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A STUDY ON THE TEMPORAL DYNAMICS OF VEGETATION COVER IN ENUGU STATE, NIGERIA

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ABSTRACT

The study focused on the effects of human activities on vegetation dynamics in Enugu State, Nigeria using five land cover classes: forest, green areas, bare land, water body and built up area. Geographic Information System (GIS) was employed for the study. The vegetation maps of Enugu State for years 2000, 2010 and 2020 was generated using Landsat TM at 1000m resolution. Results generated were subjected to Normalized Difference Vegetation Index (NDVI) and the rate of deforestation was calculated using the FAO formula. From the results for year 2000, the percentage change of forest recorded 80.38% of the total land, green areas constituted 10.87%, bare land constituted 6.87% while water body and built-up area accounted for 1.78 and 0.09% respectively, and was in decreasing order; Forest > green areas > bare land > water bodies > built-up, with forest as dominance. In 2010, the percentage change in forest cover constituted 47.25% and 37.33% in 2020, with 2010 > 2020. Result showed that average of 87.22% of the respondents indicated human activities as the major causes of deforestation, with the rate of deforestation constituting 4.2%. Therefore, environmental education becomes a panacea in maintaining a good relationship between man and nature, hence sustainable forest management for man and his environment.

KEY WORDS: Deforestation; Urbanization; Environmental education; Sustainable forest management; Land use cover; Enugu

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INTRODUCTION

Forest is an essential, important and valuable component of the ecosystem that supports sustainable agriculture; stabilize soils and climate. It regulates water flows, gives shade and shelter, and provides a habitat for pollinators and the natural predators for agricultural pest. Forest has been and is contributing to the food security and income for hundreds of millions of people, especially in developing countries such as Nigeria (Uzonu, 2018). Uzonu (2018) further opined that a huge portion of Africa's total population (2.5 billion people) are highly dependent on natural forest resources for varieties of services, while in Nigeria, approximately 60 million indigenous people are almost wholly dependent on the forest, while 350 million people depend on the forest for a high degree for subsistence and income.

Uzonu and Umoru (2020) showed that forests in tropical areas are increasingly subjected to deforestation and degradation with adverse socio-economic and environmental impacts. Forests in many areas in Nigeria are no longer in a healthy state to render their natural services to the people

(Nwajiobi *et al*, 2022), and that the northern States have been completely deforested (Molinos, 2013). Deforestation accounts for approximately 30 percent of the atmospheric build-up of carbon dioxide over the past century, and rainforests are being depleted by approximately 160,000 square kilometres annually (Clay, 2018). The deforestation taking place in the African rainforests has many causes, including logging, which is responsible for 20 to 25 percent of the deforestation, cattle herding, cash crops, construction, population growth, economic development, clearing for cultivation, and by government policy (Aurson, 2018). These degradation of the forest ecosystem has obvious ecological effects on the immediate environment, but it may also affect distant areas (Adeofun, 1991). For instance, agricultural plains or valleys that depend upon forest highlands for their water may suffer flooding or drought as a result of forest destruction. Genetic damages and losses of plants, animals and insects can also be serious and possibly permanent. Deforestation can result in erosion which in turn may lead to desertification. Nwajiobi *et al.* (2022) reported a low population of selected indigenous species Abia State wherein they were previously reported as abundant. The economic and human consequences of deforestation include loss of potential wood and paper products among others which may then need to be imported (Uzonu and Nwachukwu, 2023).

The tropical rainforests are the most diverse ecosystems on Earth and about 80% of the world's known biodiversity could be found in them; removal or destruction of significant areas of these forest cover has resulted in a degraded environment with reduced biodiversity. (Bankole and Bakare, 2020).

The apparent increase of uncontrolled degradation of forests in the last decade in Enugu State has increased with increased problems relating to human survival, welfare, and development. Yet, little or no attention has not been paid by the government of the state, as there are no new laws enacted to curtail the incident nor any research to measure the extent of deforestation in the state (Uchegbu, 2019). It has become extremely pertinent to undertake an analysis of the Land Use Land Cover distribution of the state and the major causes of deforestation in Enugu State Nigeria.

