

Environmental Science & Technology

Major Project

Shreyas Shankar (20171128)

Vijayraj Shanmugaraj (20171026)

Introduction

Deforestation, the clearing or thinning of forests by humans. Deforestation represents one of the largest issues in global land use. Deforestation can occur for several reasons: trees can be cut down to be used for building or sold as fuel (sometimes in the form of charcoal or timber), while cleared land can be used as pasture for livestock and plantation. The removal of trees without sufficient reforestation has resulted in habitat damage, biodiversity loss, and aridity.

The degradation of forest ecosystems has also been traced to economic incentives that make forest conversion appear more profitable than forest conservation. Many important forest functions have no markets, and hence, no economic value that is readily apparent to the forests' owners or the communities that rely on forests for their well-being. From the perspective of the developing world, the benefits of forest as carbon sinks or biodiversity reserves go primarily to richer developed nations and there is insufficient compensation for these services.

Literature Survey

1. Forest Conservation & Environmental Awareness:

(https://www.researchgate.net/publication/279460234_Forest_Conservation_Environmental_Awareness)

Now-a-days, forest cover is depleting rapidly due to many reasons such as an expansion of agriculture, timber plantation, other land uses like pulp and paper plantations, urbanization, construction of roads, industries, constitutes the biggest and severe threat to the forest causing serious environmental damage. Thus, there is need of public awareness. This paper offers various strategies for the conservation of forest & awareness to people, which plays a vital role for maintaining a proper balance of environment.

Objectives of the Study

In this project, our objectives are twofold.

- 1) Train machine learning models on datasets to predict trends in forest covers.
- 2) Pick specific countries with sizeable forest covers, that show deviating trends and study their history and reasoning.

The first task for both our objectives was to collect sizeable data.

Materials and methods:

We used three different datasets for our research. The links to all three of these datasets are linked below in references.

1. Forest area (% of land area) from Data World Bank
2. World Population Data from Data World Bank
3. CO2 Emission data from Open Climate Data

We used machine learning algorithms like linear regression on the data collected from the above sources to predict trends from the data.

We also wrote a script to detect anomalies in the trends of the data, so that we could identify which countries to study in detail.

Snippet of the code:

```
def linear_regression(country_code):
    Data = df.loc[[country_code]]
    Data = Data.drop(columns = "Country Name")
    y = []
    years = []

    for i in list(Data.columns.values):
        y.append(float(Data[i]))
        years.append(i)

    Model = LinearRegression()
    Model.fit(years,y)
    predictions = Model.predict(pd.DataFrame(list(range(2017,2100))))

    predictions = [u[0] for u in predictions]

    yx = [u[0] for u in y.values]
    yt = [0]*len(yx)
```

Snippet of the anomaly checker code:

```
for i in range(1, len(data_list)):
    diff = data_list[i] - data_list[i-1]
    sign_now = 1 if diff > 0 else -1

    if diff > 0:
        positive_epochs += 1

    if sign_now != sign:
        f = 1
    sign = sign_now

    if positive_epochs > 12:
        p_coun.append(country_name)

    if f and country_name not in p_coun:
        s_c_coun.append(country_name)
```

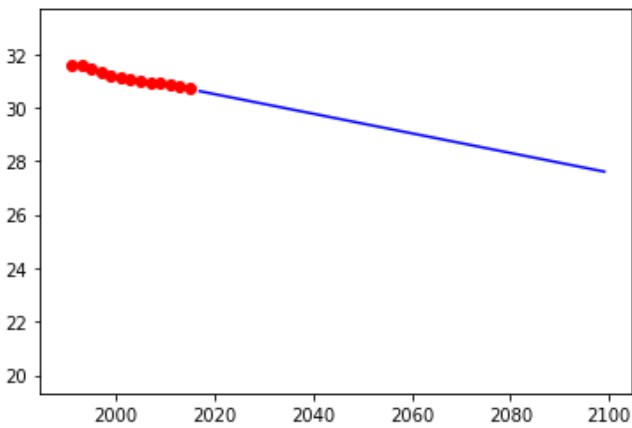
Results and Discussion

Machine Learning:

