wildlife Sanctuaries:

The study has been carried out in the fringe villages of Laokhowa and Burhachapori Wildlife Sanctuaries (WLSs) of Assam in North East India. Spreading over an area of 114.16 sq. km. and located in the Central Assam districts of Nagaon and Sonitpur, the sanctuaries represent the unique floodplain forest ecology of the state. Laokhowa was originally a game sanctuary while Burhachapori was a professional grazing reserve and were declared wildlife sanctuaries in the year 1979 and 1996, respectively. Once ideal habitat for various key species of plants, reptiles and birds, endangered mammals like Rhino, Wild Pig, Buffalo, Royal Bengal Tiger, Elephants, Bengal Florican, etc. the sanctuaries have the dubious distinction of being one of the most degraded sanctuaries of the state (SoEA, 2004) [34]. The natural and perennial wetlands here have been functioning as the breeding ground for various fish species that attract a large number of avifauna (both endemic and migratory) to the sanctuaries and are one of the prime attractions to tourists. Laokhowa and Burhachapori WLSs are strategically located since it acts as an important corridor between Kaziranga (towards East) and Orang (towards North West) National Parks. However, the sanctuaries, despite the protected area status, are highly degraded. The degradation of the forest ecosystem of the sanctuaries started during the early part of the eighties in the last century (Sivakumar *et al*. 2013) [33]. The world-famous one-horned rhino met its unfortunate fate of local extinction in these sanctuaries due to the poaching of 35 rhinos in 1983 by vandalistic gunners, which compelled other rhinos to take refuge in other nearby rhino habitat areas. It heralded an ominous beginning of the exertion of huge anthropogenic pressures in various forms.

The fringe villages here are resided and dominated by the land-hungry migrant Muslim people from erstwhile East Pakistan (now Bangladesh) whose primary occupation is subsistence agriculture. The growth of the population is very high among these illiterate and semi-literate people leading to high demand for land for both construction and farming. It results in encroachment into the forested areas of Laokhowa and Burhachapori WLSs besides other illegal collections for meeting the demands of the ever-increasing populations. All these led to rapid depletion and deforestation of the floral and faunal diversity from once rich forest ecosystems of Laokhowa and Burhachapori WLSs. Consequently, the hitherto bio-diverse sanctuaries have metamorphosed into scrublands languishing for survival. The one-horned rhino and the endangered Bengal Florican, the two key species of the sanctuaries, once found in abundance, have become locally extinct from the sanctuaries (Bora, 2004; Phukan and Sarma 2004; Sivakumar, *et al.* 2013) [3, 33].

However, the sanctuaries, though degraded, are still critically important for the overall environment as emphasised by many researchers. Being the representatives of the floodplain forests of Assam (Choudhury, 1998; Bora, 2004; Phukan and Sarma 2004) [6, 3, 26], which are a unique and endangered ecosystem, the sanctuaries are biologically more productive and diverse. Moreover, the inclusion of the sanctuaries in Kaziranga Tiger Reserve and Kaziranga-Orang riverine landscape, which have been identified as a major gateway for straying animals within the protected areas of central Assam, elevates its overall importance. The sanctuaries, thus, are critically located and are of vital importance since they act as a migratory corridor for the wild animals between Kaziranga and Orang National Park (Borthakur, *et al.* 2011) [4]. The vital importance of the sanctuaries makes a strong case for their conservation and mitigates all the constraints on their way.

2. Data

The study is based both on primary and secondary data. Secondary data was obtained mainly from the management plans and other scientific studies carried out in the sanctuaries to obtain prior knowledge about the status of the forest and the people living around the sanctuaries. Primary data was collected from the peripheral villages of Laokhowa and Burhachapori WLSs through a semi-structured questionnaire.

A two-stage sampling technique was followed for conducting a detailed investigation. In the first stage, the villages were selected purposively, in consultation with the key informants, based on community living, population pressures, close vicinity to the forest and socio-economic conditions of the people. Thus, 20 per cent or nine villages (four from Burhachapori and five from Laokhowa sanctuary) located within 2 kilometres of the forest boundary were selected. Since the villages were heavily populated, only 10 per cent of the total households of each of the nine villages were taken for detailed study in the second stage. Due care has been taken to include proportionately the households of all the communities residing in the villages. An effort was also made to incorporate heterogeneity in the distances of the households across the sampled villages from the forest boundary.

To obtain information about the extraction of various provisioning services of the forest a semi-structured questionnaire was designed, pre-tested and finally administered to 302 sample households in the selected villages. Data regarding household characteristics along with their livelihood activities and various information on their extraction of provisioning services of forest from the sanctuaries are elicited through door-to-door surveys from the sample households.

Results and Discussion

Taking cognizance of the knowledge gathered through the household survey we now present the cause, effect and resultant responses in a systematic way through the DPSIR framework.

1. Drivers (D): Natural or human-induced factors that directly or indirectly cause a change in an ecosystem are referred to as "drivers". Population growth, poverty, agriculture and industrial production, levels of consumption, socio-political, cultural, religious, scientific, technological, etc. are some of the major drivers of forest ecosystem degradation (Narain, 2005; Kumar, 2000, World Bank, 2006). The drivers responsible for the forest ecosystem degradation of Laokhowa and Burhachapori Wildlife Sanctuaries are identified and presented in Figure 1.

