



THREAT FACTORS ON THE BUTTERFLY DIVERSITY OF WALAYAR VALLEY, THE WESTERN GHATS, INDIA

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ABSTRACT

Biodiversity is encountered by serious threats due to disturbances caused in the ecosystem by anthropogenic factors. Some of the key drivers of disturbances in the terrestrial ecosystem include land use changes such as clearing of natural vegetation for agriculture, monoculture plantations, forest fragmentation, various industrial activities and forest fire. These changes happening in the ecosystem have impact on the insects, which constitute about 80 percent of the species on earth. Among the insects, the butterflies are very sensitive to even minor changes in the environment and are considered as 'bioindicators'. Hence they are also likely to be much affected by the disturbances in the ecosystem. In this context, a study was carried out from 2012 to 2015 to find out the threat factors on butterfly diversity of Walayar Valley, the major break in the Western Ghats mountain system. It was found that the major threat factors encountered by butterflies in the valley are: forest fire, extension of monoculture forest plantations, degradation of forests / formation of scrub and expansion of areas under mining. The forest degradation started in both Kerala and Tamil Nadu part of Walayar Valley from 1920s and its intensity was very high during the 50 years period, up to 1970s and the area under scrub was increasing. The forest degradation happened from 1970s to 2010 was not much, compared to the earlier period. The threat factor analysis has shown that the forest areas lying in Kerala part of Walayar Valley has undergone more disturbances, compared to Tamil Nadu part of the valley. Walayar Valley has been found to shelter six species of endemic butterflies and 10 butterfly species listed under Wildlife (Protection) Act, 1972 which are of conservation concern. Most of the tropical forest areas have undergone changes one way or other in the recent past due to anthropogenic factors and the biodiversity available has to be preserved in such areas now. Hence biodiversity conservation in partially modified landscapes, as in the case of Walayar Valley has significance and requires utmost attention. Managerial interventions towards reducing the impact of the threat factors as well as measures for eco-restoration of the disturbed ecosystem of the valley are the need of the hour to conserve the butterfly diversity.

Keywords: Threat factors, butterfly, Walayar Valley, landscape, biodiversity, conservation

INTRODUCTION

Biodiversity change is caused by a range of drivers often interacting with each other. A driver is any natural or human-induced factor that directly or indirectly causes a change in an ecosystem. In terrestrial ecosystems, the most important direct driver of change in the past few decades has been land cover change. Deforestation and forest degradation are currently more extensive in the tropics than in the rest of the world. Many tropical forests suffer from fragmentation, with significant impacts on their biodiversity. Fragmentation is caused by natural disturbance (such as fires or wind) or by land use change and habitat loss, such as the

clearing of natural vegetation for agriculture and monoculture forest plantations or road construction, which divide previously continuous habitats. Species that are specialized to particular habitats and those whose dispersal abilities are weak suffer from fragmentation more than generalist species with good dispersal ability and as such the habitat specific species are more vulnerable for extinction (MEA, 2005).

Landscapes are modified extensively and intensively throughout the world, mainly due to anthropogenic activities. Such disturbances caused by anthropogenic factors are the most important reasons for loss of biodiversity. Once the landscape is changed, it may have a fairly permanent pattern of agricultural fields, plantations and urban areas. The behaviour of insects which constitutes a lion share of species in a terrestrial ecosystem also undergoes vital changes with these alterations in the ecosystem. Studies carried out on the impact of forest disturbance on species diversity have shown a shift in species composition in the disturbed habitats. Due to deforestation and conversion of natural forests in to plantations, the species and genetic diversity of insects are being eroded. There is also a reduction or even disappearance of rare, endemic and protected species in the disturbed forests. The economic and ecological significance of most of the insect species is still not worked out.

Butterflies are a group of charismatic insects, which are playing a very vital role in ecosystem functioning and services. They provide important links in food chain and perform the very essential ecosystem services like pollination. Butterflies are of high aesthetic value and the butterfly parks and gardens are the major tourist spots the world over. Butterflies are highly sensitive to even minor perturbations in the environment and hence considered as “bioindicators” to monitor the changes happening in the environment.