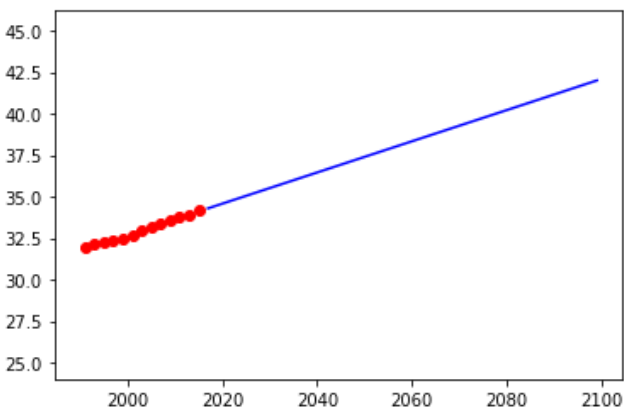
We trained the model on the world forest dataset with Co2 emissions and population as features.

We made the model make predictions in forest trends till 2100. These are some of the trends we observed,

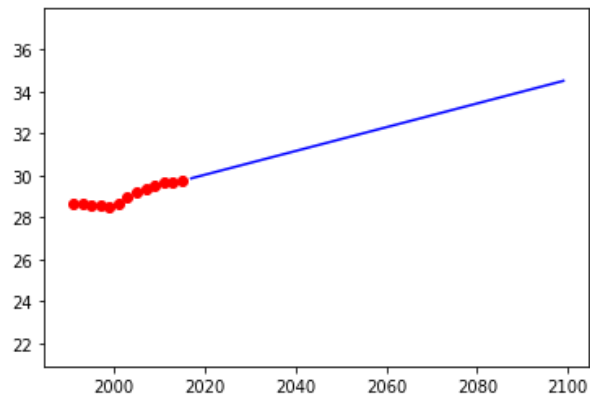
On World Average Forest Data:



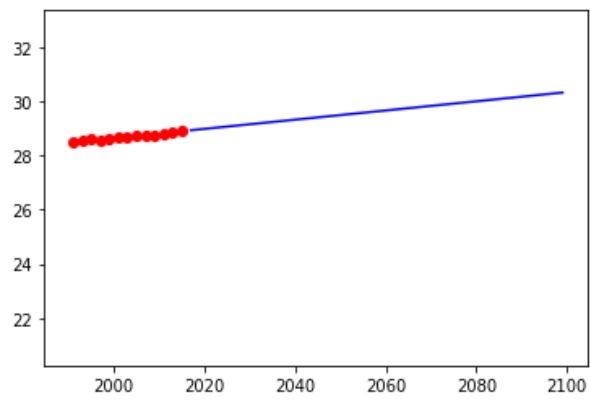
On European Union:



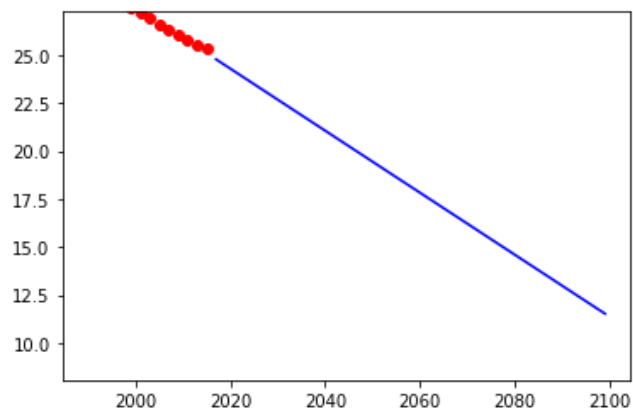
East Asia and the Pacific:



High Income Countries:



Low Income Countries:



We can notice that low income countries show a decreasing trend while high income countries are increasing.

Developing countries feel that some countries in the developed world, such as the United States of America, cut down their forests centuries ago and benefited economically from this deforestation, and that it is hypocritical to deny developing countries the same opportunities, i.e. that the poor shouldn't have to bear the cost of preservation when the rich created the problem.

