



Assessment of deforestation and forest degradation in Sri Lanka: Application of the DPSIR framework.

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Abstract—Globally, forests provide habitat for a wide variety of species on earth and play a significant role in helping control global warming by sinking CO₂. However, the world is facing a dual problem of deforestation and forest degradation, which are depleting forest biodiversity and ecosystem services everywhere and eventually leading to forest cover loss. Sri Lanka's Forest cover, a developing country in the South Asian region, has been changing rapidly for two decades. Sri Lanka needs a detailed DPSIR framework with contemporary data and robust analytical descriptions to understand the changing patterns of forest coverage and address the underlying factors affecting them. Hence, this study analyzed the key causes of deforestation and forest degradation in Sri Lanka according to drivers, pressures, state, and impact between 2000 and 2020. Through this study, we have recommended suitable and realistic responses for Sri Lanka to minimize deforestation and forest degradation.

Keywords—forest degradation, deforestation, DPSIR framework, tree coverage, Sri Lanka

I. INTRODUCTION

Forests are multiple resources that provide a variety of goods and services. The economy of a forest country plays multiple roles in the environment and culture, and they are essential for maintaining life strategies and ecosystem services. Forests are essential to the global carbon cycle and majorly impact local, regional, and global climate.

Deforestation is the conversion of another type of land use, which is often the result of human activity. Deforestation leads decreasing forest coverage and the loss of biodiversity and ecosystem services. Although there are many definitions of forest degradation, the general point that all definitions generally agree on is that forest degradation is considered an adverse environmental process. Forest degradation is a process leading to 'temporary statistically representative data on land-cover change or permanent deterioration in the density, structure of vegetation cover or species composition[1]. Forest degradation does not necessarily reduce forest coverage but rather reduces the quality of forests through such factors as changes in habitat parameters, canopy opening, etc.

Although deforestation and forest degradation have similar consequences, the human impact on the forest is different. Nonetheless, nowadays, they have become a global environmental problem similar to the struggle of humanity without a clear solution. Admittedly, this is ubiquitous worldwide; in 2010, more than 30% of the world's land area

was covered by trees. According to this Earth had 3.92Gha of tree cover in its land area [1]. In 2020, 25.8Mha of those trees lost their cover [1]. Global deforestation and forest degradation have become key subjects in recent years due to rising deforestation in various parts of the world, especially in developing countries in the South Asian region. Deforestation and forest degradation seem to be on the rise in Sri Lanka due to factors such as agriculture expansion, industrialization, urbanization, population growth, large-scale timber extraction, climate change like natural hazards and forest fires, as well as a lack of political stability and the non-implementation of laws and regulations.

Deforestation and forest degradation pose a threat to Sri Lanka's natural forests. According to the Global Forest Watch, in 2010, Sri Lanka had 3.5Mha of natural forests and more than 54% of its land area. However, by 2020, there was a loss of 11.2Kha of natural forests and the resulting CO₂ of emissions is equivalent to 4.4 million [2]. Therefore, 69.3Mt of CO₂e has been emitted in these two decades [2]. Sri Lanka's top seven regions were responsible for 53% of deforestation and forest degradation between 2001 and 2020 [1]. The highest tree cover loss in the Anuradhapura area during this period was 29.9kha [1]. Also, among the top seven regions listed responsible for the removal of tree coverage in Sri Lanka are 15.7kha from Kurunegala, 14.5kha from Moneragala, 12.5kha from Vavuniya, 9.56kha from Kegalle and 9.36kha from Mullativu and 8.76kha from Puttalam [1]. There is a need to find and address the direct causes of deforestation and forest degradation in Sri Lanka. Hence, the main objective of this review is to analyze the causes of deforestation and forest degradation in Sri Lanka that it is currently facing and to evaluate the effects of Drivers, Pressures, State, Impact, and Response (DPSIR) and understand how to strengthen it. There is a shortage of DPSIR literature on the causes of deforestation and forest degradation in Sri Lanka.