The Western Ghats is an important mountain system of Peninsular India and its forests are undergoing large scale disturbances in the past few decades. The impact of forest disturbances at four locations in the Western Ghats viz. Silent Valley, Nelliampathy, Sholayar and Parambikulam have been studied by Mathew *et al.* (1998); they noticed that the change in the vegetation has serious impact on fragile insect community, leading to the disappearance of arboreal feeding forms and colonization by herbaceous or weed feeding forms. Kunte (1999) observed that the natural forests had higher butterfly species diversity, compared to human impacted areas like monoculture plantations in the Western Ghats areas. Nayak *et al.* (2004) surveyed eight localities in various parts of the Western Ghats for pattern of butterfly diversity, distribution and abundance. The diversity of butterfly species was found to be high in natural habitats than the modified ones. Studies carried out by Sasidharan *et al.* (2020) on the butterfly fauna of Walayar Valley has revealed that this area is rich in butterfly diversity with the presence of 117 species of butterflies falling under five families. Six species of butterflies which are endemic to the Western Ghats / Sri Lanka and 10 species listed in various schedules of the Wildlife (Protection) Act, 1972 were recorded from the valley. The outcome of the study highlighted the biodiversity value of the Walayar Valley and need for its conservation.

Kumar *et al.* (2008) made an assessment of the threat factors on biodiversity in Nelliampathy Forest Region of the Southern Western Ghats and underscored the need for implementing suitable conservation measures to manage such forest ecosystems. The forests of the Western Ghats provide extensive benefits in terms of goods and services to communities that live in and around them. Increased rates of deforestation and biodiversity loss have been evident in the Western Ghats over the past few decades. To sustain livelihood benefits and ecological services in such transformed landscapes, a set of appropriate strategies and management designs is necessary (Oommen, 2011). Hence the present study is

an attempt to identify the drivers / factors which could be detrimental to the butterfly fauna of Walayar Valley, so that appropriate managerial intervention could be made to restore the ecosystem and the biodiversity.

MATERIALS AND METHODS

a) The study area

The Walayar Valley (Lat: N 10° 51' 0" & Long: E 76° 51' 0") is situated in the Palakkad Gap of the Western Ghats. The forests of the valley were more or less intact in the past, with rich flora and fauna. The Palakkad gap is a major break in the Western Ghats mountain range, in south-western India. It is located between the Nilgiri Hills in the north and the Anaimalai Hills in the south, and is about 32 km wide. The western portion of the valley is situated in Kerala State, whereas the eastern portion is in Tamil Nadu (Fig.1). A small river known as "Walayar River" flows through the boundary of Kerala and Tamil Nadu States. The total extent of the study area is about 121.22 km² with an altitude ranging from 200m to 1200m. As per the revised classification of the forest types by Champion and Seth (1968) the major forest types occurring in Walayar Valley are: Tropical moist deciduous forests, Tropical dry deciduous forests, Tropical thorn forests, Tropical semi-evergreen forests, and Grasslands.