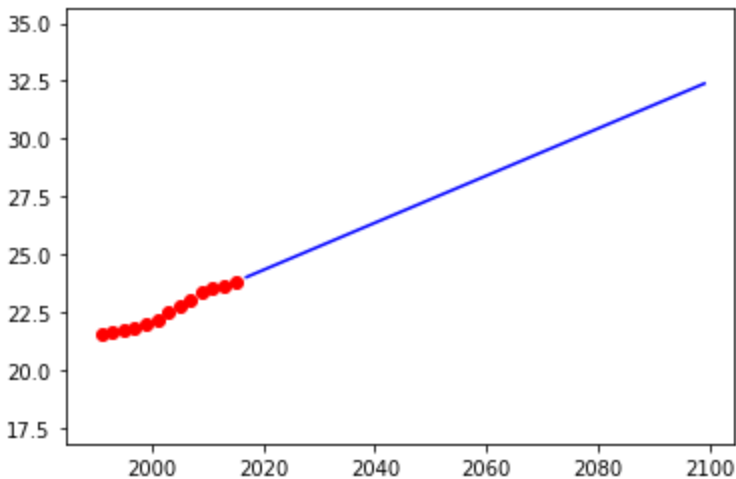
Anomaly Checker:

By running a script through the data to detect anomalies, we have identified some countries which we think would offer some special insight by studying their history of deforestation closer.

These countries are :

- 1) Malaysia
- 2) India
- 3) Philippines
- 4) China
- 5) Vietnam
- 6) Kenya

1. India



Ecological issues are an integral and important part of environmental issues challenging India. Poor air quality, water pollution and garbage pollution – all affect the food and environment quality necessary for ecosystems. India is a large and diverse country. Its land area includes regions with some of the world's highest rainfall to very dry deserts, coast line to alpine regions, river deltas to tropical islands. The variety and distribution of forest vegetation is large. India is one of the 12 mega regions of the world.

Indian forests types include tropical evergreens, tropical deciduous, swamps, mangroves, sub-tropical, montane, scrub, sub-alpine and alpine forests. These forests support a variety of ecosystems with diverse flora and fauna.

Until recently, India lacked an objective way to determine the quantity of forests it had, and the quality of forests it had. In the 1980s, space satellites were deployed for remote sensing of real forest cover. Standards were introduced to classify India's forests into the following categories: Forest Cover , Very Dense Forest , Moderately Dense Forest , Open Forest, Mangrove Cover , Non Forest Land , Scrub Cover , Tree Cover.

The first satellite recorded forest coverage data for India became available in 1987. India and the United States cooperated in 2001, using Landsat MSS with spatial resolution of 80 metres, to get

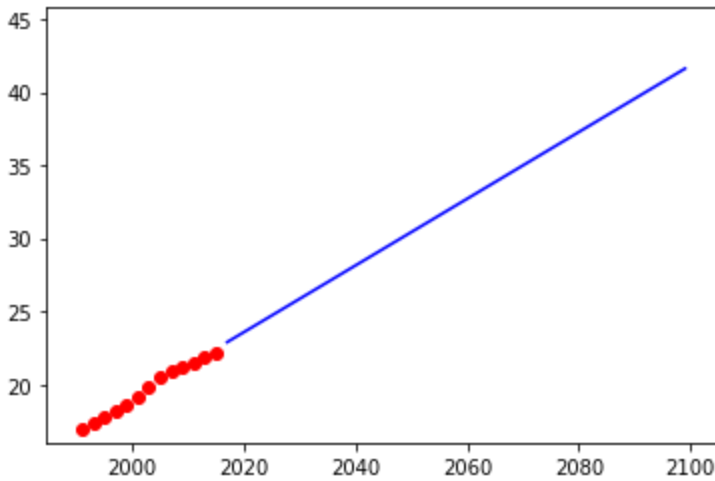
accurate Indian forest distribution data. India thereafter switched to digital image and advanced satellites with 23 metres resolution and software processing of images to get more refined data on forest quantity and forest quality. India now assesses its forest distribution data biennially.

In recent decades, human encroachment has posed a threat to India's wildlife; in response, a system of national parks and protected areas, first established in 1935, was substantially expanded. In 1972, India enacted the Wildlife Protection Act and Project Tiger to safeguard crucial habitat; further federal protections were promulgated in the 1980s. Along with over 500 wildlife sanctuaries, India now hosts 14 biosphere reserves, four of which are part of the World Network of Biosphere Reserves; 25 wetlands are registered under the Ramsar Convention.