MATERIALS AND METHODS

Study Area

Enugu State of Nigeria was created out of the former Anambra State in 1991. According to Ukwu *et al*. (2018), Enugu State is located in the south-eastern region of Nigeria, an irregular trapezoid territory between Latitudes $5^{0}55^{1}$ and $7^{0}10^{1}$ North and Longitudes 6^{0} 50^{1} and $7^{0}55^{1}$ East. It is bounded in the north by Kogi and Benue States, in the east by Ebonyi and Abia States, in the south by Ebonyi, Abia and Anambra, and in the west by Anambra State. In the views of Ukwu *et al*. (2019), the present Enugu State is a lineal descendant of the Eastern Region, one of the three original regions which since Independence has been progressively split into nine states, and these States include; Abia, Akwaibom, Anambra, Bayelsa, Cross River, Ebonyi, Enugu, Imo and Rivers States. Administratively, the State has 19 Local Government Areas with its Headquarters at Enugu.

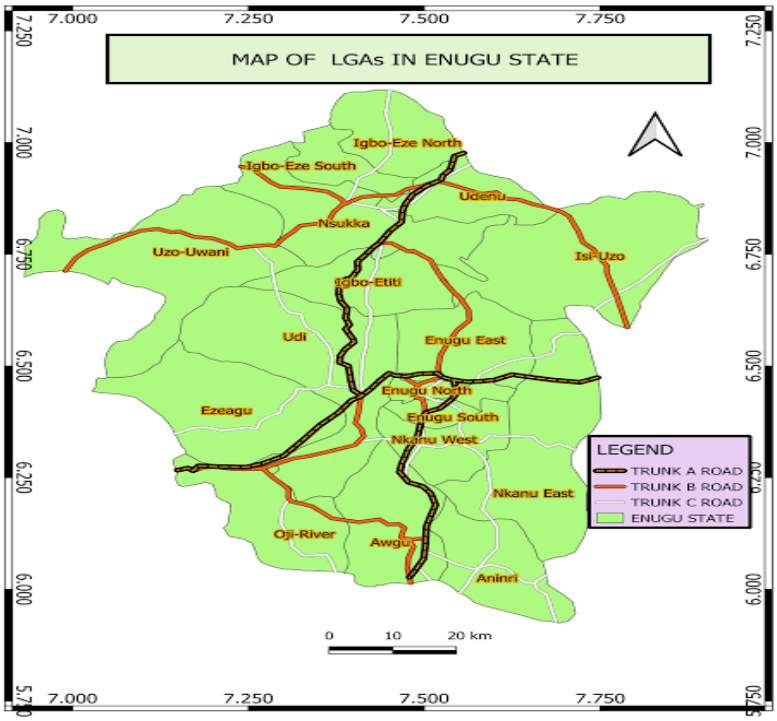

Figure 1: Enugu State showing LGAs
Source: Enugu State Ministry of Lands and Survey (2010)

In Nigeria, the natural vegetation falls into two main divisions, namely, forests (mangrove swamp forest, freshwater swamp forest and rain forest) and tropical grasslands or savannah (guinea, Sudan and Sahel) (Iloeje, 1981). Perkins and Stembridge (2018) reported that the forest region of southern Nigeria is divided into mangrove swamp forest, fresh water swamp forest and rain forest. Enugu State is characterized by mixture of savannah and rain forest area.

The vegetation of Enugu State which used to be Tropical Rain Forest is today a by-product of centuries of tree devastation by man and fire, and a continuous attempt by the plants to adapt. These made the trees grow long taproots and develop thick barks which enable it to survive the long dry season and resist bush fires. Most of the trees have umbrella6 shaped canopies which not only shade the ground but limit loss of soil moisture. Example of trees found here are the locust bean trees (*Parkia biglobosa*), sheabutter tree (*Vitellaria paradoxical*), oil bean tree (*Pentaclethra macrophylla*), Isoberlina tree among others and the trees grow in clusters, generally not more than 6 metres high, and are interspaced with elephant grass growing to a height of 3 to 3.6 metres (Iloeje, 2010).