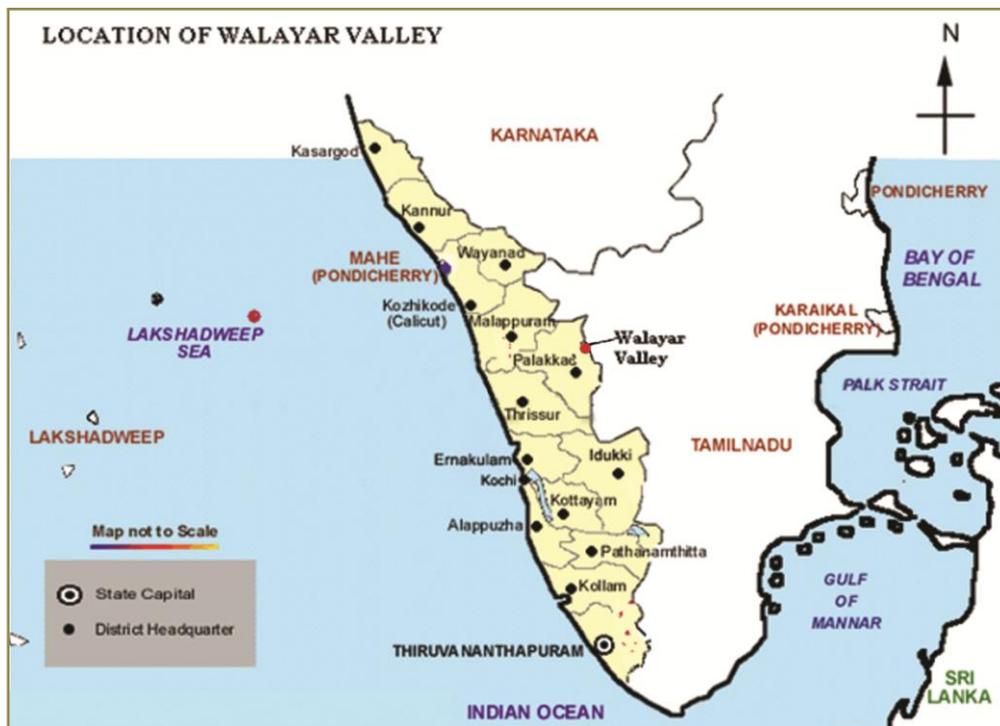


Fig. 1. Location of Walayar Valley

The Walayar Reserve Forest was purchased by the Government in 1873-74, to ensure permanent fuel supply to the Madras Railway. This reserve was brought under the operation of a working plan in 1885 (Muhammed, 1967). The forests were mainly worked for Teak poles, fuel wood and bamboos. Hence these forests were exploited and disturbed by various anthropogenic activities. At present the valley consists of a variety of landscape elements, which include various types of forests, forest plantations, rocky patches, barren areas, areas under mines, human habitations and agricultural areas, which form the habitats of diverse species of butterflies.

b) Threat factor analysis

The threat factors analysis was done, following the Relative Scoring Method Analysis (RSMA) developed by Kumar *et al.* (1995). The main threat factors which are considered to be detrimental to the butterfly fauna in the study area were identified for this analysis. Assessment of landscape changes in Walayar Valley, especially the degradation of forests / formation of scrub and expansion of area under mining was made based on Survey of India toposheets, Landsat data, IRS and Google earth images. Data on other threat factors like forest fire and extension of monoculture plantations was collected from the records maintained by the State Forest Departments of Tamil Nadu and Kerala and other sources. The criteria followed for assessing these threat factors are shown in Table-1. The contribution of each of the threat factors was expressed as “Importance Value”, in 0-10 scale, assuming that a weightage of ‘0’ indicates low impact, 10 indicates maximum impact and other intermediate figures representing progressively higher impacts. Relative weighing of each determinant was done in three pre-determined classes (high, moderate and low). Each class was given a weightage 3 for high, 2 for moderate and 1 for low. The figure obtained by multiplying the importance value and the weight attached to it is called “Impact Value”. The sum of the impact value thus obtained is called “Grand Index Value” (GI value).

Table 1. Criteria for assessing the threat factors

S.No.	Threat factor	Degree of impact	Standard
1	Forest fire (area affected)	High	>100 ha
		Medium	50-100 ha
		Low	< 50 ha
2	Extension of monoculture forest plantations	High	>500 ha
		Medium	100-500 ha
		Low	< 100
3	Degradation of forests/ formation of scrub	High	>500 ha
		Medium	100-500 ha
		Low	< 100
4	Expansion of areas under mining	High	>100 ha
		Medium	50-100 ha
		Low	< 50 ha

RESULTS

The major threat factors encountering the butterfly fauna of Walayar Valley are: i) Habitat destruction due to fire, grazing and other human interferences ii) Raising of monoculture forest plantations iii) Degradation of forests / formation of scrub and iv) Expansion of areas under mining.

The Thorn forests, which occur towards the dry tracts of Tamil Nadu, constitute the major vegetation type. The Moist deciduous forests are found in the lower elevations of the valley, in Kerala part. Small portions of Semi-evergreen forests and Dry deciduous forests are available in the valley. Very small patches of Riparian forests as well as grasslands are also found here. Rocky patches exist towards hill tops and steep slopes here and there. Some forest areas have been allotted for Limestone mines of cement factories established in Walayar Valley.

A preliminary land use analysis of the study area was carried out and the landscape modifications happened in Walayar Valley (Kerala part) during different periods of time, starting from 1920 to 2010 is shown in Table-2.

Table 2. Landscape change in Walayar Valley (Kerala part) (Area in km²)

Landscape	1920s	1970s	1990s	2010
Forest	68.79	61.24	59.94	59.00
Rock	11.53	11.53	11.53	11.51
Scrub	-	7.55	8.38	8.38
Mine	-	-	0.47	1.43
Total	80.32	80.32	80.32	80.32

It may be noted that over a period of 90 years, about 10 km² of forest areas was lost in the Kerala part of the valley. The area under scrub, which is a degradation stage, has increased by about 0.83 km² from 1970s to 2010. In 1990s with the opening of Lime Stone Mine, an area of 1.43 km² of forest areas was also lost.

The landscape modifications happened in Walayar Valley (Tamil Nadu part) during different periods of time, starting from 1920 to 2010 is shown in Table-3.