Thus, the main purpose of this study is to explain the relationship between the origin, or root cause, and consequences of deforestation and forest degradation in Sri Lanka and to understand the dynamics underlying the problem, focus on the relationships among the elements of the DPSIR framework, and explore the leverage points where appropriate responses can be exerted. Here, the DPSIR framework has been selected for the purpose of a practical assessment of deforestation and forest degradation. According to the map of Sri Lanka, researchers are looking for factors



that have led to the decline of natural forest coverage from the last decade to the present.

II. METHODOLOGY

A. Study Area

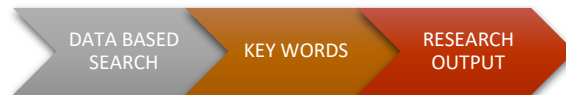
Sri Lanka, also known as Ceylon is a developing country located in South Asia between GPS coordinate 7.8731° N, 80.7718° E. Although Sri Lanka is a relatively small island, it is a country full of biological diversity [1] [2]. As Sri Lanka is an island close to the equator in terms of climate, it is generally tropical and warm, with temperatures between 28 Celsius – 30 Celsius. However, the mean annual rainfall differs from above 900mm to above 5000mm on the southern-eastern, northwestern and western slopes of the central lands, respectively [2].

The total area of Sri Lanka is 65610 sq km, of which 29% or 120644 sq km is forest cover [3]. From this, 8.6% is primary forests cover. Sri Lanka's forest cover decreased by 188kha (4.8%) between 2001 and 2020. Fig.1 is a map that depicts how the tree coverage of Sri Lanka changes over time between 2001 to 2020 [3].

The rate of deforestation during the previous 20 years is depicted in Fig. 2 below. The dry zone of the country is more impacted by this problem than the wet zone. This study was done to determine the reasons for Sri Lanka's deforestation and forest degradation [4].

B. Data Sources

The study was carried out with the literature part based on the DPSIR assessment combined with the driving key factors of deforestation. Web-based resources like Google, Google Scholar, and Science Direct have been used for the literature search of scientific reviews. The focus of the research on deforestation in Sri Lanka in the recent decade has been considered openly, and journals, articles, and research articles have followed. Basic keywords that were used for finding the proper sources were “FORESTS “, “DEFORESTATION “, “SRI LANKA “, “FOREST DEGRADATION”, “IMPACTS”. According to the DPSIR applications. Fig. 3 demonstrates the process of finding resources with the keywords.



- Google
- Google scholar
- Deforestation and Forest degradation Sri Lanka.
- DPSIR application on deforestation.
- Lit for deforestation with drivers, pressure, state, impact, response

Fig. 3. Process of data gathering

C. DPSIR Framework

Drivers, Pressure, State, Impact, and Response – DPSIR is a framework that has organized and analyzed the importance and interconnection between humans and the environment. The "Organization for Economic Cooperation and Development" developed this in 1993, and the "European Environmental Agency" established it in 1999 [1]. There are various indicators, and we undertake data analysis based on the five elements. This aids in identifying the issues related to each element, applying for the responses, and demonstrating the consequences of each problem as well. According to the analysis of the relationship between the elements, driving forces cause the pressure to occur and change the state. Due to the change in state, there will be impacts on those responses back to the drivers. For instant, human activities that occur create needs economically and socially that pressure the environment. This entails altering environmental conditions that affect the ecosystem, such as global warming, resource scarcity, and climate change. The impact generates due to the above consequences leads the way to respond to the feedback of the human activities with the consequences. There are a few advantages and disadvantages connected to the DPSIR framework. This is a simple way that demonstrates the connection between human beings and the environment and also helps to get an idea among the researcher and stakeholders, etc., but “the DPSIR framework is built for ex-post assessment, and it is not so plain for ex-ante assessment as state and impact indicators are generally based on measured data,” as an advantage of the DPSIR.