Methodology

The vegetation maps of Enugu State for years 2000 and 2020 was generated using Landsat TM at 1000m resolution; results were subjected to Normalised Difference Vegetation Index (NDVI) to ascertain the different sizes of required parameters (built up area, bare ground, greenery and vegetation). Deforestation rate was calculated using the FAO formula:

$$Q = (A2 / A1) X1/ (t2 – t1) –1 \ldots\ldots\ldots (1)$$

Where:
Q = deforestation rate
A1 = initial forest cover
A2 = final forest cover
t2 – t1 = difference in duration; 2020 -2000 = 20

The relationship between urban area and forest loss in the State was determined using the Pearson Product Moment Correlation model given as:

$$r = \frac{n\sum XiYi - \sum Xi \sum Yi}{\sqrt{\{n\sum Yi\,2 - (\sum Yi)2\}\{n\sum Xi2 - (\sum Xi)2\}}} \quad \ldots\ldots\ldots (2)$$

r is the Pearson Product Moment Correlation Coefficient between X and Y (i.e. any pair of the dependent variables), and 'n' is the sample size.
Factors Influencing Deforestation in the Study Area was investigated using a structured questionnaire distrusted randomly in the study area. The questionnaire was pre-tested for reliability using the test-retest method (Oppenheim, 1992) and a reliability coefficient of 0.89 was obtained.

RESULTS

Land Cover Distribution of Enugu State in 2000 – 2020

The results obtained on the land cover distribution in Enugu State from 2000 to 2020 is indicated in Tables 1 to 4 and figures 2 to 4 below. Table 1 shows the proportion of the total area occupied by each land cover class. It shows that Forest Area has the highest proportion of the total land accounting for 1685448.99 ha representing (80.38%) of the total land. This is followed by Green Areas with 227819.07ha (10.87%) bare land has 144172.44ha representing (6.87%) while water body and built-up area amounted to 37448.01ha (1.78%) and 1874.16 (0.09%) respectively.
Figure 2 is an accurate assessment of the classified image. It shows that the pattern of land cover alteration was restricted to perforation and dissection of lands.
Table 2 show that the Forest Area has reduced in size from 1,685,448.99 ha (80.38%) in 2000 to 990,753.03 ha (47.25%) in 2010 while an increase in bare land patches from144,172.44 ha (6.87%) to 65,2246.38 ha (31.11%), Green Areas from 227819.09 ha (10.89%) to 390229.56 ha (18.61%), and water body from 37448.01 ha (1.78%) to 61812.54 ha (2.94%) was observed.
The image classification in Figure 3 showed a marked significant decrease in the Forest Area class with scattered matrixes that have undergone massive deforestation. Fragmented patterns of the Forest Area matrix were observed to the extreme southeast and southern part of the study area. To the Southwest and northeast part, the Forest Area fragmented matrixes continue to shrinkage, while in the north-central part, a massive shrinkage was recorded.

The result in Table 3 depicts a decrease in Forest Area cover from 990753.03ha (47.25%) in 2010 to 682993.66ha (37.33%) in 2020. It also shows an increase in bare land from 31.11% to 37.65% from 2010 to 2020 while the built-up area remained unchanged (0.08%) over the same period.

Figure 4 shows that the major pattern of land covers at this period was characterized by attrition and shrinkage. Attrition pattern has fully developed into a complete disappearance of the Forest Area giving rise to bare land patch formation at the Northwest and South West part of the study area and a little shrinking fragments of Forest Area and Green Area classes to the Northeast. To the South, Southeast, and Southwest is the fragmented pattern of Forest Area and Green Area matrixes with perforated patches of bare lands.

Table 4 shows the changes in land cover class for forest and bare land between 2000 and 2020. It shows a high level of forest loss from 2000. Classification showed that Forest Area occupied the total of 1685448.99 ha equivalent to 80.38% and was the highest land cover suffering a decline in the area amounting to 694696 ha which equals to 33.13% in 2020. The pattern of land cover changes at the early stage was restricted to dissection and perforation in 2000. Deforestation rate determined by using the FAO index below, which was described earlier, show that the deforestation rate in Enugu State for the period under study is 4.2%.

$$\mathbf{q} = \left(\frac{\boldsymbol{A2}}{\boldsymbol{A1}}\right)^{1/t2-t1} - 1 = q = \left(\frac{682993.66}{1685448.99}\right)^{1/20} - 1 = 0.955 - 1 = 0.045 \text{ X } 100\% = 4.2\%$$