In 2003, India set up a National Forest Commission to review and assess India's policy and law, its effect on India's forests, its impact of local forest communities, and to make recommendations to achieve sustainable forest and ecological security in India. The report made over 300 recommendations including the following:

India must pursue rural development and animal husbandry policies to address local communities need to find affordable cattle fodder and grazing. To avoid destruction of local forest cover, fodder must reach these communities on reliable roads and other infrastructure, in all seasons year round. The Forest Rights Bill is likely to be harmful to forest conservation and ecological security. The Forest Rights Bill became a law since 2007.

2. China



China has contributed to 25% of the increase (of 5.5 mn sqkm), and India 6.6%, according to a global study between 2000 and 2017.

The rehabilitation of forest land in China can largely be attributed to a series of six national forestry programmes which have been implemented since the late 1990s, through which China has planted more than 4 million hectares of forest every year. Between 1998 and 2014, investment across the six programmes is estimated to have reached USD 100 billion and involved the participation of 20% of China's rural population.

The rapid rehabilitation of forest and landscapes at a massive scale in China proves that ecological restoration of large-scale, complex ecosystems is possible, and can be achieved by human hands. Three-North Afforestation Program (TNAP) was behind this large scale afforestation. The TNAP, which has been ongoing for 40 years, is said to be the world's largest tree-planting project covering more than 95 percent of China's wind-sand damaged areas and 40 percent of areas hit by soil erosion.

According to the assessment, the forest area of TNAP has increased by 21.56 million hectares since 1978. The completed afforestation areas have been up to 46.14 million hectares, amounting

to 118 percent of the planned afforestation tasks in the same period. Since 2000, desertification has overall been under control and key areas have been significantly improved, the report said.

In addition, the areas of soil erosion by water in the TNAP regions have been reduced by 67 percent in total. The total value of forest ecosystem services in the TNAP regions increased from 4.8 billion yuan (around 695 million U.S. dollars) in 1978 to 234.47 billion yuan (about 34 billion U.S. dollars) in 2017.

Apart from this, the local economy and social development have been promoted by the forest fruit industry and forest tourism in TNAP regions. At present, the annual output value of forest fruit and forest tourism has reached 120 billion yuan (around 17 billion U.S. dollars), absorbing 313 million rural laborers and achieving stable poverty alleviation for about 15 million people.

Notable checkpoints of China's reforestation program are:

- China increased forest cover from 16.74% of its territory in 1990 to 22.5% in 2015, an increase of 511,807 square kilometres.
- Since the late 1990s, China has planted more than 4 million hectares of forest every year.
- Between 1998 and 2014, investment across the six forestry programmes is estimated to have reached USD 100 billion and involved participation of 20% of China's rural population.

In 2018, China set a target to achieve forest cover over 30% of its land by 2050. China's rapid transition to reforest vast swathes of depleted and deserted territory represents the largest ecological restoration project the world has ever seen.

Though the project has achieved much success, challenges remain. Since most of TNAP regions are arid and semi-arid areas, lack of systematic consideration of the local water resource can lead to forest decline. The average afforestation rate of TNAP is 47 percent, but about 25 percent of the forests are in an unhealthy state.

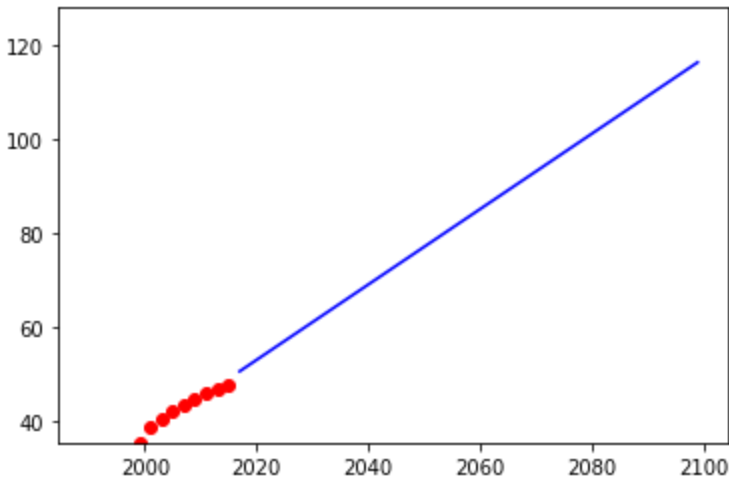
Besides, TNAP plays a limited role in reducing severe desertification; the effect of TNAP is far from counteracting the disturbance of human activities.