Fig. 1. Map showing the tree cover change in Sri Lanka. [1]

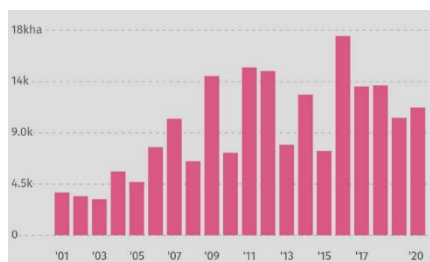


Fig. 2. The way of change in Sri Lanka's forest cover between 2000 and 2020 [1]

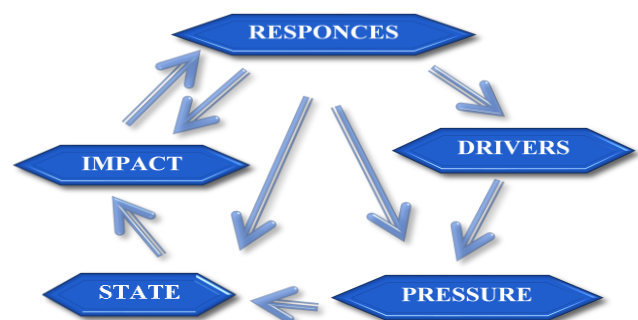


Fig. 4. Schematic outline of DPSIR Framework.

III. RESULTS AND DISCUSSION

The DPSIR Framework with secondary data was used to provide information on the underlying causes and effects of the deforestation and forest degradation of Sri Lanka.

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A. Drivers for the Deforestation and Forest Degradation

The drivers of deforestation have changed over time, but they have influenced the current drivers. Significant underlying past drivers were foreign and local export demand for timber, global demand for plantation crops, and development of irrigation and landless and poverty [1]. Current drivers can be classified as follows.

1) Agricultural expansion

The expansion of agricultural capability in Sri Lanka has become a major reason for deforestation. Commercial agricultural projects have cleared existing forest areas for their cultivation [3]. The shifting cultivation or Chena cultivation has become an attributing factor for deforestation in pre-modern times and continues in some areas. Now the typical Chena cultivation where the cultivation occurs in rain-fed highland landscapes has been modified. Now there is continuous, intensive commercial cultivation of a few crops rather than the cultivation of diverse crops over a long period. So for this forests are cleared to take the lands for cultivation mainly for commercial purposes [1].

2) Overgrowing Population.

With a growth rate of 0.6%, the Sri Lankan population is increasing annually, which has direct implications for deforestation. Urban population growth has substantially increased compared to rural population growth in Sri Lanka. It has increased from 18.585 per 100 population to 18.713 per 100 population from 2019 to 2020 [3]. As a result, people's demands have increased over time as urban people need more forest products for their resources, such as timber, food products, and also land. The land is constant but when there is increasing population people need more land for their residential and other purposes. Then they clear forests to take up space. In concurrence, the increasing rural population will take up more land in forest areas for residential and commercial farming purposes which again causes deforestation. Fig 5 reveals that the yearly rising population has directly reduced the forest cover in Sri Lanka [1].

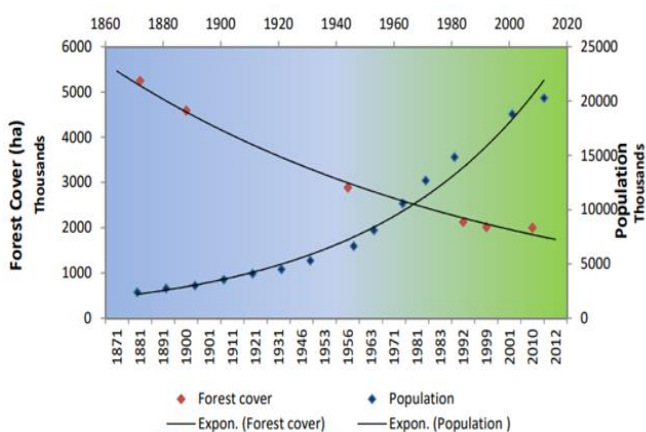


Fig. 5. Population growth and forest cover change in Sri Lanka [3]

3) Economic and social development.