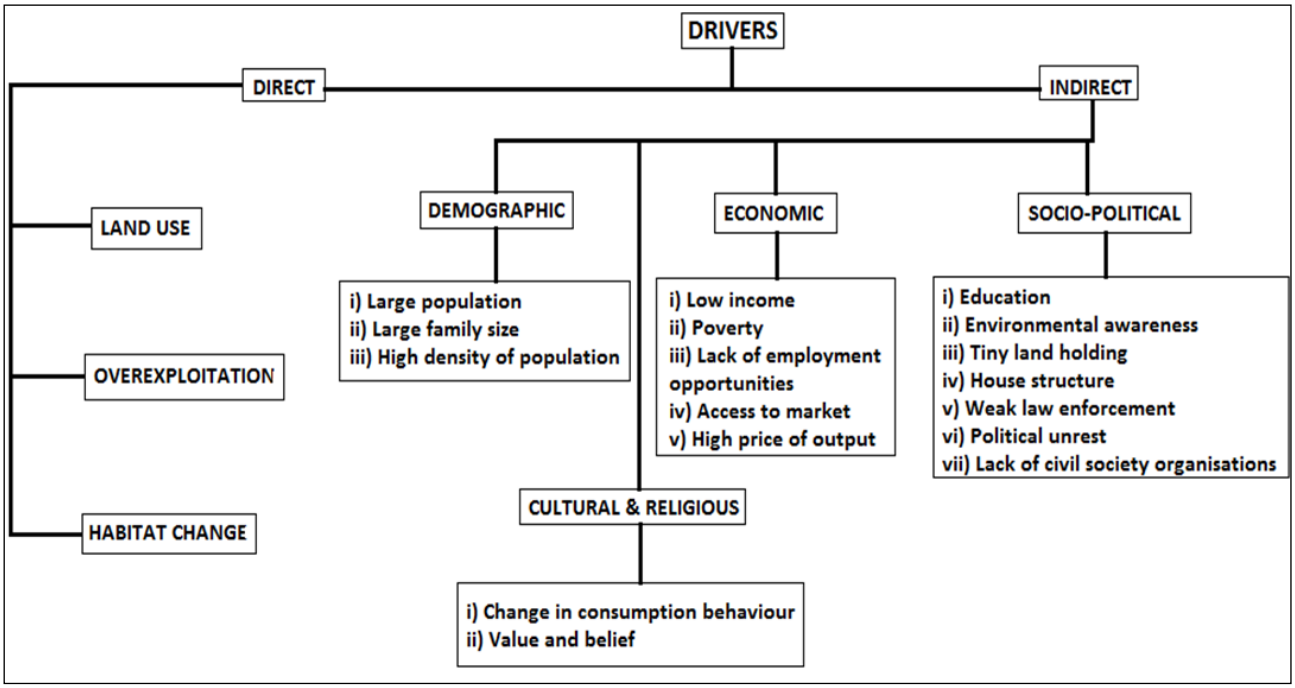


Fig 1: Drivers of forest dependency of fringe people on LBWLSs

1.1 Direct Drivers: There is significant land use change in the periphery of the Laokhowa and Burhachapori WLSs over the last three decades. The land has been utilized for house construction and also for agricultural expansion resulting in the encroachment of large tracts of fertile land in the forest (Bora, 2003-04; Phukan & Sarma, 2003-04) [3]. This is absolutely due to increased population pressures in the periphery of the forests. Overexploitation of the forested area by the fringe people is taking two forms namely illegal collection of fuel wood and other NTFPs including fish and overgrazing which are putting huge pressures on the grassland ecosystem of the sanctuaries. Ojah (2016) [24] shows empirically that the habitat of the LBWLSs is being adversely impacted by such anthropogenic pressures of the peripheral people. He further stated that the mighty Brahmaputra has eroded huge tracts of land of the Burhachapori WLSs.

1.2 Indirect Drivers: The indirect drivers shown in the flowchart have been discussed below:

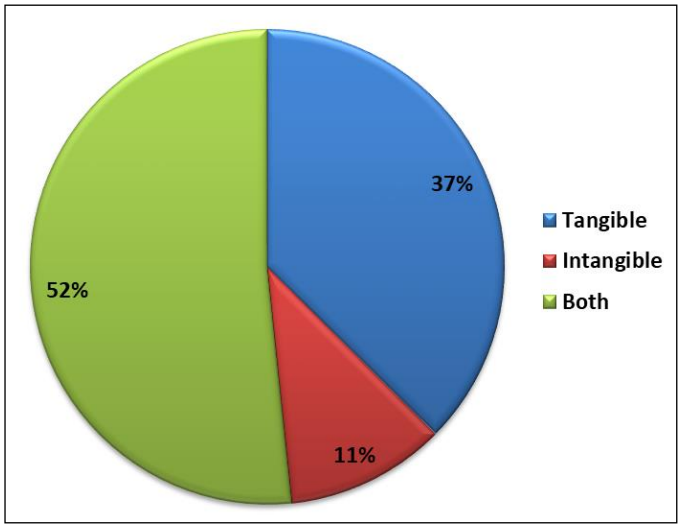
1.2.1 Demographic Drivers: Huge population coupled with a large family size is the prime demographic characteristic of the peripheral villages of Laokhowa and Burhachapori Wildlife Sanctuaries. The study finds large number of children, low education, and a tiny size of landholding to be the important drivers of forest dependency.

The household survey conducted in the fringe villages of LBWLSs shows that the stocking density of different cattle populations is very high (7.62 cattle units per household). 94 per cent of the sample households maintaining livestock depend absolutely on LBWLSs for grazing. The cattle population are mixed and graze freely inside the sanctuaries and have a devastating impact on the grassland ecosystem of the sanctuaries.

1.2.2 Economic Drivers: The poor economic background, lack of employability owing to low education and skill is compelling them to be cocooned into the village periphery. Fuelwood is collected for cooking and heating purposes. Fish and other edibles act as food as well as a safety net for the poor people living at the periphery of the LBWLSs. Demand for thatch is also high since most of the people live in kutcha houses. Thus, there is a readymade market for these products that leads to competitive exploitation of the forest produces impacting adversely the ecosystem of the sanctuaries. Thus, people are trapped in the web of poverty and in the absence of any gainful employment opportunities they remain as NTFP collectors. Thus, close vicinity of the forest and market availability are found to be important drivers of forest dependency here.

1.2.3 Socio-political drivers: In the case of the LBWLSs it would not be appropriate to forget the disastrous and unhealing impact of the great turmoil of the eighties of the last century. It is this political unrest that adhered the LBWLSs to near destruction. The disaster began in the year 1983 when 33 Rhinos were poached in the sanctuaries and there is no looking back since then. People took advantage of weak law enforcement in the aftermath of the incident and the absence of any strict vigil by the department exploited the sanctuaries to the point of destruction. This was coupled with other socio-institutional drivers like lack of education and thereby environmental knowledge, tiny land holding, and absence of any strong civil society organization barring them to destroy the forest and its ecosystem. In the absence of strong law (forest) enforcement, the dependency of the poor people on the forests is increasing.

1.2.4 Cultural and religious drivers: Values and beliefs can be termed as two of the most important cultural drivers of forest dependency. The people in the fringe of forests value only the tangible goods that can be collected from the forest. It is evident from figure 2 that 37 per cent of the respondents know only about the tangible goods and services that they are deriving from the LB WLSs. Only 11% of the respondents spoke about any kind of intangible benefits of the sanctuaries. But, the majority of the respondents know about both tangible and intangible benefits derived from the sanctuaries. It shows, perhaps, the value and perception of the fringe people towards the forest ecosystem.