Some scientists worry that the planting could worsen water scarcity. Many of the trees are not native to the regions where they have been planted, and they use a lot of water — despite being placed in areas that are experiencing less rainfall due to global warming.

A closer look at the data reveals that all this new tree cover isn't actually forest, according to a recent study. It finds most reforestation efforts simply planted one tree species, making a plot of reforested land equivalent to a monoculture plantation. These interviews revealed that these households paid attention to government policies and tended to plant species that were promoted. This decision was largely based on how much money they stood to make through government incentives aimed at encouraging the planting of certain types of trees – at times even cutting down actual forest to do so. The researchers say the fault lies in the failure of these policies to differentiate monoculture tree cover from real forest.

There is also inconsistent estimates of forest cover change from satellite data, that could be caused by factors such as algorithm parameters, spatial resolutions of monitoring, and forest definition, all of which can strongly influence the estimates with a magnitude comparable to the real change signal. Considering the increase in forest cover indicated by the majority of datasets, combined with independent evidence from other studies, and the implementation of forest conservation policies, a large decrease in China's forest cover during the study period is less probable. However, we cannot rule out the possibility that forest cover for this period was relatively stable with comparable magnitudes of forest loss and gain.

3. Vietnam:



Vietnam has the second highest rate of deforestation of primary forests in the world, second only to Nigeria. However, regarding total forest cover, Vietnam has undergone a forest transition: its forest cover has increased since the early 1990s, after decades of deforestation. As of 2005, 12,931,000 hectares (the equivalent of 39.7% of Vietnam's land cover) was forested, although only 85,000 hectares (0.7% of the land cover) was primary forest, the most biodiverse form of forest.

Vietnam has experienced an exceptional turnaround from net forest loss to forest regrowth. This so-called forest transition, starting in the 1990s, resulted from major changes to environmental and economic policy. Investments in agricultural intensification, reforestation programs, and forestland privatization directly or indirectly promoted natural forest regeneration and the setting-up of plantation forests mainly stocked with exotic species. Forest cover changes, however, varied widely among regions due to specific socio-economic and environmental factors. The reforestation occurred at a higher rate than deforestation in the previous decades, and was due in similar proportions, to natural forest regeneration and to planted forests.

Vietnam has been largely successful in rehabilitating its lost and damaged forests over the past 15 years. The government began passing a series of laws to protect forest health and support

reforestation at the turn of the century. It also started expanding its relationship with international partners aimed at environmental conservation.

The UN's REDD+ program, (Reducing Emissions from Deforestation and forest Degradation in developing countries), an international effort dedicated to stopping deforestation and climate change, lists Vietnam as one of its earliest collaborators, which got international backing from the UN to implement reforestation efforts and reduce GHG emissions.

International and local efforts to protect existing forests and to replant hectares-lost have helped Vietnam chart a more sustainable course for the future; but the country still has many challenges to navigate ahead.

By 2011 Forest Trends found tree coverage in Vietnam nearing pre-war levels, with all three classifications of forests comprising 40.2 percent of its land area. Similarly, the Food and Agriculture Organization of the UN has consistently listed Vietnam's forests as moderately expanding between 1990 and 2015.

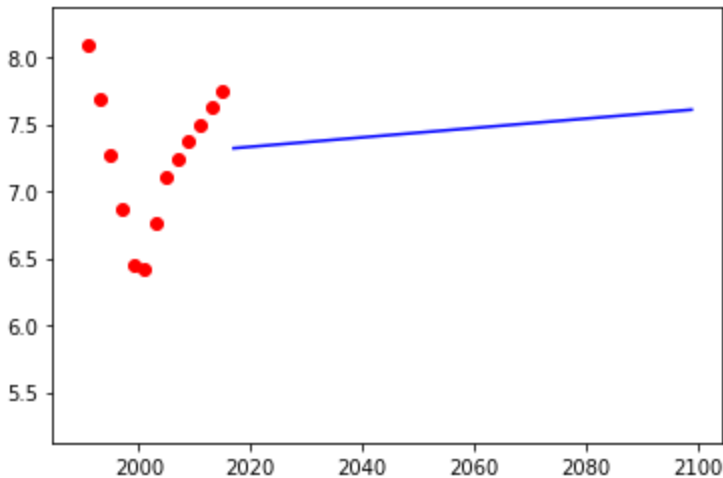
The fast-growing exotic species have also provided some revenue for landowners in deforested areas. However, planting the monocultures does not provide the same level of biodiversity and watershed protection as planting natives – something researchers are placing greater significance on as environmental stresses from climate change intensify.