Compared to the pre-independence era, in the current, there is progressively increasing socioeconomic development in the country. Increased industrial economics, as well as the

emergence of new technologies and new industries, have directly affected the forest state of the country, as some industries are based on forest products and others need land from the forest to develop their industries. Especially after the conclusion of the war in 2009 government has planned several urban development projects, irrigation plans and also resettling war zone people which subsequently affected the quality of the forest [1].

4) Political instability and policy issues

Political influences at all levels of the country have become a leading cause of the deforestation of Sri Lanka. According to press reports and public complaints about politicians and their friends engaging in illegal forest extraction for personal gain, politicians' general power over land and forest issues appears to promote groups that are opposed to the conservation of the country's forest resources. In the highly charged, competitive political structure of the country, these impacts appear to be motivated more by competitiveness for political advantages than by economic gains [1]. A good example of this is the issue of the illegal construction of housing schemes inside Wilpattu.

5) Drawbacks in legal processes.

According to Forest Department (FD) authorities, a fundamental issue that facilitates encroachment is the lack of adequate evidence about forest ownership. The FD, or Department of Wildlife Conservation (DWC), owns the vast bulk of existing forests. Although FD and DWC are the "owners," even their officials are unsure of the exact boundaries and extent of some forested regions. The situation is exacerbated in cases where forest areas have lately been transferred from the previous authority of district secretaries to the FD. Encroachers have always taken advantage of the confusion that has resulted as a result of this [4].

FD has launched court actions against encroachers of 12,385 hectares of encroached forest lands in the last 25 years, according to administrative reports. However, due to lengthy delays in court proceedings, the forest cover in the encroached regions has continued to deteriorate. One of the major issues for the FD is the absence of survey plans to demonstrate the foe's exact limits [4].

6) Forest offences.

Forest offences contribute to forest degradation. Some of these offences include illegal felling, illicit timber transport, illegal extraction of non-timber forest products such as medicinal plants, and the spread of invasive species [4]. Due to increased economic development in the country and increased demands from the rising population, the usage of timber as a fuel for their daily work as well as for commercial purposes has increased. So they try to take this timber in illegal ways by cutting down the forests without permission from the authorities.

7) Forest fires

The peak fire season usually starts in late July and lasts for 14 weeks in Sri Lanka. The year with the most fires was 2005 when 90 Kha were burned. Over the past two years, Sri Lanka has received 6589 fire alerts [1]. When fires are occurring in remote areas, there is a tendency for authorities not to pay necessary attention to them, and subsequently, they spread to



a larger area. However, this tendency is not seen in urban areas [4]. The main reason for this may be that in urban areas there are more people employed for the management of fires, and there are also evaluation procedures to check whether authorities are working responsibly.

B. Pressures for the Deforestation and Forest Degradation.

1) Encroachments.

The main reason for encroachment is agricultural expansion. An evolved form of Chena where maize, pulses, and vegetables are mainly cultivated is an important attribution to this agricultural expansion. This predominantly takes place in Anuradhapura, Moneragala, and Hambantota districts. In Kaluthara and Rathnapura areas; the wet zones are mainly used to cultivate tea, rubber and cinnamon [1].

2) Residential settlements.

In addition to this, due to an overgrowing urban population, people use forests for residential settlements, which can be connected with agricultural purposes as well. There are instances of using forests for gem mining mainly in Rathnapura and Kandy districts and also for shrimp farms in Kalpitiya, Chilaw and Puttalam [4].

3) Infrastructure development projects.