Table 1. Land cover distribution in 2000

Land cover	Area cover	Percentages %
Forest area	168,544,8.99	80.38
Bare land	144172.44	6.88
Green area	227819.07	10.87
Water body	37448.01	1.78
Built-up	1874.16	0.09
Total	**209, 676,2.65**	**100**

Table 2. Land cover distribution in 2010

Land cover	Area cover ha	Percentage %
Forest Area	990753.03	47.25
Bare land	652246.38	31.11
Green Area	390229.56	18.61
Water body	61812.54	2.95
built-up	1721.16	0.08
Total	**2096762.63**	**100**

Table 3. Land cover distribution in 2020

Land cover	Area cover (ha)	Percentage (%)
Forest Area	682993.66	37.33
Bare land	849218.49	37.65
Green Area	385976.35	17.11
Water body	176678.88	7.83
Built-up	1895.22	0.08
Total	**225,576,2.75**	**100**

Table 4. Changes in land cover class (Forest Area and bare land 2000 to 2020

Years	Forest Area	Bare land	Change in Forest Area	Change in bare land
2000	1685448.99	144172.4	-	-
2010	990753.03	652246.38	694695.87	-508073.94
2020	682993.66	849218.59	307759.37	-196972.21

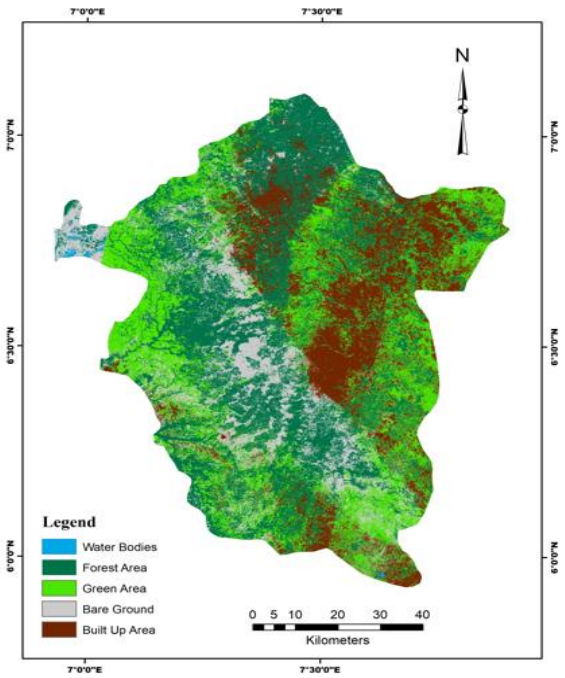

Figure 2: LULC for Enugu 2000

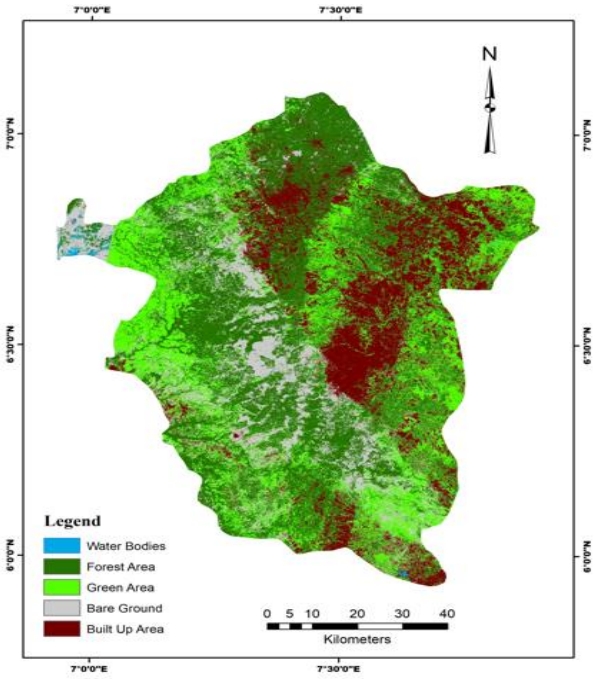

Figure 3: LULC for Enugu 2010

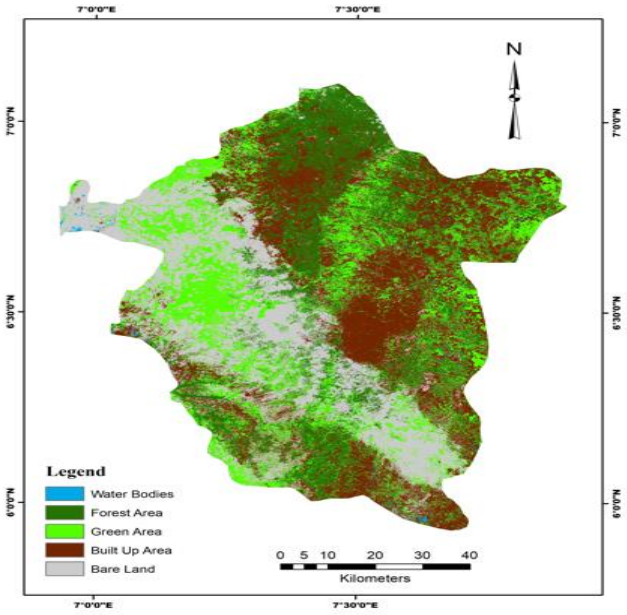

Figure 4: LULC for Enugu 2020

Correlation between urban area and forest loss

The result of the correlation analysis between forest size and urban area contained in the below Table 5 shows that a strong negative correlation (r = -0.81) exists between forest size and urban area implying that an increase in urban area as observed in the study led to decrease in forest size (deforestation) .

Table 5. Correlation between Urbanization and Deforestation Correlations

		Forest	Bare ground
Forest	Pearson Correlation	1	-.815
	Sig. (2-tailed)		.885
	N	4	4
Urban area	Pearson Correlation	-.815	1
	Sig. (2-tailed)	.885	
	N	4	4

Factors Influencing Deforestation in the Study Area

Result presented in Table 6 shows that 90%, 93.3%, 80% and 85.56% of the respondents indicated bush burning, corruption, faming activities, and fuel wood extraction respectively as factors influencing deforestation in the study area. Also 76.67%, 75.56%, 92.22% and 91.11% indicated lack of value for forest, over grazing, over population and road construction respectively. Whereas corruption was perceived by the highest score of 93.33

