Chapter 4
Investigating the impact of Human Population and Population Pressure on Forest Biomass Dynamics Using Delay Differential Equations

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ABSTRACT

The ever-increasing human population has posed a significant risk to forest biomass density. Humans are less conscious of the value and relevance of forest biomass. As consequently, they chopped down the woods for a variety of reasons, including agricultural demands, industrial and economic expansion, and so on. This work proposes a non-linear mathematical model to investigate this lack of awareness among humans and its negative impact on forest biomass. The findings of this study demonstrate that forest density decreases as human population and population pressure grow. On the contrary, as human understanding of the necessity and justifiable value of forest biomass grows, the rate of deforestation slows. As forests supply oxygen for all living humans, this will result in good health and well-being (SDG-3) for both humans and forest biomass, as well as a clean environment (SDG-13). MATLAB simulation provides strong support for the numerical findings.

INTRODUCTION

The forests are one of the paramount mundane ecosystems out of the four major ecosystems of earth. Additionally, it is described as terrain that is greater than 0.5 hectares in size and has trees that are at least 5 metres tall with a canopy cover of at least 10%, or trees that can meet these criteria. The portion

DOI: 10.4018/979-8-3693-2655-8.ch004

of the land which is mainly is used for urban and agricultural practices is not included in this (Lata & Misra, 2017).

As a matter of fact, the forests serve as both a habitat for a variety of wildlife species and a contributor to the world cycling of water, oxygen, carbon, and nitrogen. It provides numerous advantages to humans, including fuel, water storage, recreational space, industrial raw material, etc. A 2010 FAO report states that human activity is causing 4 million hectares of forest area to disappear annually. Thus, improving forest resources while meeting the increasing demand for their products is a difficult issue that all communities must deal with (Fekadu, 2015). Raising subsistence needs and expanding rural populations have forced farmers to cultivate on more marginal soils and decrease their times of fallow, which has resulted in erosion and a loss of soil fertility (Morie, 2007). It is believed that as the human population grows, the forest resources would be reduced because humans rely on forests for daily requirements including food, fuel, medicinal plants, fodder, etc (Dubey et al., 2009; Misra, 2015).

Many models have been proposed recently to study and measure the depletion of forestry resources. The primary function of all these models is to calculate the amount of forest biomass resulting from population density and demand in the forestry environment. The relationships between forestry biomass, wildlife population, human population, population pressure, industrialization pressure, and alternative conservation have all been taken into consideration.

A mathematical model is proposed to explain how population pressure, industrialization, and human population growth are causing forestry biomass to decline. It is discovered that the biomass density of forestry resources falls when industrialization causes more congestion. Therefore, to maintain the stability of the forestry resources, industrialization must be controlled (Ahmed, 2013). In order to reduce population pressure, a conservation model is also put out that would give people financial incentives, the size of which is supposed to be proportionate to the level of population pressure (Misra et al., 2014). The population's demand, or population pressure, rises with population growth. In order to meet this demand from the population, forestry resources are overused by the people, clearing forest area and increasing agricultural land, which eventually results in deforestation (Patra, 2013). Kumar and Dipesh studied the toxic and allelopathic effect in competing plant population using delay differential equations (Dipesh & Kumar, 2023; Dipesh & Kumar, 2023; Dipesh, 2022; Dipesh, 2022)]]. Mishra and Lata worked on conservation of forest biomass using technological efforts (Misra & Lata, 2013). Fanuel et al. worked depletion of forest biomass and forest biomass dependence on wildlife population using fuzzy non-linear mathematical modeling (Fanuel et al., 2023). Gao et al. studied the numerical method for analysing the finical system (Gao, 2023). Shukla et al. observed the influence of reduced nutrient-rich topsoil quality according to natural factors such as corrosive weather and rainfall on agricultural yield is examined via the perspective of a single economic development model (Shukla, 1996). Liu et al. investigating how human activities affect the temporal and geographical distribution of forest biomass carbon (FBC) stock and density across Chin, and observed 44.2%-54.6% of the FBC stock was concentrated in four provinces (Heilongjiang, Yunnan, Inner Mongolia, and Sichuan). Furthermore, FBC density increased from heavily inhabited southern provinces to less densely populated northeastern and western areas (Liu et al., 2017). Coulston et al. examined the Investigate changes in carbon cycles in the ecosystems in the southern United States to determine the variables that lead to these changes, such as land use, management practices, and disasters (Coulston, 2015). Peres et al. studied on the Braziline amazon to examine the changes in surface forest biomass as a result of several scenarios of large-fruited animal extinction induced by hunting (Peres et al., 2016). Baud et al. examined the level of organic matter (as assessed by loss-on-ignition, LOI) in modifying possibly exaggerated recent SAR (sediment accumulation rate)