Infrastructure development due to the increasing population and increasing needs of the population has significantly affected the deforestation process in Sri Lanka. There are many projects, such as irrigation development, major and minor hydropower projects, road development, tourism, airports, and harbours, that are contributing to this deforestation. It has been mentioned that these applications for the release of the lands come with very short notices leading to communication and administrative failures to take necessary compensations for that [1]. Deforestation is directly impacted by the construction of highways along forest boundaries and the expansion of these highways. The recent 2020 construction of a road through the nationally significant Sinharaja Forest from Lankagama to Duniya is an excellent illustration of that [6].

4) Urbanization

As a result of the developing socio-economic status of the country, urbanization is an irreplaceable process. So urbanization needs more land for developing new buildings and other projects as well as for the modification of rural areas. So this has a greater impact on the rural areas' forests, which leads to deforestation or forest degradation.

5) Private agricultural ventures.

Large-scale banana and sugar cane plantations in various places have been a consequence of agricultural expansion. The land over 36000ha has been given for developmental projects of which 47% (17273ha) has come under private agricultural ventures [4].

6) Grazing areas.

Largely, forests have been converted to grazing areas, mainly for cattle grazing. This has become a huge problem in Pattipola and Nuwara Eliya areas.

C. State of the Deforestation and Forest Degradation.

The above pressures are directly affecting the state of the forest. The biodiversity of the forest is at risk as a result of these effects, and continuous harm has also been done. So the

forest's resources, its flora and fauna, and the natural habitat for the animals get depleted, which leads to a reduction in forest quality. And also damage and pollute natural water and river bodies. There is a reduction in forest cover annually due to these human activities. Table 1 shows that 60% of the forest cover loss is from dense forest class in 2017 [1] [4].

D. Impact from the Deforestation and Forest Degradation.

Hence, over time, forest quality will be reduced. The natural habitats for animals and birds will be destroyed, and the ecosystem of the forests will be destroyed soon. The forest remains stagnant, and there is no regrowth as a result of the disturbance in the forest ecology. As a result, the forest is gradually turning into shrubland. Sri Lanka has some 751 known species of amphibians, birds, mammals, and reptiles, according to figures from the World Conservation Monitoring Centre. Of these, 21.7% are endemic, meaning they exist in no other country, and 11.9% are threatened. Sri Lanka is home to at least 3314 species of vascular plants, of which 26.9% are endemic. 9.6% of Sri Lanka is protected under IUCN categories I-V [4] [1]. But with deforestation and forest degradation, biodiversity is now in danger.

Deforestation has direct implications for human health as well. Because deforestation directly affects temperature, which aids mosquito breeding, it can act as an incubator for vector-borne diseases and also increase the spread of life-threatening malaria and dengue fever [4].

Increased CO_2 emissions due to deforestation have caused global warming around the world. Therefore the fluctuating high temperatures also affect the way it rains. This in turn creates a vicious cycle where, due to inadequate rain flow, the biodiversity of the forest will again be negatively affected. CO_2 emission has increased over the years with slight fluctuations. Due to the loss of forest cover in Sri Lanka, the emission of CO_2 was an average of 3.47 million tonnes per year into the atmosphere between 2001 and 2020 [1].

TABLE I. FOREST COVER LOSS IN DIFFERENT FOREST CLASSES IN 2017

Forest Class	Map areas	Bias corrected areas	%
Densen Forest	14,862	51,381	60
Sparse Forest	8,522	29,462	35
Forest Plantations	1,177	4,068	5
Mangroves	10	36	0
Total	24,571	84,947	100

As forests act as watershed areas, the reduction of forest cover leads to the reduction of water resources, which then causes the loss of valuable aquatic life. There will be more natural disasters like floods and landslides, which will cause many issues for human life. There are ongoing wildlife-human conflicts, such as elephants and leopards coming to villages and damaging human lives and habitats, which is a consequence of deforestation and forest degradation. Between 2010 and 2019, there were over 14,500 occurrences of human-elephant conflict, with 42 leopard deaths linked to snare-related injuries [5].



