

Flood Impact on Biodiversity and Ecosystems In The Athirapilly-Malakkappara Region (Athirapilly Grama Panchayath) An Executive Summary Along With Policy Inputs Of The Case Study

Amitha Bachan K.H¹. and M. P. Shajan²

¹. Assi. Prof & Research Guide, Research and PG Department of Botany MES Asmabi College, P. Vemballur Thrissur.

². Director, Western Ghats Hornbill Foundation, Thrissur Kerala, 680685.

Abstract

The abnormal rainfall and subsequent flood happened in Kerala in August 2018 had severe impact on river systems, riparian forests as well forest areas with landslide. The Kerala State Biodiversity Board had entrusted the team with a case study on impact of flood and landslide on forest and biodiversity and selected Athirapilly Grama Panchayath as suitable unit. The study using rapid assessment methods, mapping in comparison with the previous biodiversity data available with the research team has brought out a wide range of inputs on impact on forests, unique ecosystems such as riparian forests, endangered species, hornbill nesting trees, and other biodiversity and also on forest dependent ethnic and other community. The results are summarized here as an executive summary and policy document.

Introduction

India has a total geographical area of about 329 million hectares with forests cover 23 % of geographical area of the country. The country supports a diverse array of habitats or ecosystems such as forests, grasslands, wetlands, coastal, marine and desert and each with rich and

unique floristic diversity. The forest cover of the country constitutes about 21.05% (692,027 km²) of India's total geographical area. Champion & Seth (1968) have recognized 16 major forest types comprising 221 subtypes in the country. The Western Ghats mountain chain running parallel to the Western Coastline of Southern India is one among three Biodiversity Hotspot of the world (Myer *et al.*, 2000) and is considered as one among the eight hottest hotspots of biodiversity across the world. The Western Ghats harbors 7,402 species of flowering plants, 1,814 species of non-flowering plants, 139 mammal species, 508 bird species, 179 amphibian species, 6,000 insectsc species and 290 freshwater fish species including nearly 325 globally threatened taxa (Bawa *et al.*, 2007).

Kerala has richest biodiversity wealth including 5094 flowering plants with 1709 endemic taxa (Sasidharan, 2004). The Anamalai landscape unit extend from Nelliampathi Hills upto the Anamudi Peak (highest mountain chain in the Western Ghats 2694m) in Munnar are considered one among the three-biodiversity hotspot regions within the Western Ghats (Nair, 1996). The Chalakkudy River is considered as richest fish diverse river in the region with 104 fresh water species with 3 Critically

Endangered (IUCN) species endemic to the River (Raghavan *et al.*, 2000). The forests areas of Athirapilly region comes within one of the high biodiversity rich forests tracts (Nair, 1997; Bachan, 2006; Sasidharan, 2004). The pioneering studies on riparian forests were conducted in the Chalakkudy River in the Western Ghats and are account for the fish diversity (Bachan, 2003, 2010; Bachan *et al.*, 2014; Bachan and Pooja 2018).

The abnormal rainfall and subsequent flood happened in Kerala in August 2018 had severe impact on river systems, riparian forests as well forest areas with landslide and severe erosion. According to data from India’s ministry of home affairs, a total of 1375 human lives were lost and over 400 were injured this monsoon season due to floods across eight states. Of the eight states, the damage in Kerala is the most prominent as it recorded loss of 498 human lives so far (till September 13) and injuries to at least 140 persons, the death of 46,867 animals and 17.2 million poultry. The areas of the Chalakkudy river Basin is one of the worst affected due to heavy

rainfall and subsequent landslide and also due to torrential river runoff since the six major dams in the upstream (Upper Sholayar Dam, Lower Sholayar Dam, Parambikulam Group Dams (Parambikkulam, Peruvapipallam, Thunakkadavu) and the Poringalkuthu) had to open on a sudden due to heavy rainfall in the 1704 Sq Km Catchment. The results were heavy damage to the Ecosystems especially the Riparian Forests as well as other forest areas due to Landslide.

The results are summarized here as an executive summary and policy document. The study collected benchmark data on all the ecosystems ranging from riparian forests to the evergreen forests in, biota all the groups of plants and animals and the impact of flood on them towards developing proper suggestions for the management of the ecosystem.