Table 3. Landscape change in Walayar Valley (Tamil Nadu part) (Area in km²)

Landscape	1920s	1970s	1990s	2010
Forest	24.25	21.34	21.11	20.57
Rock	16.65	16.53	16.35	16.35
Scrub	0	2.72	2.72	2.72
Mine	0	0.30	0.71	1.27
Total	40.9	40.9	40.9	40.9

The forest area lost in Tamil Nadu part is less compared to Kerala side and it is only about 4 km². The area under scrub or degradation stage (2.72 km²) formed during 1920s to 1970s remained stable till 2010 without any change. An area of 1.27 km² was lost when the Limestone quarry was developed in Tamil Nadu part for the cement factory, from 1970s. In general, forest degradation started in both Kerala and Tamil Nadu part of Walayar Valley from 1920s and its intensity was very high during the 50 years period, up to 1970s (Fig.2 to 5).

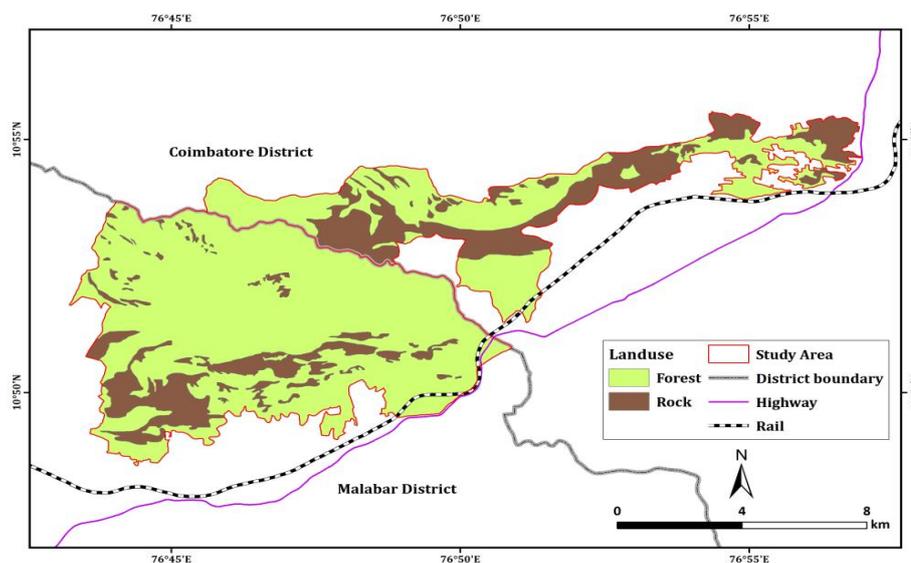


Fig. 2. Landscape in 1920s- forests almost intact, without formation of scrub jungles