E. Responses for the Deforestation and Forest Degradation.

Several measures can be implemented to mitigate the negative effects of deforestation. Several rules, regulations, and laws have been implemented by the ministry of wildlife and forest conservation to preserve the forests. Implementing forest conversion management plans and laws and regulations for fauna and flora protection are some of the instances. Examining current forest regulations and protected area management techniques concerning infrastructure development projects, encroachments, and localized forest degradation drivers and taking necessary amendments to improve the poor areas in policies is another strategy that can be used.

The government can organize several deforestation awareness programs in various areas to raise public awareness of the negative consequences of deforestation. Conservationists and environmental NGOs have a major role to play in this matter. Environmental education should be incorporated into secondary and tertiary education, and more undergraduate and postgraduate subjects should be created in environmental-related fields.

Off-farm work options are rationally thought to be a deforestation inhibitor. Such changes may present themselves in both deforested and non-deforested locations. Projects based on reforestation should be considered. Taking necessary steps for the people who go against the laws and regulations is also a must to prevent future forest offences.

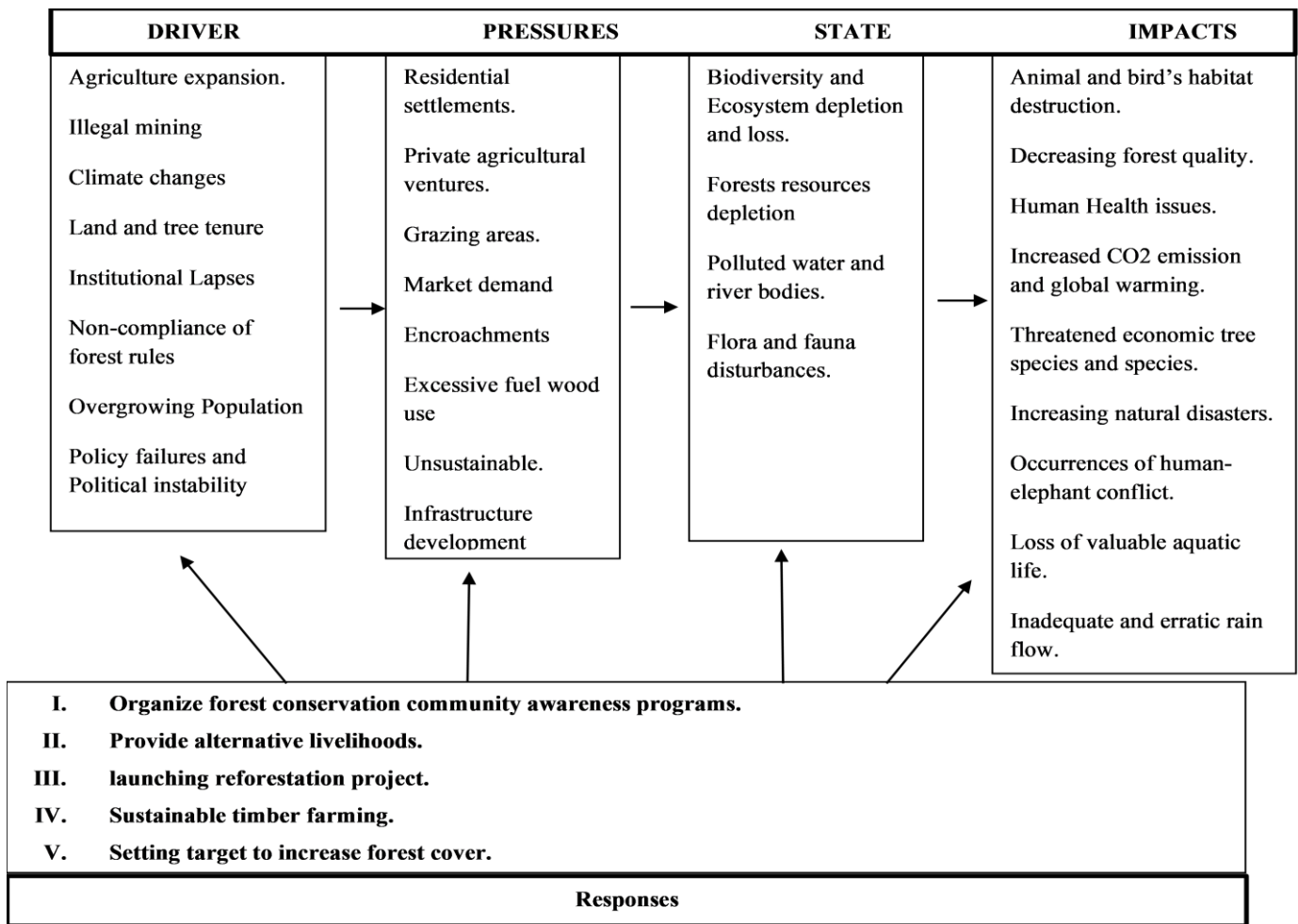


Fig. 6. DPSIR framework interconnection with the five elements.

Encouraging and developing more opportunities for sustainable timber farming is another strategy for inhibiting ongoing deforestation. For a better future for forests, developing and strengthening the environmental impact assessment (EIA) of the Central Environmental Authority (CEA) and the strategic environmental assessment (SEA) should be made a requirement for all sectorial, inter-sectorial, and large-scale development projects. Developing home gardens is an effective inhibitor of deforestation, and taking the required steps to promote them through community involvement programs and collaboration with current livelihood development programs is should be considered [4].

IV. CONCLUSION.

This is a study report on deforestation and forest degradation in Sri Lanka. To this end, a large number of data sources were taken from Google Scholar, and analysis was performed. For this purpose, data on deforestation and forest degradation in Sri Lanka has been used in various ways. That is to say, we have contributed a lot to the study of indicators of deforestation, the study of research and review articles on this subject, and the use of legal website data, blogs, and other e-documents. The benefits of forests to Sri Lanka, as well as the world, are mentioned here. It also describes how forests