Materials and Methods

Study Area

Athirapilly Grama Panchayath is the largest of the Thrissur district and fourth

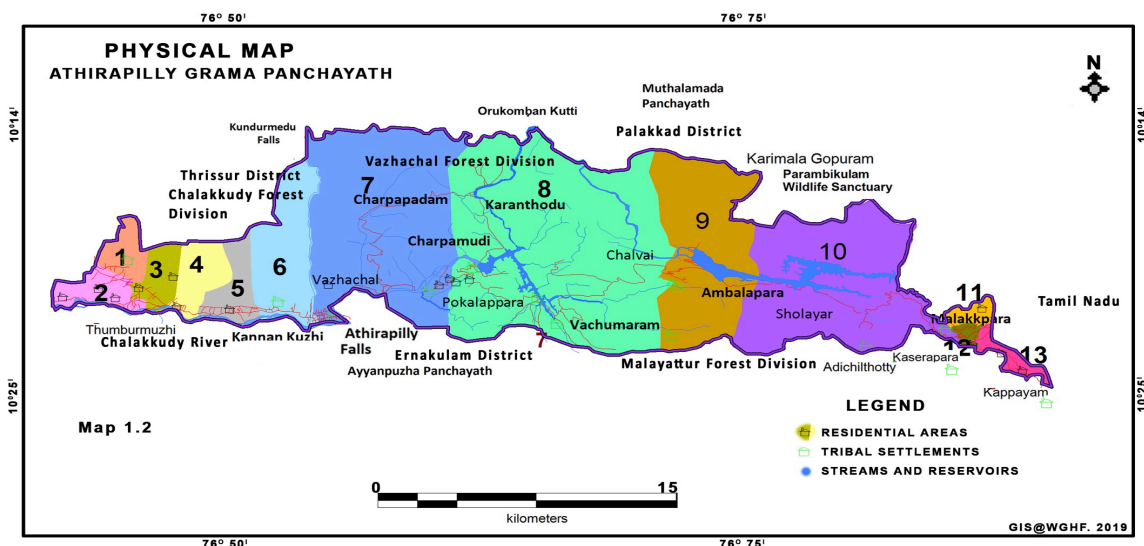


Fig.1 Study Area

among the Gram Panchayaths of the Kerala state. Athirapilly panchayath has high biodiversity richness and is an important eco tourism location in Southern India, blessed with the famous Vazhachal and Athirapilly Waterfalls and the Vazhachal-Sholayar Forests. The Vazhachal Forest Division completely comes within the Administrative boundary of the Grama Panchayath and portions of Parambikulam Tiger Reserve and Chalakkudy Forest Division of central forest circle account for high biodiversity value. The Athirapilly Grama panchayath is located $10^{\circ} 14' 47.72''$ - $10^{\circ} 22' 59.77''$ N and $76^{\circ} 26' 18.78''$ - $76^{\circ} 54' 5.56''$ E in the Chalakkudy thaluk of Thrissur district, 24-95 km East from the Chalakkudy town along the Anamala Road. The Grama Panchayath is 60 km away from the district headquarters in Thrissur city, 70 km northeast of Kochi city, 55 km northeast of Cochin International Airport and 30 km from Chalakkudy town. The southern boundary is covered by Chalakkudy River, and Ernakulam district, Valaparai of Coimbatore Dstrict of Tamil Nadu at the Eastern Boundary of Thrissur District, and the Western boundary is covered by Pariyaram and Kodassery Grama Panchayaths (Fig 1).

Methodology

1. Assessment of Impact of Flood and Landslide

The Athirapilly Grama Panchayath area was gridded into 108 grids for systematic sampling (Fig 2). The grids were used as a common platform for sampling of impacts such as i. Landslide impact, ii. Flood impact on riparian areas, iii. Impact on Ecosystems including Forest types, iv. Impact on Flora and v. Fauna following the methods used in rapid assessment (MoEF, 2014; Bachan *et al.*, 2019).