Table 6. Factors Influencing Deforestation in the Study Area

Deforestation Factors	Frequency (n=90)	Percentage
Bush burning	81	90.00
Corruption and political causes	84	93.33
Farming activities	72	80.00
Fuel wood extraction	77	85.56
Lack of value for forest	69	76.67
Overgrazing	68	75.56
Overpopulation and poverty	83	92.22
Road construction/ development projects	82	91.11

**Multiple Response*

DISCUSSION

Land Cover Distribution of Enugu State in 2000 – 2020

There was evidential decrease in forest cover in Enugu from 2000 to 2020. This agrees with Uzonu (2018) and Nwajiobi *et al* (2023) that forest sizes reduce and that the population of indigenous tree species has diminished to what was previously reported in the southeast. Forest indeed had greatest size in earlier years than bare land and green areas (Uzonu, 2018). The findings of this study is also supported by that of Uyanga (2019) who noted that the reason for high forest land mass in the past is because deforestation is usually low in earlier years as pressure on land was low. These changes reflected in the pattern of land cover alteration as perforation and dissection of lands. Both Green Area and Forest Area classes have remained in a matrix formation with little or no alterations. Also, easily identifiable matrices of Forest Area that covered the entire study area with less dissected corridor pattern of bare lands and patch formation of built-up area towards Northern part of the study area was observed. This suggests that the Forest Area was intact with little or no interference by rural farmers that use crude implements.

Similarly, the findings show that the Forest Area has reduced in size with an increase in bare land patches. The increased in bare land to Green Areas was due to the clearing of Green Areas by farmers for cultivation, while the increase in water bodies was due to accelerated deforestation of the Forest Area that was shielding the water initially. This agrees with Uzonu (2028) and Nwajiobi *et al.* (2022) that noted that forest sizes reduce and that the population of our indigenous tree species has diminished to what was previously reported in the southeast. According to Uzonu (2018) any forest loss amounting to 56888ha (8.69% loss) per annum is very significant.