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affect key criteria for the survival of living things, such as the carbon cycle. Additionally, it defines what deforestation is.

Furthermore, it discusses how deforestation harms both Sri Lanka and the entire globe. The declining forest coverage in Sri Lanka over the past few decades is noted here. The DPSIR framework with secondary data has been used to make practical assessments of deforestation and provide information on the underlying causes and effects. The various drivers that affect deforestation are listed here. Agriculture expansion, population growth, forest offences, and forest fires are currently the key drivers contributing to forest degradation and deforestation. Here is a detailed explanation of the key drivers of deforestation and forest degradation. Also listed are the pressures that contribute to deforestation. These are encroachments, residential settlements, infrastructure development projects, private agricultural ventures, and grazing areas. The results of this study paper describe how those pressures mostly affected each region in Sri Lanka separately. In addition, there are examples of destruction done for political gain. The depletion of different types of forests, such as dense forests, sparse forests, forest plantations, and mangroves, is clearly shown here through a table.

The major impacts of Sri Lanka's deforestation are listed here. In addition to the loss of natural habitats, declining bird populations, and landslides, this issue has also affected the unique problems faced by the people of Sri Lanka, such as elephant poaching. Increased carbon dioxide emissions, as mentioned here, are a problem affecting global climate change. The important factor in studying this review paper is that it gives an understanding of the response to the problem of deforestation and forest degradation, which is a major social and environmental problem that has been happening in Sri Lanka for two decades. Conducting community involvement programs to promote sustainable forest use along with the development and implementation of policies against

deforestation by the government have been drawn as the main responses here. The above fig.6 summarizes the assessment of Drives, Pressures, States, Impacts, and Responses in relation to deforestation and forest degradation in Sri Lanka from 2000 to 2020.

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