2. Landslide impact

The entire area of the Panchayath is surveyed to understand landslide locations. All such location were photographed, GPS recorded and plotted in the map using GIS software: QGIS and Google earth platform. The dimension of each landslides were measured in the field and were 3 types; i. Small, ii. Medium and iii. Large Landslide. Detailed Fieldworks were carried out thoroughly in selected landslide locations of Athirapilly Panchayath for quantitative estimation of the landslide. The impact area measured for each selected landslide from each type. The data was tabulated and estimated to understand the total area loss due to landslide and also for estimating loss happened to each category of forest ecosystem and also to residential areas.

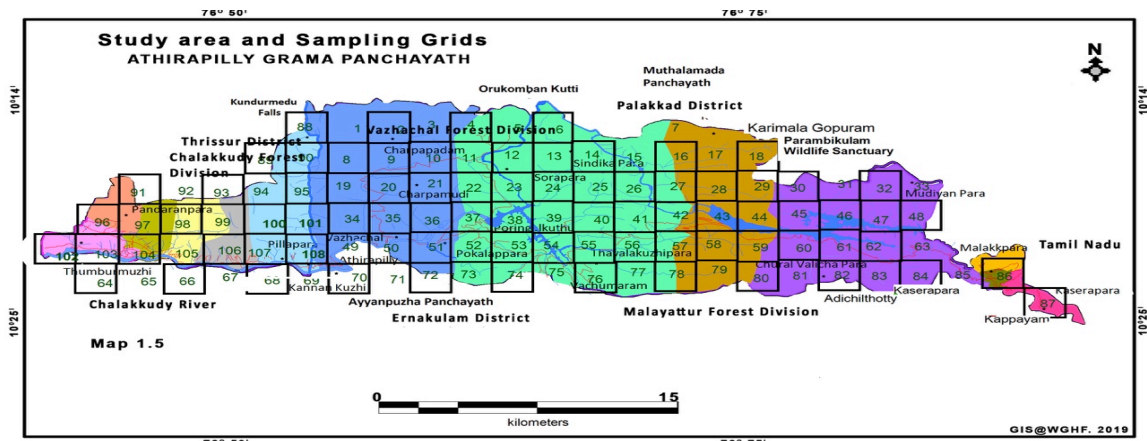


Fig.2 Sampling grids

3. Impact on River habitat:

The main river from Orukombankutty up to the Athirapilly Falls was divided into 3 zones and sampling locations were selected from each zone, they are

- Zone A Orukombankutty - Poringalkuthu
- Zone B poringal – Vazhachal rapid
- Zone C Vazhachal rapid– Athirapilly waterfalls

Each sampling locations were surveyed systematically for impact of flood 2018 on various habitats in the river. A datasheet was prepared for a rapid assessment and the survey was conducted January - February 2019. The affected sites were ranked based on the level of damage caused to them and recorded in the datasheet. The criterion were LA-Little Affected, MA-Moderately Affected, SA-Seriously Affected and CD- Completely Destroyed. Criteria for ranking are water level, siltation, vegetation, soil deposition and erosion.

4. Impact on Flora and Endangered species

The distribution of endangered species and important flora were mapped based on the information collected. The area of impact due to landslides in each location were calculated to understand the impacted species as well as impact on endangered flora. Quantified estimation of the loss of endangered species were enumerated from the phytosociological data.

5. Impact on Riparian Forests and Riparian Flora

Systematic sampling locations were selected for Riparian areas from the previous data (Bachan, 2003, 2010). The river

stretches divided into different zones (A, B, C, D, E, F, G,H). All the zones except E and F completely comes under the Athirapilly Grama Panchayath. All these zones coming under different grids were surveyed with a scheduled prepared especially for the assessment of the impact on riparian forests. The same schedule has been given for preparation of schedule for assessment of riparian vegetation in other rivers including Chalakkudy River on a different collaborative project funded by KSBB. The data were analysed to understand the impact on riparian vegetation. The areas were mapped using the GIS and quantitative estimation of the species composition and structure were done laying out quadrats of sample size 20 x 15 m (0.333 ha). The impacted resilient taxa from each locations and also from the quantitative assessment were elucidated for the analysis.