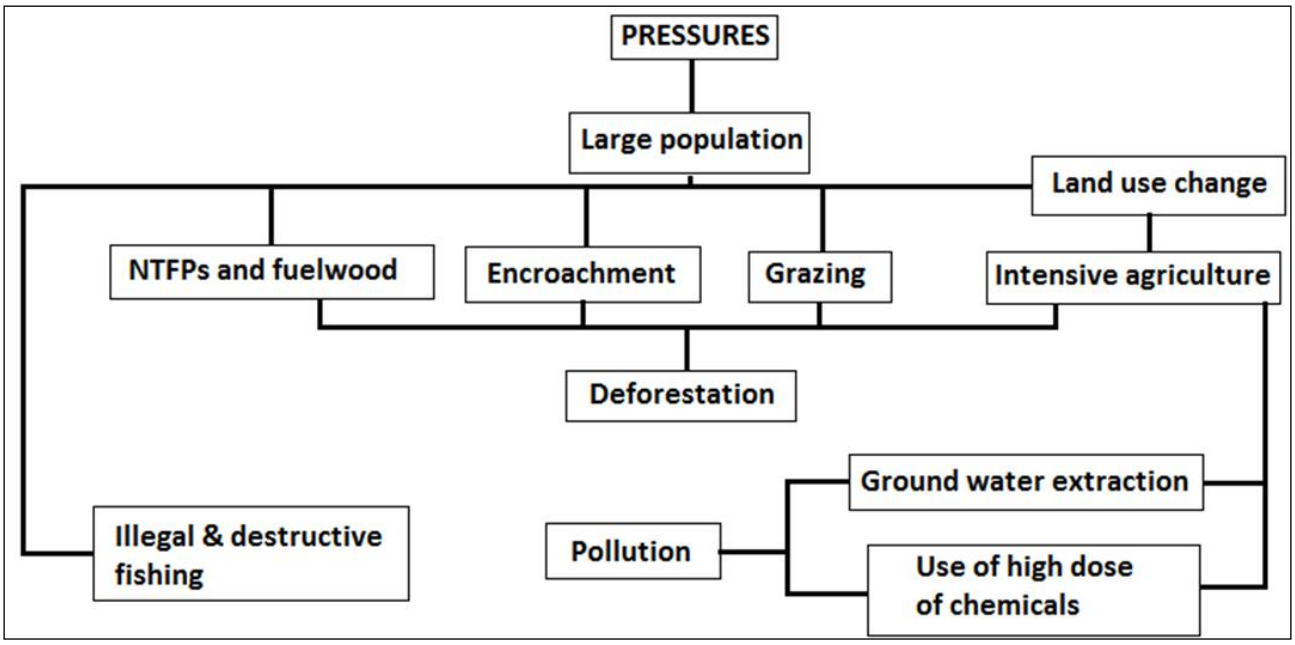
Source: Household survey, 2016

Fig 2: Awareness level of the respondents regarding ESS

2. Pressure (P):

Pressures are human activities that create stress on the environment. Pressures may refer to emissions (of pollutants, wastes, or other disturbances), the use of resources (all use or uses above a threshold) to the intensity or the efficiency of human activities, changes in lifestyles and activities, or even to general socio-economic features (Gabrielsen and Bosch, 2003) [10]. Pressures can have different effects such as land use change and deforestation which leads to climate change in the long run. In a study at Simen Mountain National Park (SMNP), Nebyou (2010) [20] reported deforestation, forest fire, illegal hunting, the negative impact of roads, production of waste, noise disturbance, domestic overgrazing and wildlife diseases as the main pressures.

There are varied pressures in the LBWLSs emanating from the drivers mentioned above. Sivakumar, *et al*., (2013) [33] reported that the nineties decade saw an exponential increase in pressure of biotic interference in the form of poaching of wild animals, encroachment, deforestation, cattle grazing, and illegal removal of Non-Timber Forest Products (NTFPs) and other forest products. The habitat of Laokhowa-Burhachapori suffered tremendous degradation during this period. The cattle population of the khuttis (cattle camps) of Burhachapori WLS too started to increase during this decade and excessive grazing by the cattle in the two sanctuaries took its toll on the fragile grassland ecology of the two sanctuaries. Figure 3 depicts various pressures the LBWLSs have been witnessing during the last three decades.



Source: Author's estimation based on analysis of field survey results.

Fig 3: Pressures resulting from the drivers

It is evident from figure 3 that the increase in population is the single largest and most important driver which is putting massive pressure in different forms on the forest and forest ecosystem of LBWLSs. With the increased population, demand for fuelwood, which is the only reliable source of energy for cooking for the fringe villagers, and other NTFPs increases. Increased demand for timber and fuel wood led to massive felling of trees. There are a few studies which confirm that the villagers generally collect dry stems and twigs and hence exert no adverse impacts on the forest. But the usual practice is that the persons (fuel wood collectors) keep their axes hidden in the forest. They would go and cut their quota of wood and leave it to dry, then they would collect the wood they had cut and stacked some ten days earlier, which would by now be dry enough to be burnt, and bring it out. This is also confirmed by Ranjitsing (2017) [28] who says this practice goes on, on a rotational basis. The forest guards turn the proverbial Nelson's eye into how the so-called fallen, dry wood is being produced in such a volume in regular intervals. This leads to declining forest cover and thereby massive land erosion of BWLS by the Brahmaputra.

Increased population also necessitates more amount of land both for house construction and to grow more food resulting in the intrusion of the forested land. The dominant land use in the study area is intensive agricultural farming. The fringe areas of LBWLSs have witnessed agricultural intensification to a large extent. Multi-cropping is practised here using HYV seeds and very high doses of chemical inputs. 49 per cent (148 households) of the sample households extract groundwater through Shallow Tube Well (STW) for irrigating the agricultural fields and 37 per cent of these households have their STW while the others buy water from their neighbours. In the absence of any agricultural extension service by the agricultural department, the illiterate and semi-literate farmers follow the advice of the traders of the locality and apply a very high dose of chemical inputs in agriculture accordingly which surely has adverse implications on the natural resources. Thus, intensive agricultural practice is putting huge pressure leading to the change in the land use of the forest in the study areas.

Since the forest is in close vicinity the people also rear large numbers of cattle and let loose them into the forest putting massive pressure on the grasslands of the forest. 76 per cent (or 230 households) of the sampled households possess different cattle populations amounting to 1753.79 cattle units. Out of this 88 per cent of the households graze their cattle in the forests putting enormous pressure on the grassland ecosystem of the forests. Besides annihilating the habitat of the wild animals and trampling over the eggs of various grassland birds the non-inoculated captive animal stock also carries the danger of contagion of disease from them to the wild.