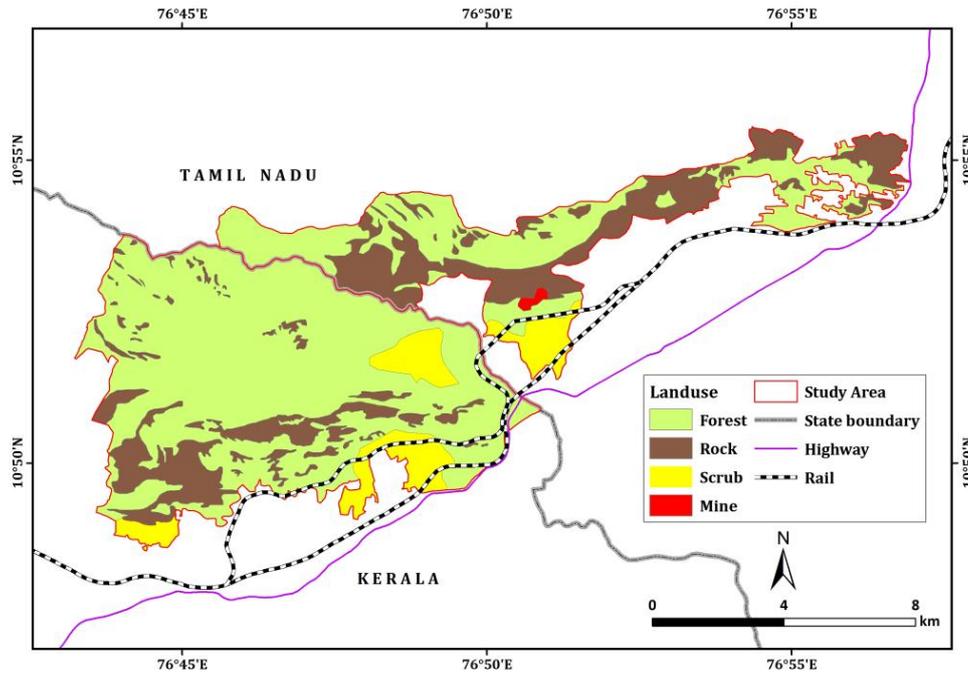


Fig.3. Landscape changes 1970s -formation of scrub and starting of mining

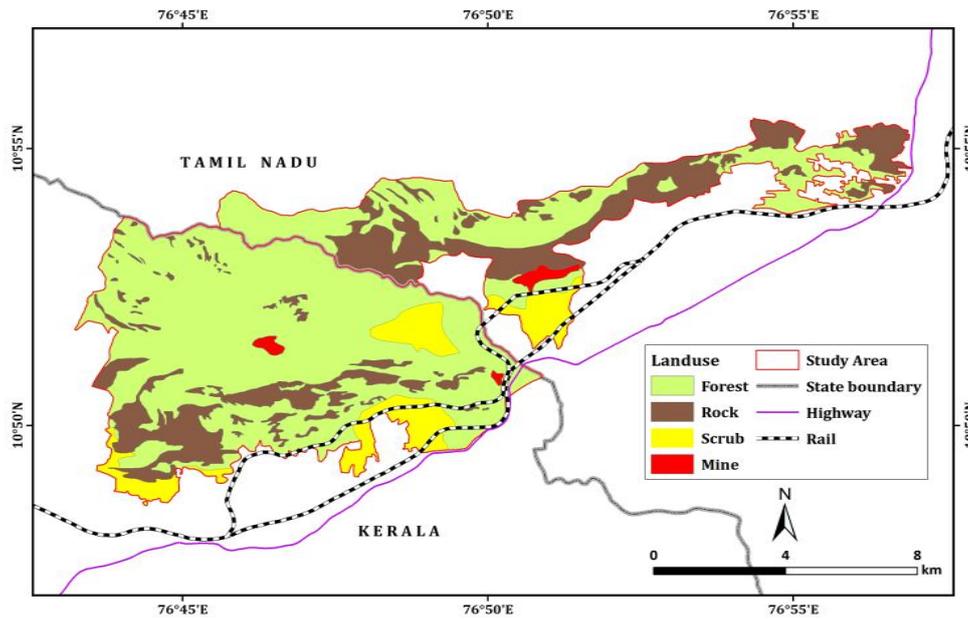


Fig. 4. Landscape changes 1990s - increase in areas under scrub and mining

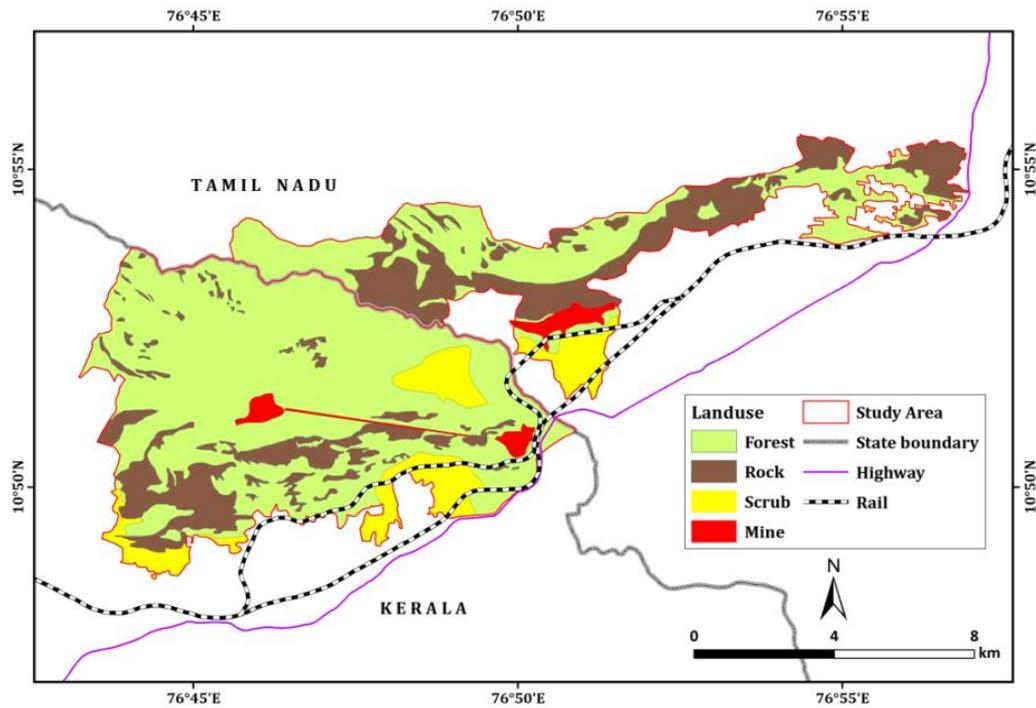


Fig. 5. Landscape changes 2010 - increase in areas under mining and slight increase in scrub