Results

1. Landslide and Impact

The study documented 28 landslides of small to large category causing loss to 283.72 ha area and major reason is the improper construction of roads along high slope or removal of vegetation cover in steep flowing streams. A Total of 5 landslides occurred in residential areas one in Non- tribal land Pandarampara and 4 landslides occurred in the tribal agricultural land mainly in Thavalkkuzyppara, Anakayam, Adichilthotty and Kappayam. One of the high impacted landslides occurred at Pandarampara area near Vettikuzhin in the 1st ward of the Athirapilly Grama Panchayath. The Anakkayam Tribal settlement is the another badly affected due to a clustered huge landslide

happened along the Anamalai Road in the anakkayam Valley

2. Impact of landslide on vegetation as well as endangered species

Since the majority of the landslides were concentrated in the higher slope and medium elevation areas especially along the Anamalai road the major loss happened to the good quality 236.52 Ha of Medium Elevation Evergreen forests. This was followed by 0.0043 Ha of degraded Medium Elevation Evergreen forest, 4.25 Ha of the Semi evergreen forest and 21.259 Ha of the Low elevation evergreen degraded forest.

The present study revealed 1164 species of flowering (angiosperm) plants. These plants belong to a total of 692 genera, 142 families. *Cycas circinalis*, *Gnetum edule* are commonly seen wild gymnosperms plants apart from few garden varieties. A total 61 Pteridophytes taxa were enumerated from the study area, which include 52 species of true ferns and 10 species of fern allies. Chalakkudy River, Sholayar River and the wetlands are good natural habitat for aquatic, microscopic plants like algae. A total of no of 242 algae were enumerated in the region. Out of the 1164 species of plants listed, 269 of them are endemic 70 comes under IUCN threatened category.

The present estimate on affect of flood on Endemic and Endangered taxa revealed that nearly 63 Endemic plants were affected during the landslide and flood. Of them 24 are endemic to Southern Western Ghats such as *Cinnamomum riparium*, *Cinnamomum sulphuratum*, *Cullenia exarillata*, *Dipterocarpus indicus*, *Drypetes venusta*,

Drypetes malabarica etc and 27 are endemic to Western Ghats including *Calamus hookerianus*, *Calamus thwaitesii*, *Calophyllum calaba*, *Canscora diffusa*, *Canscora pauciflora*, *Capparis rheedei* etc, *Diospyros candolleana*, *Ensete superbum*, *Diospyros paniculata*, *Ficus virens* etc are endemic to Peninsular India and *Artabotrys zeylanicus* is endemic to Peninsular India and Sri Lanka.

A detailed analysis of 13 endangered species revealed that a total of 1200 individuals may be damaged or lost due to landslide. Detailed species composition of these areas were given for prioritizing ecorestoration activities. Awareness shall be created locally on other endangered species such as trees like *Cryptocarya anamalayana*, *Kingiodendron pinnatum*, riverine herbs such as *Lagenandra nairii*, *Willisia selagenoides*, reptiles such as Cochin Forest Cane Turtle, amphibians like The balloon Frog etc. similar to the awareness created there on Hornbills and Hornbill nesting since 2005 (Bachan et al. 2019).

3. Impact on fish and fish habitat

Habitat wise analysis shows out of 8 pools there are 2 Least Affected, 3 Moderately Affected and 3 Seriously Affected. Out of 22 riverbanks locations there are 4 Least Affected, 7 Moderately Affected, 3 Seriously Affected and 8 Completely Destroyed. Out of 16 locations in river stretches with streams sand riffles there are 2 Least Affected, 2 Moderately Affected, 12 Completely destroyed with complete wipe out or complete mud deposition.

4. Impact on birds, butterflies, odonata other animals

A total of 71 species of mammals belonging to 25 family were observed from the study area including many endemic and endangered including Asiatic Elephant, Tiger, Leopard, Wild Guar, Flying Squirrel, Lion Tailed Macaque, Nilgiri langur. A special survey conducted for birds, butterflies and odonata revealed total of 196 species of birds, 131 species of butterflies and 51 species of odonata during the survey. total of 63 reptiles were enumerated from this area including once thought extinct Cochin Forest Cane Turtle (*Vijayachelys silvatica*) from the riparian forests. 32 species of amphibians were reported from the area and they belong to 18 genus including the *Nasikabatrachus sahyadrensis*, the balloon frog which has been recommended to enlist as the state frog. The study helped to enumerate 107 species of fishes belongs to 25 families from the Chalakkudy River and the areas of Vazhachal Forest Division.