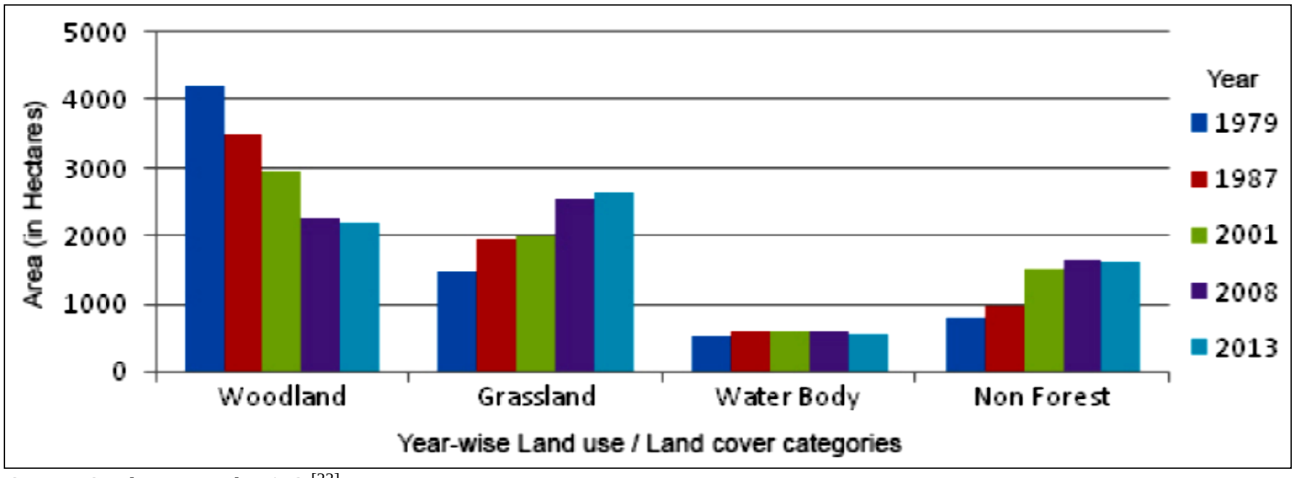
The water bodies (beels) are also good repositories of endemic fishes which fetch handsome prices in the market. The fishermen catch fish illegally violating all kinds of fishery laws and regulations culminating in habitat destruction and hence jeopardizing the very existence of some of the endemic fish species. The abundance of diverse fish species in the water bodies ensures the incoming of various waterfowls, both endemic and migratory, who feed on these enormous fishes. Thus, the degradation of the water bodies is linked with the reduction of both the endemic and migratory waterfowl having long-term socio-environmental implications. Thus, a significant number of pressures are being exerted upon the LBWLS in a variety of different ways by fringe dwellers.

3. State (S): The state or 'S' is described as the quantity and quality of the environment and natural resources (EEA, 2003). It includes the concentration and quantity of physical and chemical variables through inputs of contaminants or sediments. It leads to the alteration of the abundance, size, and diversity of biological variables by causing mortality or altering interactions among species. Changes in precipitation pattern, more drought or flood, quality and structure of habitats, loss of soil, air and water quality, soil erosion, biological deterioration, etc. are some of the major states of the environment which are referred to by various

studies (Burkhard *et al*, 2012; Porta J., 2011; Svarstad, *et al*., 2007) [17, 27, 35].

The Pressures mentioned above have led to many unintentional changes in the State of the environment of Laokhowa and Burhachapori WLSs. River erosion, loss of biodiversity and even local extinction of many key species of floras and faunas like Rhinoceros, Bengal Florican, etc. have been reported by Ojah (2016) [24]. The birds migrating from different parts of the globe during winter visited the wetlands of the sanctuaries have ironically ceased to visit now. One of the major causes of such reduction of birds is the reduction of different varieties of fishes (due to destructive and illegal fishing by the fringe dwellers) in these wetlands once found in abundance. Large-scale tree species' felling has denuded the sanctuaries' fringe areas. Erratic weather (precipitation and flood), declining (soil) quality of the agricultural field, etc. have been witnessed and realized by the people which, of course, requires further investigation.

Temporal assessment of the Land use & land cover analysis of the two WLSs shows the state of both the sanctuaries over the years. The result of the analysis has been shown in figures 4, 5 and 6.

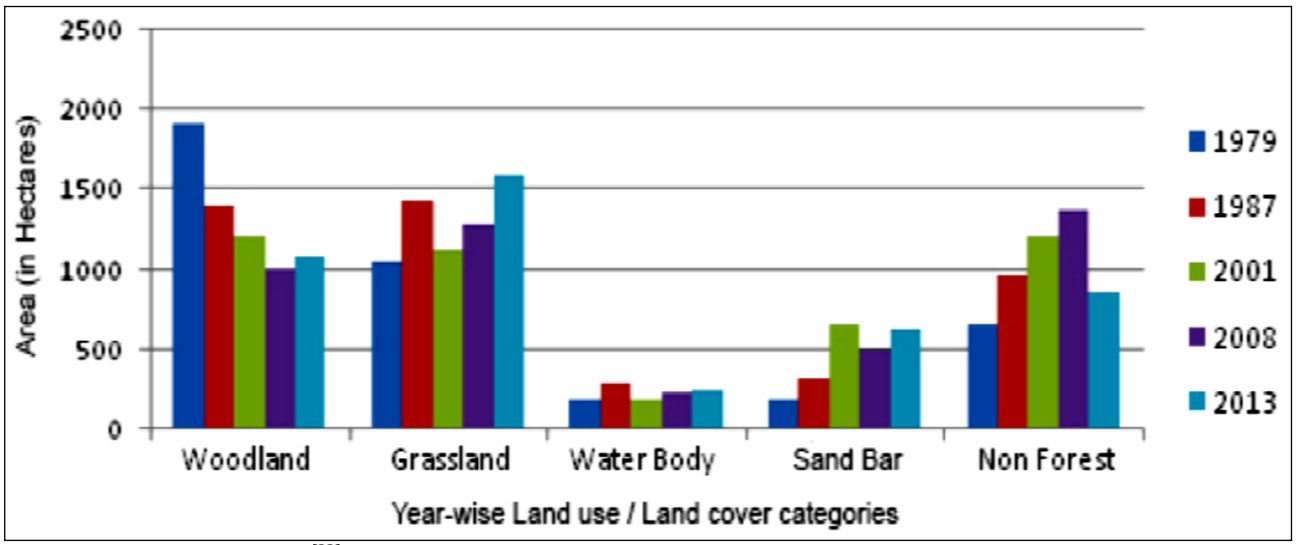


Source: Sivakumar *et al*., 2013 [33]

Fig 4: Temporal Change in Land Use & Land Cover of Laokhowa WLS

An observation (figure 4) of the pattern of temporal change in the land use and land cover classes of Laokhowa WLS shows a gradual decline in the woodland from 1979 till 2008. The area under grassland showed a steady increase while areas under non-forest activities (area under encroachment, forest and taungya village area) showed a slight decline.