The forests of Walayar Valley have been over-exploited from the British period onwards for meeting various demands and its quality has steadily deteriorated. Raising of lot of monoculture forest plantations has affected the floristic diversity of natural forests adversely. The extent of monoculture forest plantations raised in Tamil Nadu part of Walayar Valley is 546.01 ha (Table-4) and in Kerala part of the valley is 734.02 ha (Teak: 714.02 ha & Miscellaneous species: 20 ha).

Table 4. Details of forest plantations raised in Tamil Nadu part of Walayar Valley

S.No.	Species	Year	Area (ha)
1	Misc/NTFP/Bamboo	1991 to 2013	376.66
2	Tamarind	1975 to 1994	103.43
3	Acacia	1983 to 1991	36.92
4	Bamboo	1997 to 2013	29.00
		Total	546.01

There are several human habitations adjoining the forests of the valley and therefore they are affected by forest fire almost annually. Two major railway lines, i.e. "A" and "B" lines connecting Palakkad to Coimbatore pass through the forests of Walayar Valley. Further, the National Highway, Palakkad to Coimbatore passes through the valley. This sector has high rail and road traffic almost 24 hours a day. The lighted cigarettes and splinters thrown by rail and road users as well as graziers pose big threat to the forests of this valley, particularly during the summer months, when the trees shed leaves and lot of dried leaves accumulate on the ground and during the drying stages of shrubs and annuals. The fire incidences recorded in Walayar Forest Range (Kerala) during 2012-2015 are given in Table-5.

Table 5. Fire incidences in Walayar Forest Range (Kerala) during 2012-2015

S. No.	Date	Location	Approx. Area (ha)
Fire incidence data: 2012-13			
1	6.1.2013	Elichiram, Mottamala	-
2	8.1.2013	Kunnathukadu, Akathethara Section	-
3	12.1.2013	Dhoni Vested Forests	-
4	16.1.2013	1963 Teak Plantation, Walayar Section	-
5	24.1.2013	Karadikunnu, Walayar Section	-
6	24.1.2013	Pannikamba, Pudussery North Section	-
7	3.2.2013	Azhagampara, Akathethara Section	-
8	12.2.2013	Nellisery Malavaram, Pudussery South Section	-
Fire incidence data : 2013-14			
1	15.2.2014	Kattadikunnu, Pudussery North	-
Fire incidence data: 2014-15			
1	11.2.2015	1977 Teak Plantation, Varali beat, Walayar Section	2.00
2	15.2.2015	Palakambam, Walayar Section	3.00
3	16.2.2015	Pudussery North Section	0.80
4	22.2.2015	Nadupathy	2.00
5	8.2.2015	Akathethara Section	5.00
6	24.2.2015	Pudussery South Section	1.60
7	23.2.2015	Kottamutty, Pudussery South Section	3.00
8	21.2.2015	Ayyappan Mala, Pudussery South Section	5.00
9	23.2.2015	Uruttupara, Walayar Section	3.00
10	22.2.2015	Kottamputty, Vellaramkunnu, Pudussery North Section	5.00
11	23.2.2015	Mozhamanda, Vadassery Malavaram, Pudussery North Section	3.00
12	28.2.2015	Poolambara beat, Near IFGTB lease area	1.60
Total			35.00

Details of fire incidences recorded in Tamil Nadu part of Walayar Valley during 2012-13 and 2013-14 are shown in Table-6 and Table-7 respectively.

Table 6. Details of fire incidences in Tamil Nadu part of Walayar Valley during 2012-13

S. No.	Date	RF	Location	Beat	Section	Area affected (ha)
1	29.01.2012	Bolampatti Block I	Ulagambikai	Ettimadai	Karadimadai	0.10
2	20.02.2012	Bolampatti Block I	Ettimadai	Ettimadai	Karadimadai	2.00
3	16.03.2012	Bolampatti Block I	Karadimadai	Karadimadai	Karadimadai	1.00
4	18.03.2012	Bolampatti Block I	Namakkarpalai	Ettimadai	Karadimadai	5.00
5	20.03.2012	Bolampatti Block I	Ulagambikai	Ettimadai	Karadimadai	5.00
6	24.03.2012	Bolampatti Block I	Kadapalai Kandi	Koochimalai West	Navakarai	3.00
7	26.03.2012	Bolampatti Block I	Ayyamalai	Modamathi	Karadimadai	9.00
8	13.01.2013	Bolampatti Block I	Chinna Reserve	Solakkarai	Navakarai	2.60
9	23.01.2013	Bolampatti Block I	Chinna Reserve	Solakkarai	Navakarai	0.28
					Total	27.98