5. Impact on Riparian Vegetation – Unique Ecosystem

As per the data, 23 % area were washed out during the flood. 50% of the area had heavy impact 20% were partially impacted and the remaining 6% area only less impacted. The riparian vegetation in the Vazhachal region (Poringal downstream to Vazhachal Waterfalls) hit badly with the torrential water flow. The impact is reflected in the destruction of almost 90% of the islands, most of the trees were uprooted except some high *Hopea* trees. The zone from downstream of the Vazhachal rapids upto the Athirapilly falls had severe impact in which 66.7% of the riparian area especially islands completely washed out.

The low elevation riparian vegetation in the Orukomban – Thumboormuzhi (50-400m) is unique and no elsewhere found in the Southern Western Ghats. They were resilient to the flood impact and they functioned it well in the areas preventing further damage to the river and riverine biota.

Discussion

Landslide and Impact

The road construction along the steep terrains requires much physical support for the embankments. Proper waterways across the roads and space for animals to cross for both larger animals such as elephants and smaller ground dwelling organism like reptiles and also for arboreal mammals are necessary. This can add to long-term stability of the roads as well as reduce the conflicts. Special action plans have to be developed for the restoration of the residential as well as agricultural areas in these locations. The people were shifted to the quarters of Electricity Boards and now they moved their own to top of a rock near the Anakkayam forest area. Being a PVTG tribal group with special right under FRA 2006 including the CFR and habitat right Their Grama Sabaha has to be consulted to prepare a proper relocation plan.

Impact on endangered flora

Out of the 1164 plants listed, 70 (6%) of them comes under the IUCN conservation Status. The following 7 of them are Critically Endangered *Allophylus concanicus*, *Impatiens auriculata*, *Dryptes malabarica*, *Aglaia malabarica*, *Syzygium occidentale*, *Syzygium travencoricum*, *Piper barberi*. 21 Endangered including *Pothos crassipedunculatus*, *Humboldtia*

vahliana, *Glochidion zeylanicum*, *Bulbophyllum aureum*, *Vepris bilocularis*, *Desmos viridiflorus*, *Aralia malabarica*, *Kingiodendron pinnatum*. 34 taxa comes under Vulnerable category including *Mycetia acuminata*, *Ochreinauclea missionis*, *Semecarpus travencorica*, *Solenocarpus indicus*, *Orophea uniflora*, *Ceropegia metziana*, *Impatiens herbicola*, *Garcinia wightii*, *Dipterocarpus indicus*, *Hopea parviflora*, *Hydnocarpus macrocarpa*, *Actinodaphne malabarica*. 2 *Aglaia lawii*, *Amomum petrocarpum* under Least concern and 6 are Near Threatened *Anaphyllum wightii*, *Phaeanthus malabaricus*, *Tabernaemontana alternifolia*, *Tabernamontana gamblei*, *Arisaema barnesii*, *Elaeocarpus munronii*.

Impact on fish and fish habitat

The riverine habitat with riffles and small pools are critically damaged. There are 41 species of fishes occur in the river lives in this kind of habitat. These species must be considered seriously in post flood monitoring and analysis. The flood impact on agricultural land, fish and aquatic habitat seems to be temporary some post flood data indicates increase in fish production and agriculture with nutrient enrichment but it has to be monitored for a long term.

Species recovery plans has to be prepared for the Fish Diversity. This shall include the following criteria. i. Ranching of non Native species has to be banned because that can over predate the surviving population of native fishes, 2. Restoration of riverine habitat to enhance the breeding and population of rich fish diversity in the river depending on specific riverine habitat, 3. Restoration of

riparian vegetation since that has great correlation with fish diversity and abundance and 4. Localized breeding of native fishes from their local population involving indigenous people has to be planned for proper fish diversity conservation.