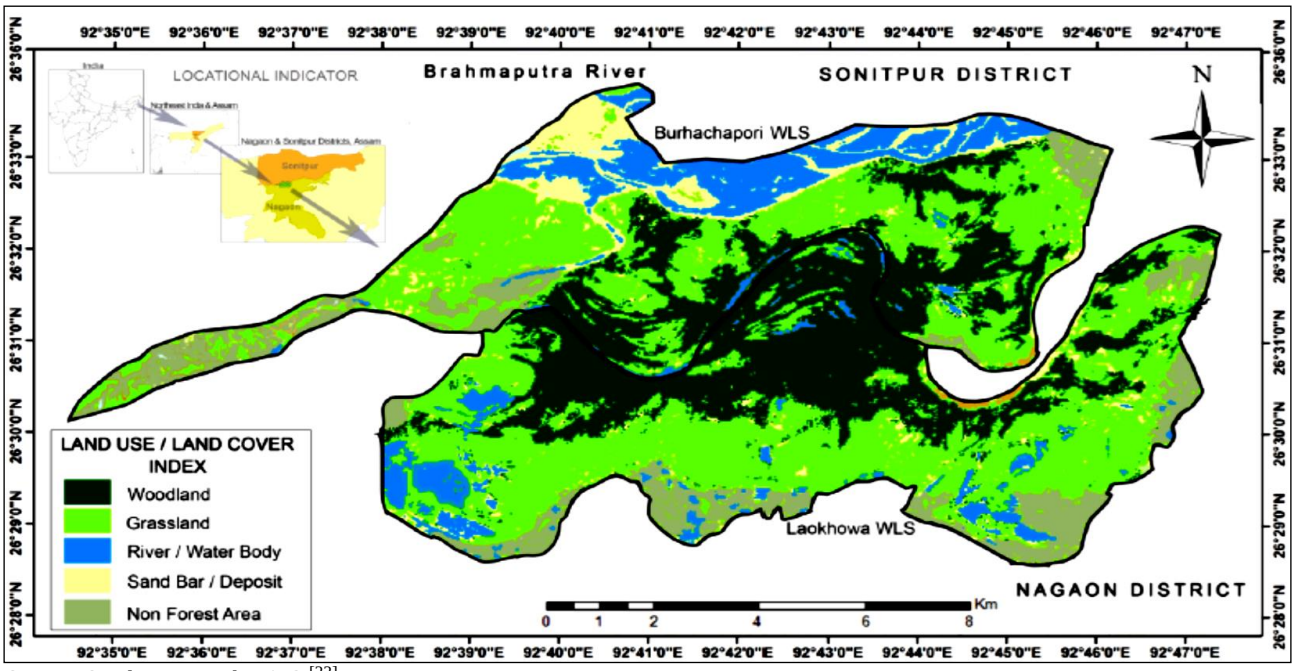
Sivakumar *et al*. also report an exponential decline in woodland cover in Burhachapori WLS till 2008 and a slight recovery in it after this period till 2013 (figure 5). Further, the area under grassland too increased post-2008. Interestingly, the area under sand deposit in Burhachapori WLS has shown a constantly increasing trend throughout the period of analysis. Post-2008, the area under non-forest activities shows a significant decrease.



Source: Sivakumar *et al*., 2013 [33]

Fig 5: Temporal Change in Land Use & Land Cover of Burhachapori WLS

The state of the BWLS is at stake as the Brahmaputra has been eroding part of the sanctuary (towards the North of it) continuously and thus a significant amount of it has already been lost to the river. This would be evident from the following map (figure 6) taken from Sivakumar *et al*. (2013) [33]:



Source: Sivakumar *et al*., 2013 [33]

Fig 6: Map showing loss of forest cover of Burhachapori WLS due to erosion

Thus, the LBWLSs have been witnessing tremendous pressure on it both from the natural and anthropogenic factors changing the state of the sanctuaries. Such changes in the quality and functioning of the Ecosystem 'State' have an 'Impact' on the welfare or well-being of humans through the reduced provision of ecosystem

4. Impact (I): Impact 'I' describes the effects that change in the 'state' have on environmental or human health (EEA, 2003). Analysing the household dependency of the fringe people in Sariska Tiger Reserve Jain and Sajjad (2015) said that human activities in PAs hurt wildlife survival, habitat protection and biodiversity conservation and ultimately the fringe communities suffer from human-wildlife conflict. Moreover, declining food availability, increased vulnerability to diseases, lost species resulting in a reduction of tourism activities, loss of climate regulation function of forests, etc. are some of the prominent impacts of environmental change (Oman *et al*. 2009; Carr, 2007) [5].

The loss of biodiversity in LBWLSs has critically impacted the socio-economic lives of the fringe people of the sanctuaries. Loss of biodiversity resulted in the local extinction of two of the most important species namely, Rhinoceros and Bengal Florican which are classified as 'critically endangered by the International Union for Conservation of Nature (IUCN) and listed in Schedule I of the Indian Wildlife (Protection Act), 1972.

Ninan (2007) attributed grazing pressure to be an important factor contributing to biodiversity loss in many developing countries including India. He further states that since the graziers treat the forests as open access resources a phenomenon elaborated by Hardin (1968) as the 'Tragedy of Commons' arises. According to the Chief Wildlife Warden of Karnataka state, grazing by single cattle head destroys habitat requisites of two chitals. In addition to the deer facing a crisis of survival, the grazing cattle also pose a hazard to endangered species such as tigers when the food-chain ecosystem of herbivores and carnivores is taken into account (Ninan, 2007). A study of livestock grazing pressure in the Mudumalai WLS in the Western Ghats region of India notes that livestock grazing coupled with the removal of cattle dung from the forest floor adversely affected forest regeneration and also encouraged the proliferation of weeds (Silori and Mishra, 2001) [13].

The intensity of grazing could be gauged by the fact that the sample households possess, as mentioned earlier, 1753.79 cattle unit which is grazed freely in the forests. There must be much more livestock on the fringes and free grazing by these animals would surely destroy the habitat of the grassland birds of the sanctuaries. This is, probably, one of the prime factors responsible for the extinction of the famous Bengal Florican (IUCN endangered), a grassland bird, from the sanctuaries. Bindra (2017) [2], in this regard, terms livestock as the biggest threat as they may trample over the eggs of the grassland birds. She further adds 'as, in most bird species, frequent disturbance during the incubation period may dim the chance of successful hatching'.

On the other hand, the NE region is considered one of the hotspots of freshwater fish biodiversity in the world (Kottelat and Whitten, 1996) [14]. A literature review by Sen (2003) confirms that 291 species under 119 genera, 38 families and 12 orders are available in the NE region. She further states that 107 threatened species are occurring in this region. Many researchers reported that the fish biodiversity of India and especially in the NE region has been dwindling over the last couple of decades due to the increasing degradation of inland water. Sarkar and Poniah (2000) attribute habitat modification, over-exploitation and manmade interventions to the drastic reduction in the abundance and distribution range of fishes.