Viewing reforestation as a strategy to protect the country against climate change has become part of the national platform in Vietnam, with great value placed on replanting mangrove trees to protect against sea level rise and intensifying tropical storms.

One highly successful mangrove project is the Can Gio Mangrove Biosphere Reserve, located just southeast of Ho Chi Minh City. The area has been able to restore almost all of the previously defoliated sites to full health, which UNESCO touts on its website. Much of that success is attributed to replanting efforts by researchers in the Mekong Delta and eco-tourism opportunities that connect both tourists and locals back to the land.

Coming out of the same forest conference was a proposed plan by the Ministry of Agriculture and Rural Development to stop forest loss in the central highlands of Vietnam. Costs for implementing the plan are estimated to be \$886 million between 2016 and 2025, with over half of that expected to come from outside Vietnam's state budget.

4. Kenya:



Deforestation is an ongoing environmental issue in Kenya. In 1963, when Kenya became an independent nation, its forest cover was approximately 10%. By 2012, the forest cover had dropped to 6% and it was estimated that the country was losing 12,000 hectares of forest annually despite the Kenyan government's efforts to alleviate the problem. Four causes of deforestation in Kenya are:

- **Demand for farming land:** At local level, farmers face the ever-rising demand for cash crops to meet their unlimited needs, owing to the ballooning population. Over the years, the local administration has been on the forefront in allocating parcels of land to individuals without a conservation mind, leading to immense deforestation.
- **‘Polluted’ Politics:** The unthinkable levels of deforestation we witness today largely stem from backward politics and poor leadership. For decades, politicians have used forestland to gain political mileage at the expense of a suffering environment. Politicians allocate land directly or indirectly to become popular.
- **Nonfunctional Government Agencies:** Human activities like logging, charcoal burning and encroachment of forestland continue to happen in the eyes of Kenya Forest Services, and other government agencies, which seem not to appreciate the need for a green economy.

- **Globalization:** There is high demand for raw materials by industrialized nations for processing. This pressure makes third world countries like Kenya shelve their environmental conservation agenda and focus on exploiting natural resources for business. In the end, the negative effects of deforestation supersede the economic gain. For instance, China has been buying timber from Kenya for years, leading to the escalation of legal and illegal deforestation countrywide.
- **Population:** Kenya's growing population is exerting considerable pressure on natural resources. As forest resources dwindle with the expansion of agriculture onto forest land, forests will no longer be able to meet the rising demand for wood and non-wood products.

Clearly from the data, there is a growing trend in Kenya towards expansion of tree cover and species diversification in intensive farming systems which include trees. As natural formations shrink, are destroyed, or become less accessible, social forestry becomes increasingly important. Forest plantations, in decline because the rate of replanting has failed to offset the rate of felling, are giving way to grassland. At the same time, farms and settlements are encroaching upon remnants of indigenous forests at an annual rate of 5 000 ha and upon woodlands at a rate of 55 000 ha/yr, with bushland dwindling as well. As timber resources from forest estates decline, wood supply will increasingly come from farmlands and remnant natural woodlands.

Early in the 1930-1940s, the high-potential zones still had a fair amount of plant cover and natural forest, but much of the area was then cleared in the process of agricultural expansion. To offset this loss, farmers were offered incentives during the 1970-1980s for extensive tree-planting on farms, with secure land tenure as a pre-condition. The social and economic benefits of this are felt today in the form of income and product diversification which acts as a safety-net to buffer the risk of hardship and destitution. In the low-potential zones where land tenure is less secure, there are two major trends. Tree resources are being depleted in areas of rapid agricultural expansion, but degradation is less severe where traditional land-use systems are still firmly entrenched.

The Kenya Forestry Master Plan (KFMP) stressed the on-farm contribution of trees, which provide wood and poles for construction, fence posts, fuelwood and charcoal, not to mention fruit, fodder, medicines, gums and resin, all for home consumption and/or sale.