Impact on birds, butterflies, odonata other animals

The study indicated high diversity of birds, butterflies, odonates and fishes in the riparian sampling sites where as a comparison with previous data abundance was less. The less abundance of many species along the riparian areas may be because of loss of riparian habitats especially islands. The researchers observed less abundance of bird, butterflies and odonates in the flood impact zones in comparison with non impact zone in similar habitat. They also noted loss of foraging, nesting and roosting sites and trees along the riparian areas and islands from Orukomban to Athirapilly.

Out of the total 64 Great Hornbill nesting trees in the area 12 nests were affected by flood and 4 nests were lost in the heavy rainfall and flood. The percentage of impact of flood on Hornbill Nesting areas in the study area is 18.75 % and the percentage of loss of Nest trees is 6.2%.

Impact on Riparian Vegetation – Unique Ecosystems

The damage happened to the riparian vegetation were severe in the areas just downstream to the dams especially Poringalkuthu-Vazhachal region and just downstream to the Vazhachal rapids (60-80% damage), just downstream to the Sholayar dam (50-

60%), indicating the impact of sudden release of dam waters. The study recommend an immediate revisal of rule of curves of dams in Kerala as recommended by CWC (2018) also synchronized management of dam waters in the Chalakkudy catchment including PAP in the monsoon season to effective management of the heavy flood as well as to have normal flood waters to the downstream of all dams to enrich the river basin, its aquatic – agricultural productivity and other ecological functions.

The study suggest involvement of riparian BMCs, Local Self Governments, Tribal GSs, CFRMCs/FRCs, VSS/EDCs and other riparian community associations through developing a Local Body level plan using the Eco restoration protocol (Bachan 2017) including development of an online module similar to hornbill monitoring (www.hornbillmonitoring.in) with support from Forest Department in the Forest areas and Kerala State Biodiversity Board as a monitoring agency.

A comparison with pre flood data (Bachan, 2010), showed 66% reduction in Density, total number of individuals and 50% reduction in the species diversity. A detailed structural analysis of the impacted vegetation shows that facultative riparian species such as *Hopea parvilifera*, *Humboldtia vahliana*, *Madhuca nerifolia*, *Homonoia riparia*, *Syzigium occidentale*, *Dipterocarpus indicus* *Barringtonia acutangula*, *Mallotus aureopunctatus*, *Pongamia pinnata*, *Lophopetalum wightianum*, *Enteda scandense* etc are highly resistance to the flood including the

torrential flow and dam water release. These species showed high survival tendencies. *Ochlandra scriptoria*, *Cinnamomum ripariaum*, *Garcinia sps.*, *Lagerstromea sps*, etc also survived to a greater extent but the torrential flow uprooted many of the *Ochlandra scriptoria* patches in the riparian areas.

Declaration of the Riparian forest areas along with river stretches into a protected area of the Hornbills and Kadar indigenous community or as Biodiversity Heritage Site is essential for the conservation of the unique low elevation riparian forests in the Athirapilly Grama Panchayath.

Policy Recommendation for reducing the landslide impact in Kerala

General

1. The road construction along the steep terrains require much physical support for the embankments, steel bars along with boulders if necessary used along railway lines can be a good interventions which can support prevention of landslip as well can maintain growth of vegetation cover.
2. Necessary pathways for movement of animals especially larger mammals like elephants as well as arboreal species are required across the roads with steep slopes and hairpin bends. The embankments shall be provided with gaps which enable movement of ground dwelling organisms.
3. Proper management of waterways across the roads is also a necessity i.e the dimension of the Chappath or Culverts shall be made assessing the order, slope and at least considering the water level in the extreme monsoon.
4. The steep cutting or the straight running streams in very hill terrain also found to

be causing landslides and chance increases with degraded landuse and slope. These areas shall be notified as 'Vulnerable zones' especially "downstream areas of steep cutting or straight running streams with natural vegetation or mixed cropping is less than 30%". since such areas more prone to landslides, making residential zones downstream to such areas should be avoided.