On a similar note, it can be said that the study area is also confronting such a decline over the last couple of decades. The beels and sutis (stream) inside the forests are the repositories and breeding grounds of the local and endemic fish species of the state. The abundant fish species in these beels and sutis are used to lure a large number of local and migratory water birds to the sanctuaries which further

attracts many bird lovers. However, the scenario has changed over the years and it came out during the household survey that 93 per cent of the respondents believe that all the local fish species in and around the sanctuaries have been depleting drastically during the last 20-25 years. Although people opine, that all the endemic fish species have been dwindling, household survey results report that the Pavo (pabda catfish, *Ompokpabda*), Bhedengi (Gangetic leaffish, *Nandus nandus*), Sol (Striped sneak head, *Channa striatus*), Cheng (Smooth brassed sneak head, *Channa gachua*), Chengeli (Asiatic sneak head, *Channaorientalis*), Selkona (Large razorbelly, *Salmostomarbacalia*), Sal (Giant snakehead, *channamarulius*) are the species hit hardest by all kinds of anthropogenic pressures put by the fringe villagers. Out of the fishes named above the Pabda is marked as Endangered by both IUCN and NBFGR (National Bureau of Fish Genetic Resources). Use of mosquito net (with less than 1 c.m. Bar/2 c.m. mesh *Mosaijal* in size is prohibited in any fishery throughout the year) and fishing during the breeding season, i.e., between the fifteenth day of April and the last day of July each year (The Assam Fishery Rule, 1953) have been the primary causes of depleting fish species in and around the sanctuaries according to the respondents. Following is the list (list may not be exhaustive) of the fish species generally caught by the people in and around the study area:

Table 1: Fishes caught by the fringe people in and around LB WLSs

Sl no	Assamese Name	English Name	Scientific Name
1	Karoti	Indian river shed	*Gudusia chapra*
2	Chital	Humped feather back	*Notopterus chitala*
3	Kandhuli	Feather back	*Notopterus notopterus*
4	Selkona	Chela	*Chela atpar*
5	Darikana	Blackline rasbora	*Rasbora daniconius*
6	Eleng	Bengla barb	*Rasbora elanga*
7	Moa	Mola/ Indian carplet/ Pale carplet	*Amblypharyngodonmola*
8	Puthi	Swam barb/ Chola barb	*Puntius chola*
9	Cheniputhi/	Olive barb	*Puntius sarana sarana*
10	Bhakua/ Bahu/ Dhekera	Catla	*Catla catla*
11	Mirika	Mrigal	*Cirrhinus mrigala*
12	Lachim	Reba	*Cirrhinus reba*
13	Bhangone/ Nara/	Bata labeo	*Labeo bata*
14	Bhangone	Bogalabeo	*Labeo boga*
15	Mali/ Kaliajora	Calbasu/ Black rohu	*Labeo calbasu*
16	Kurhi	Kurialabeo	*Labeo gonius*
17	Silgharia	Kalabans	*Labeo dero*
18	Silgharia	Brahmaputra labeo	*Labeo dyocheilus*
19	Rau/ Row	Rohu	*Labeo rohita*
20	Common carp	Scale carp	*Cyprinus carpio* *
21	Grass carp	Grass carp	*Ctenopharyngo donidella**
22	Botia	Loach	*Noemacheilus beavani*
23	Gethu/ Rani botia	Nectie loach/ tiger loach	*Botia dario*
24	Singorah	Day's mystus	*Mystus bleekeri*
25	Barsingorah	Gangeticmystus	*Mystus cavasius*
26	Arii	Giant river cat fish	*Aorichthys seenghala*
27	Pabhoh	Pabdah cat fish	*Ompok pabda*
28	Barali	Freshwater shark	*Wallago attu*
29	Bordaia	Indian Potasi	*Pseudotropiusatherinoides*
30	Magur	Magur	*Clarias batrachus*
31	Singhi	Stinging cat fish	*Heteropneustes fossilis*
32	Kokila	Freshwater garfish	*Xenento doncancila*
33	Cheng garaka/ Garaka Cheng	Spotted snake head/ Barca snake head	*Channa barca*
34	Sal	Giant snakehead	*Channa marulius*
35	Chengeli	Smooth-breasted snakehead/ Asiatic snakehead	*Channa orientalis*
36	Cheng	Smooth brassed snakehead	*Channa gachua*
37	Goroi	Green snakehead/ Spotted snakehead	*Channa punctatus*
38	Sol	Striped snakehead/ Banded snakehead	*Channa striatus*
39	Chengeli	Assamese snake head	*Channa stewartii*
40	Kuchia/ Cuchia	Cuchia/ Gangetic mud eel	*Amphipnous cuchia*
41	Chanda	India glassy fish	*Chanda ranga*
42	Dum Vacheli	Badis/ dwarf chameleon	*Badis badis*
43	Gedgedi/ Bhetki/ Khaloibhangi	Mottled nandus	*Nandus nandus*
44	Patimutura	Bar-eyed-goby	*Glosso gobius gutum*
45	Kawai	Climbing perch	*Anabas testudineus*

46	Kholihona	Banded colisa/ Striped gourami / Giant gourami	*Colisa fasciata*
47	Bhasaylee	Colisa	*Colisa colisa*
48	Bami	Spiny eel/ Tire-track spiny eel	*Mastacembalusarmatusarmatus*
49	Tora/Turi	White-spotted spiny eel/ Striped spiny eel	*Macrognathuspancalus*
50	Tora/ Tura/ Turi	One- striped spiny eel	*Macrognathusaral*
51	Gangatop	Ocellated puffer fish	*Tetradon cutcutia*

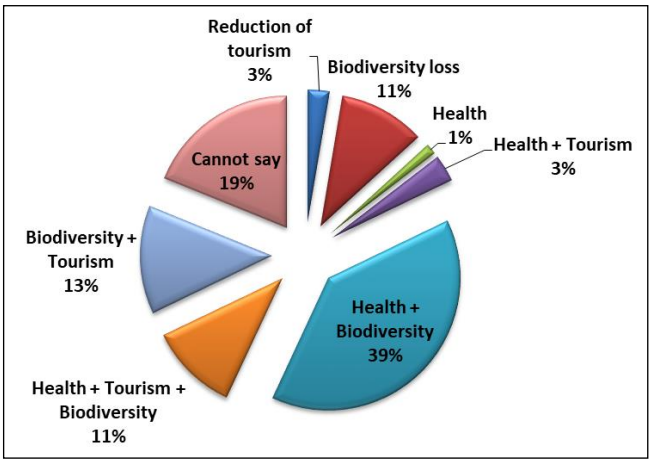
Respondents opine that almost all the local and endemic fish species here are dwindling over the years which has a negative externality on the socio-economic status of the fringe areas. For example, depleting fish stock is acting as a repellent to the waterfowl and thereby the tourists' flow to the sanctuaries. On the other hand, the declining volume of the endemic fishes called for the introduction of other fish species like Indian Major and Minor carps along with different exotic fishes such as Tilapia, Common Carps, Grass carp, Silver Carps, Big Heads and the dangerous, highly carnivorous and banned Thai Magur with negative environmental implications (Table 2). These fishes are cultured in the cultured fisheries of the area and the supply is increasing over the years despite its Genetic, ecological and socio-economic impact.