The image classification in Figure 3 showed a marked significant decrease in the Forest Area class with scattered matrixes that have undergone massive deforestation. Fragmented patterns of the Forest Area matrix were observed to the extreme southeast and southern part of the study area. To the Southwest and northeast part, the Forest Area fragmented matrixes continued shrinkage, while in the north-central part, a massive shrinkage was observed indicating that Green Areas dissected by bare lands were gradually reclaiming the thickness of the forest. The tremendous decreases in the Forest Area is probably the result of massive deforestation caused by increased lumbering activities and an increase in built up area due to estate development in the recent few decades in the area. The findings supported Umeh (2016) who reported that urban expansion is one of the major causes of forest loss and that about 10.26% of forest cover in Enugu State transitioned to built-up areas and bare ground.

The Forest Area kept on decreasing with time as a result of massive deforestation going on in the area. Bare land keeps increasing due to the springing up of more farms from the remnants of the forest that were cleared. Water bodies keep on rising due to exposure of some streams and ponds that were hidden beneath the foliage of the Forest Area that was cut down, and a negligible increase in built-up areas was recorded due to new built-up farmsteads. The major pattern of land covers at this period was characterized by attrition and shrinkage. Attrition pattern has fully developed into a complete disappearance of the Forest Area giving rise to bare land patch formation at the Northwest and South West part of the study area and a little shrinking fragments of Forest Area and Green Area classes to the Northeast. To the South, Southeast, and Southwest is the fragmented pattern of Forest Area and Green Area matrixes with perforated patches of bare lands. This means that there is a continued dispersal and decrease in Forest Area cover, which adds to the existing loss of lands within the class involving all the characterized patterns of land cover changes.

The deforestation rate in Enugu State for the period of the study at 4.2% is considerably high. Although the pattern of land cover changes at the early stage in 2000 was restricted to dissection and perforation, a remarkable expansion of bare land patches accompanied by total attrition of Forest Area was identified indicating high forest loss. The findings are in line with that of Umeh (2016) which reported that about 10.26% of forest cover in Enugu State transitioned to built-up areas and bare ground. Furthermore, built up areas and the size of bare ground and built up area increased to 18.31% between 2009 and 2019. They further noted that the total difference of loss in vegetal cover between 1989 and 2019 is just about 1.38% while the total gained by built up area between 1989 and 2019 (30year period) is 7.6%.

From the GIS analysis, Enugu State suffered from serious deforestation due to various economic activities including agricultural production and infrastructural developments. All these factors contribute to the rate of increase in bare land patches with a decrease in the Forest Area matrix. Butler (2019) asserted that the forest loss is as a result of urban and residential area growth as they lead to consumption of building materials and as a source of land. While urbanization can reduce direct burdens on forests by the movement of rural residents to population centers, urban and suburban sprawl can be damaging when they occur in frontier settlements and boomtowns. He strongly pointed that centrally planned urban trials has resulted in great forest loss in parts of the world.

Correlation between urban area and forest loss

A strong negative correlation ($r = -0.81$) exists between forest size and urban area implying that an increase in urban area led to decrease in forest size (deforestation). This is in line with the finding of Uzonu (2018) who reported a significant relationship between urbanization and deforestation in Bwari Area Council, Abuja (Federal Capital Territory), Nigeria.

Factors Influencing Deforestation in the Study Area

The findings are indication that the problem of deforestation is caused by many factors. Research findings of Adepoju and Salau (2021) corroborates this research finding as they noted

that the constant deforestation in many States of Nigeria are caused by multi factors such as lack of value for forest, over grazing, over population and road construction. Also, Ogigirigi (2016) who made similar findings in Ogun state noted that fuel wood extraction is one of the causes of deforestation since fuel wood is being used as the main household cooking fuel in most developing nation such as Nigeria due to the high cost of other fuel alternatives (kerosene, gas and electricity). This finding is also in line with that of Nzeh and Eboh (2017) who opined that lack of alternative fuel could promote the effect of deforestation.

CONCLUSION

The study revealed that the conversion of land for various uses including bare ground and green areas have led to loss in forest size otherwise called deforestation. A correlation exists between sizes of urban area and the size of forest area indicating that an increase in urban areas leads to reduction in forest size thereby creating a scenario where the increase in bare land leads to decrease in thick forests. The rate of deforestation at the period under study was found to be 4.2%. The loss in forest size have been caused by factors such as bush burning, corruption, faming activities, fuel wood extraction among others.

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