5. The hills and hill slope shall maintain at least 30 % natural vegetation or mixed cropping including diverse natural tree growth.
6. Clearing of the natural vegetation at the top of the hills shall be banned and ecorestoration of natural vegetation shall be promoted in hills tops.
7. Removal of riparian vegetation in the public places shall be banned or that has to be based on a sustainable harvest plan developed by riparian community associations and recognized by each BMC and local bodies.
8. Reservoir operations has to be revised according to the following
 - a. i. Flood management – the reservoirs shall be kept at least below 80% storage upto 30th September every year. So that any emergency high rainfall can be managed. The remaining can be stored during October – November.
 - b. ii. Ensuring normal monsoon flow (July) and minimum flow during the summer months (Feb-April) in the river for drinking water, fish migration, agriculture production and other ecological functions of the river.
9. Since the riparian vegetation more resilient to the flood impact and they functioned it well in the areas preventing further damage to the river and riverine biota restoration of the damaged riparian areas and their monitoring based on a detailed plan is a necessity.
10. Incentives have to be given for landowners and community involved in i. protection of natural vegetation in the hilltops, ii. practicing mixed cropping with at least 30 % of the area of natural native tree growth along hills, iii. Ready for ecorestoration of hilltops and riparian areas, iv. Protection, monitoring and sustainable harvest practice of riparian areas. The incentives can be a minimum of MNREGS wages for the family who endorse for the activities.
11. Ecorestoration or species planting shall follow ecorestoration protocol or shall plant only the pre existed or currently existing species as per bench mark data collection and as approved by BMC and LSGs. Planting of Non natives or exotic and not following the ecorestoration protocol and approval by BMC/LSGs has to be banned since it may have serious impact on biodiversity.
12. Ecorestoration and planting of species on landslide degraded areas shall be following a suitable ecorestoration or species selection protocol. Bench mark data collection, selection of proper species suitable to the bioclimate and approval from BMC/LSGs shall made mandatory. Planting of non native / exotics shall be banned.
13. Giving more popularity for the requirement of Ecorestoration and Ecological monitoring involving local community in the awareness programs. Involving students, women groups and indigenous communities in awareness and monitoring programme is important.
14. The riparian ecorestoration and monitoring plan of Athirapilly Gram Panchayath in The Chalakkudy River can be taken as a pioneering model.

15. A sustainable Eco restoration and harvest plan for non forest riparian areas has to be developed in the Chalakkudy River and can be replicated in other rivers simultaneously.
 16. A river basin- watershed level approach for development planning and approval from LSGs/River Basin advisory body has to be made mandatory.
 17. National and State Eco restoration policy: A state level and national level eco restoration and species selection protocol has to be discussed in a forum/conference, developed and made mandatory. The present document and the protocol developed (Bachan 2018) can be sued as a draft.
 18. Ecological monitoring involving local community as approved by BMCs also shall be made as part of the national and state level policy for ensuring ecological accountability and sustainability goals envisaged by UN, IUCN and UNDP.
 19. A general policy for rehabilitation of flood impacted people has to be developed binding to the LAAR 2013 and FRA 2016 (especially section 4(2) in the case of tribal people). Otherwise flood /landslide related rehabilitations can increase future conflicts and violate resource and land right of citizens.
- b) The BMCs can take initiatives to make action plans for eco restoration and monitoring programs of the riparian area and landslide degraded areas with leadership of BMC incorporating MNREGS in the Athirapilly GRama Panchayath adhering to the prepared eco restoration plan.
 - c) An eco restoration programme for the degraded hornbill nesting habitat shall be initiated since the hornbill monitoring programme (Bachan *et al* 2019) have ample data since 2005. The flood impacted nesting sites shall given priority.
 - d) The biodiversity data collected here has to be added to the Biodiversity Register of the Athirapilly Grama Panchayath. The BMC has to take initiative for that.

Athirapilly Grama Panchayath – Vazhachal Forest focused

- a) Endangered plants like *Cryptocarya anamalayana*, *Kingiodendron pinnatum*, riverine herbs such as *Lagenandra nairii*, *Willisia selagenoides*, reptiles such as Cochin Forest Cane Turtle, amphibians like The balloon Frog etc. shall be made programs of awareness, monitoring and restoration similar to the awareness created there on Hornbills and Hornbill nesting since 2005 (Bachan et al. 2019).

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