Table 2: Name of the exotic fish species reared in the study area

English name	Scientific name	Originally come from
Common carp	Cyprinus carpio	Thailand
Grass carp	Ctenopahryngodonidella	Japan
Silver carp	Hypophthalmichthysmolitrix	Hong Kong
Tilapia	Tilapia mossambica	South Africa
Pangasius	Pangasius sutchi	Thailand
Thai Magur	Clarias gariepinus	Africa
Bighead carp	Hypophthalmichthys nobilis	China

Perception study: Upon enquiring about the loss of floras and faunas from the sanctuaries all the respondents answer positively. 51 per cent of the respondents say that Rhinos has been extinct from the LBWLSs whereas 29 per cent opine that both rhino and tiger has been lost from LBWLSs. 8 per cent of respondents express their inability to observe if any animal has ever been missing while a few respondents said that apart from rhino and tiger, the fox has also vanished from LBWLSs. 57 per cent of the respondents opine that vulture and greater adjutant are the two birds that have declined largely. 15 per cent of respondents believe that all bird species have been dwindling however 11 per cent expressed their inability to speak regarding this. 49 per cent of the respondents opine that all endemic fish species are going down in the locality. 42 per cent think that all species of tree have dwindled while 17 per cent of the respondents do not know anything about it.

The LBWLSs have been perceived to be impacted differently by the respondents due to the loss or dwindling of floras and faunas. Figure 7 represents the respondents' views regarding the impact.



Source: Author's calculation based on the primary survey, 2016.

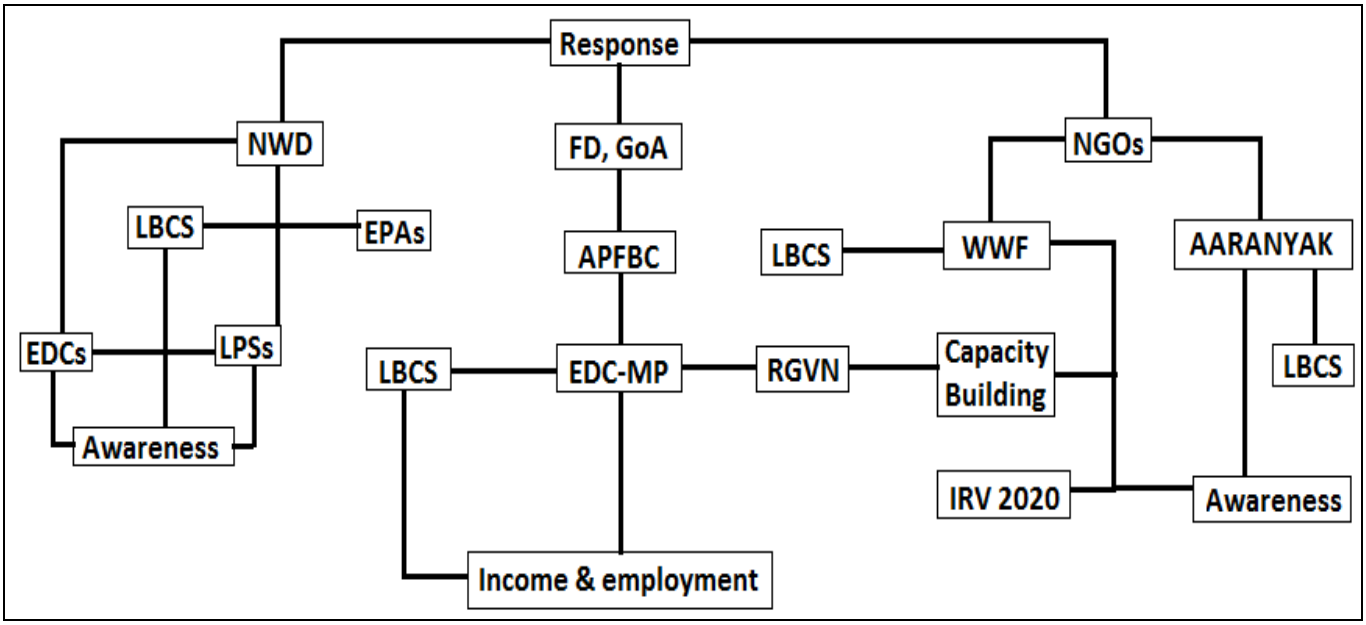
Fig 7: Impact of the loss of wild floras and faunas

It is evident from the diagram that most of the respondents are aware of the adverse socio-environmental implications of the loss of different flora and fauna from their nearby forests.

All these happenings have a dwindling effect on the tourist flows into the sanctuaries accompanied by the loss of tourist revenue. The fund flow from all sources, both government and non-government has also ceased consequently. It had a profound negative implication on the socio-economic development of the surrounding villages.

5. Response (R): According to Carr (2007) [5] responses refer to institutional efforts to address changes in the state of the environment. The response is a policy action initiated by both government and non-government organisations and most importantly by the affected community to reverse the state or adapt it (Oman *et al* 2009; EEA, 2003) [25].

The responses vis-à-vis the state and impact of all the negative happenings discussed above in LBWLSs manifest in a variety of different forms. The initial response comes, indeed, from the department itself which has strongly and very effectively been bolstered by the support of the stakeholders later on. The formation of a stakeholder organisation called Laokhowa Burhachapori Wildlife Conservation Society (LBCS) by the Nagaon Wildlife Division accentuates the process of awareness generation and formation and rejuvenation of the hitherto defunct Eco Development Committees (EDCs) in the fringe villages of the sanctuaries.



(FD, GoA – Forest Department, Government of Assam; NWD – Nagaon Wildlife Division; LBCS – Laokhowa Burhachapori Wildlife Conservation Society; EPAs – Entry Point Activities; EDCs – Eco Development Committee; LPSs – Local Protection Squads; APFBC – Assam Protection of Forest and Biodiversity Conservation; EDC-MP – Eco Development Committee Micro Planning; RGVN – Rashtriya Gramin Vikash Nidhi; WWF – World Wide Fund for Nature; IRV2020 – Indian Rhino Vision 2020.)
Source: Field survey and Ojah, (2016) [24].