Table 7. Details of fire incidence in Tamil Nadu part of Walayar Valley during 2013-14

S. No.	Date	RF	Location	Beat	Section	Area affected (ha)
1	03.02.2014	Bolampatti Block I	Malaynkinaru	Ettimadai	Karadimadai	0.934
2	06.02.2014	Bolampatti Block I	Perumalkoil	Karadimadai	Karadimadai	0.438
3	09.02.2014	Bolampatti Block I	Namakkalparai	Ettimadai	Karadimadai	3.898
4	16.03.2014	Bolampatti Block I	Kulla nuthu, Killi kanuvai	Karadimadai	Karadimadai	0.356
5	21.03.2014	Bolampatti Block I	Manal Pallam	Solakarai	Navakarai	3.100
6	24.03.2014	Bolampatti Block I	Amman Padukai	Koochimalai West	Navakarai	0.041
7	30.03.2014	Bolampatti Block I	Thadikaran koil	Karadimadai	Karadimadai	3.230
					Total	11.997

The records show that on an average, about 25 ha of forest areas are destroyed by fire annually in Walayar Valley.

Analysis of threat factors have shown that the Kerala part of Walayar Valley is encountering more threat (Grand Index Value: 72), compared to Tamil Nadu part (Grand Index Value: 57), when the four major factors were taken into consideration (Table-8). The maximum theoretically possible Grand Index Value estimated in the present case is 90 (i.e. $9 \times 3 + 8 \times 3 + 7 \times 3 + 6 \times 3$), when all the four threat factors identified are at “high” level.

Table 8. Threat factor analysis

S. No.	Threat factor	Importance Value	Impact Value	
			Walayar Valley (Kerala part)	Walayar Valley (TN part)
1	Forest fire (area affected)	9	9	9
2	Raising of monoculture forest plantations	8	24	16
3	Degradation of forests/ formation of scrub	7	21	14
4	Expansion of areas under mining	6	18	18
Grand Index Value			72	57

DISCUSSION

Sasidharan *et al.* (2020) reported the presence of four butterfly species viz. *Troides minos* Cramer (Southern birdwing), *Curetis siva* Evans (Shivas sunbeam), *Idea malabarica* Moore, (Malabar tree nymph), *Kallima horsfieldii* Kollar (South Indian blue oakleaf) endemic to the Western Ghats and another two species like *Cirrochroa thais* Fabricius (Tamil yeoman) and *Mycalasis patina* Moore (Gladeye bush brown) endemic to the Western Ghats / Sri Lanka from Walayar Valley, which shows the biodiversity richness of the area. They have also recorded a total number of 10 butterfly species falling under Schedule-I viz. *Hypolimnys misippus* Linnaeus (Danaid eggfly) and *Pachliopta hector* Linnaeus (Crimson rose); under Schedule-II like *Euthalia aconthea* Cramer (Common baron), *Tanaecia lepidea* Butler (Grey count),

Appias albina Boisduval (Common albatross), *Appias lyncida* Cramer (Chocolate albatross), *Cepora nadina* Lucas (Lesser gull), *Pareronia valeria* Cramer (Common wanderer) and *Euchrysops cnejus* Fabricius (Gram blue) as well as under Schedule-IV namely *Appias libythea* Fabricius (Striped albatross) of the Indian Wildlife (Protection) Act, 1972, which further add to the conservation importance of the area.

In most of the landscapes in India, two factors caused by human beings influence the species diversity and composition of flora and fauna. These are grazing by domestic cattle, and fires. Grazing alters grass and herb species composition in grasslands (Rodgers, 1986). According to Anderson (1982) grazing causes replacement of palatable plant species with weedy, non-palatable invaders. In this way the diversity of larval host plants of many species of butterflies are lost. Although grazing of cattle is not officially permitted, the forests of Walayar Valley are not free from grazing. During the process of grazing, it destroys the larval and nectar host plants of butterflies apart from trampling the natural regenerations coming up in the area.