Fig 8: Responses from the stakeholders

It is, thus, clear that the response on the part of the Nagaon Wildlife Division is towards a participatory management approach (Table 8). The discourse on participatory management has been there since the late seventies of the last century (Nadkarni 2001; Shylajan and Mythili, 2003; Gunatilake, 1993; Kothari, 2001) [18, 31, 11, 13]. The participatory management here is taking the form of an Eco Development programme wherein both the conservation of forest and forest ecosystem and the peripheral development are linked together. As discussed earlier the LBCS is, in fact, very instrumental in motivating and sensitizing the fringe people to take part in conservation activities through rejuvenating the EDCs. Local Protection Squad (LPS), a later addition to the existing institutions, also plays a vital role in the conservation of Laokhowa and Burhachapori WLSs. Since these are the crucial stakeholder organizations for the NWD, therefore, need a bit more elaboration in terms of their conservation activities and responses.

5.1 Laokhowa Burhachapori Wildlife Conservation Society (LBCS): The "***Laokhowa Burhachapori Wildlife Conservation Society***" (LBCS) has been formed to function as an umbrella organization to bring people interested in nature conservation into one platform and primarily aims at undertaking initiatives for the management of Laokhowa and Burhachapori WLSs. Massive awareness generation and the formation of new and re-establishment of the old EDCs were the important tasks of LBCS initially. It was also instrumental in forming the Local Protection Squad (LPS) which is supposed to work in close coordination with the frontline staff of the NWD. LBCS actively cooperated in organizing training programmes for forest staff, EDC and LPS members. It helps the department in all kinds of research and documentation and provides all the expertise of its members for attaining the larger goal of restoring the landscape.

5.2 Eco-Development Programme – early initiatives: Nagaon Wildlife Division took the much-needed step of establishing participatory management practices in the fringe villages of Laokhowa WLS way back in 2002. 11 Eco Development Committees have been formed altogether in the fringe villages of the sanctuary though could not function properly and faded away in the following years (Ojah, *et al*., 2012) [24]. This failure can be attributed to the following factors:

1. The initiative was a forest department initiative and proper procedure was not followed for the formation of the EDCs. The needs and necessities of the people remained on the back foot.
2. Generation of public awareness for the formation of the EDCs, i.e., its aims, objectives, etc., which is a pre-requisite was not taken care of at all.
3. The department arbitrarily selected the executive committee members instead of getting them selected in the open general meeting of the EDC.
4. No activity could be performed due to lack of funds and hence people lost confidence in the EDCs.

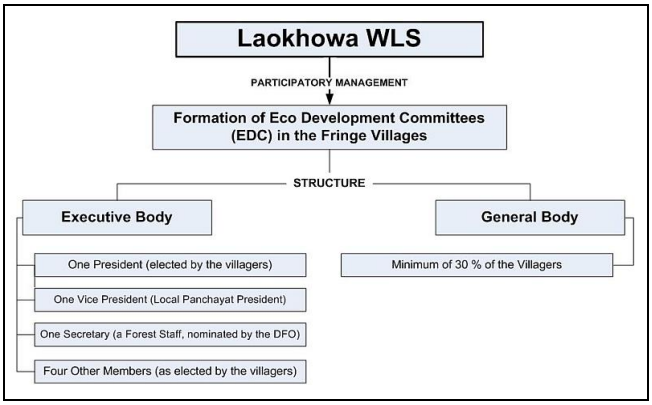


Fig 9: Early initiative for the formation of EDCs

These were glaring lacunae in the process of establishing eco-development committees in the fringe villages of Laokhowa WLS by the local forest department and it comes as no surprise that the programme failed to see the light of the day and the existence of EDCs remained confined only to official papers.

5.3 Local Protection Squad (LPS): A lesson was well learnt by the department from analysing the shortcomings of earlier efforts of establishing EDCs in the villages of the region. The top-down model has failed. With the re-establishment of the EDCs, many youths showed interest to contribute voluntarily towards the conservation of the two sanctuaries which were utilized till then as one of the important sources of income for the people. Some of the youths started giving information about the illegal happenings inside the sanctuaries. Looking into the interest of such youths and their voluntary contribution towards conservation the then Divisional Forest Officer (DFO) thought of capturing the momentum by forming a group whose services could be utilized for the greater interest of reviving the two sanctuaries. Accordingly, the onus was on the LBCS and the EDCs to identify willing and trustworthy youths. Consequently, three 'Local Protection Squads (LPS)' were constituted comprising motivated youths from the fringe villages as identified by the EDC and LBCS. Since then, the LPSs are being engaged in active patrolling duties with the frontline staff. The members of the LPSs are being paid a monthly stipend. The impact of such efforts on the ground was enormous. It is, indeed, the result of such participatory management effort implemented by the department that an examination of the departmental records for the past few years showed a considerable decrease in the various illegal activities being carried out inside the two sanctuaries.

Thus, it took a long time as such to converge and streamline the entire conservation effort in Laokhowa and Burhachapori WLSs and once things were settled other NGOs also started responding and joined hands for the greater cause in a later period. The gargantuan task, thus, undertaken is the implementation of the IRV (India Rhino Vision) 2020 programme in LBWLSs by the World-Wide Fund for Nature (WWF) India. This is a highly ambitious project with a vision to attain a wild population of 3000 greater one-horned rhino by the year 2020 in the protected areas of the state to which the International Rhino Foundation (IRF) and the department of forest, Government of Assam is a party. Along with this programme, various capacity-building projects are undertaken by WWF, AARANYAK and later by Rashtriya Gramin Vikash Nidhi (RGVN) for the fringe people. NWD is optimistic that the responses so far obtained from different stakeholder organizations mentioned above will sustain and that the forest ecosystems of Laokhowa and Burhachapori WLSs would be restored to bring their past glory.

Conclusions

The degradation of Laokhowa and Burhachapori WLSs has enormous negative externalities in and around the sanctuaries and the lives and livelihoods of the fringe dwellers. Depleting fish stock is responsible for changing the breeding ground of migratory birds. Depletion of wild animals along with the birds is primarily responsible for lessening tourists' flow. Adequate tourists flow could have acted as a driver of positive economic development in the area. Man-animal conflicts are rising as a result of the loss of the habitat inside the forest. Elephants come out of the forest and raid the agricultural crop. The population of wild boar has been increasing fast as a result of the loss of the food chain and is always at loggerhead with the locals destroying large croplands. These are all classic examples of the negative externality of the degradation of Laokhowa and Burhachapori WLSs.

Despite all these negative impacts, the habitat has been restored to a great extent and with it, the tiger, the top predator, has entered the sanctuaries and its population has increased to five. Rhino has started visiting the sanctuaries straying from Kaziranga and Orang National Park. The census of 2022 also confirms the presence of 20 swamp deer, another schedule I species. The recent Bird Census also shows an increasing number of birds of various species. It is wonderful news that the participatory model employed has been gaining a positive response from the people of the vicinity though still going a long way.

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