The fire results in destruction to the undergrowths which are serving as larval and nectar host plants of butterflies. The gaps formed in the forests due to fire were colonized by many secondary species and weeds, leading to changes in the vegetation structure. In an area with moderate rainfall and frequent fires, tall grasses dominate the ground vegetation (Evans *et al.* 1989). Naturally, the floral diversity is adversely affected in this process. Fire also destroys the roosting sites of butterflies. Lot of eggs, larvae and pupae of butterflies are killed during the forest fire. Kunte (1997) observed that fire played a significant role in determining species composition of butterflies in fire-afflicted areas and affected flight periods of some species, but did not affect species richness. He also pointed out that in ecologically isolated regions where fires are extensive and the area burning in fires is large, the effects of fire on the populations of species with poor dispersal abilities could be drastic. Mathew *et al.* (1998) found that at four locations in the Western Ghats of Kerala, the fire spreading from grasslands to adjacent evergreen forests was affecting its delicate ecosystem, leading to disappearance of many evergreen species and the associated insect fauna, including the butterflies.

A comparative study of the species richness between disturbed mine lease area and undisturbed forest area made in Bellary district of Karnataka has shown that there is marked difference in species richness of butterflies in these two habitats. In disturbed areas 23 butterfly species were recorded in Bellary, 46 species in Sandur and 17 species in Hospet; whereas in undisturbed forest areas 33 butterfly species were enumerated from Bellary, 66 species from Sandur and 37 species from Hospet. Further, it was noticed that loss in vegetation cover, habitat degradation and proliferation of weeds due to mine related disturbance and consequent change in floral diversity and species composition had significant impact on the butterflies. Impact of mining on agriculture habitat due to deposition of dust emission is also predicted to have impact on butterflies, which is the fauna of agro-ecosystems also (ICFRE, 2011). The dust particles released by mining and industrial activities settle on the surrounding forest vegetation in Walayar Valley. Therefore, the dust pollution poses a severe threat to the vegetation as well as butterfly fauna of this valley.

Many tree plantations have been traditionally labelled as “green deserts” and are presumed or found to be hostile to native species and largely devoid of wildlife (Kanowski *et al.* 2005; Sodhi *et al.* 2009). But there are also examples of plantation systems that are providing habitats for some threatened taxa (Hartley, 2002; Carnus *et al.* 2006). The butterflies which are occurring in the moist deciduous and dry deciduous forests of Walayar Valley are found to frequent the Teak plantations with good undergrowth of small trees, herbaceous, shrubby and climber species and hence such forest plantations also provide habitats for several

butterfly species. Sasidharan *et al.* (2020) recorded 82 percent of butterfly species occurring in moist deciduous forests of Walayar Valley from the adjoining Teak plantations. Adjaloo *et al.* (2012) found that the monoculture plantations of Cocoa in Ghana that maintain similar microclimate to that of the adjoining natural forests could provide abundance and diversity of food, nesting sites and hiding places for resident insects, including butterflies. However, exotic monoculture plantations have been reported to be highly dissimilar with natural forests in terms of structure and composition and therefore less beneficial for biodiversity conservation (Anand *et al.* 2010).

Much of the areas of the Western Ghats are at present a mosaic of forests and human impacted landscapes which include various monoculture plantations. Many of these areas have the potential to play a vital role in the long term persistence of biological diversity (Oommen, 2011). Nayak *et al.* (2004) did an analysis on commonness and rarity of butterfly species in various parts of the Western Ghats which showed that the rare butterflies were recorded only in natural habitats. They also observed that the presence of natural habitats in the heterogeneous matrix influenced the species encountered in modified habitats. Even though the monoculture plantations are not at all comparable with the natural forest ecosystems, such modified landscapes existing in the midst of natural forests also should form part of the local Biodiversity Management Plan, since they also can shelter some amount of biodiversity. Kumar *et al.* (2008) identified major threat factors on biodiversity like fodder collection, fuel wood collection, pole collection, cattle grazing, fire, weed invasion, forest discontinuity and road accessibility in Nelliampathy Forest Region of the Southern Western Ghats. Most of these threat factors are common to different parts of the Western Ghats and as such they are relevant to the present study also.

CONCLUSION

The landscapes and ecosystems are being modified in various ways to meet ever increasing human needs. In most of the tropical countries, development has taken place at the cost of ecosystems, so much so that there are only a few places left without any anthropogenic disturbance. The biotic impacts of many types of disturbances might not be completely irreversible. Therefore, partially modified landscapes, as in the case of Walayar Valley are important and valuable assets for biodiversity conservation and should not be overlooked or abandoned, so that the disturbances are not further escalated and the remaining biodiversity is conserved.

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