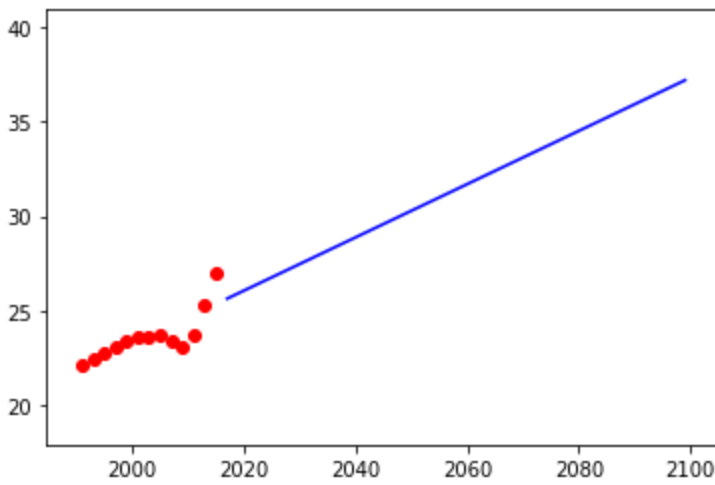
Kenya, hence has taken strong measures for forest recovery. Families that practice farming in Kenya have diversified their farmland production and increased their income through sustainable farming practices and an agroforestry technique known as the Forest Garden Approach. Over 80 percent of Kenyans use firewood or charcoal to cook. But that's a problem in a country with high rates of deforestation. As a substitute to firewood, biogas units are being built in Kenya's Kiambu County. As the units also cut down on hazardous smoke, they are better for people's health, too. They also mean farmers no longer have to collect or buy wood or fell trees, which is helping to halt deforestation.

Cabinet Secretary for Environment and Forestry Keriako Tobiko said the country is embracing research, education and training in the forest sector to increase forest cover from 6.9 percent to 10 percent by 2030.

Kenya and the United Nations Environment Programme (UNEP) on Thursday signed a memorandum of understanding (MoU) to help increase forest cover as part of efforts to protect the country against the vagaries of environmental destruction.

The program dubbed "Greening Kenya" campaign will ensure that about 50 million tree seedlings are planted from May. Seed-balling, seed bombing or in some cases aerial reforestation, is a technique of introducing vegetation to land by throwing or dropping seedballs. This tree-planting technique is helping fight deforestation in Kenya in recent years.

5. Philippines



Philippines, a picturesque archipelago home to 105 million people, is among the most biodiverse countries in Southeast Asia. Yet extensive deforestation has wreaked havoc with local ecosystems, pushing numerous species of flora and fauna to the edge of extinction, including hundreds of endemic species.

Over the past century most local forests, which once covered more than two-thirds of the country, have been felled. Today only a fifth of the Philippines is covered in forests and illegal logging continues to take its toll on remaining forests around the country.

Although the national government allocates funds for reforestation, projects have been largely dependent on foreign funding. Moreover, opportunities for rehabilitation created room for graft and corruption. On Sept. 22, 2010, Sen. Franklin Drilon exposed on national television the alleged use of P1 billion in DENR funds for the May 2010 general elections.

Reforestation efforts also tend to endanger forest biodiversity. Studies show that native species should be used for reforestation. Fast-growing, alien tree species such as mahogany, gmelina, acacia and fire tree are ecologically harmful because they prevent native species from growing

with them. The survival of endemic animals and insects dependent on native species for food and shelter are adversely affected because they are not adapted to the alien tree species.

The main strategy for protecting and conserving biodiversity in the Philippines is the establishment of an integrated protected area system (IPAS). The IPAS was set up to protect and preserve a representative sample of all ecosystems and habitat types in the country, as well as their plant and animal species. Executive Order 192 created the Parks and Wildlife Bureau to consolidate government efforts to conserve biological diversity in the protected area system.

In June 1992, Republic Act No. 7586, otherwise known as the National Integrated Protected Area Systems (NIPAS) Law, was passed. The law, which is being implemented by the Department of Environment and Natural Resources (DENR), has the following special features:

- It requires the designation of a buffer zone to stabilize protected areas whenever and wherever applicable;
- It recognizes ancestral rights and includes community interests with concern for socioeconomic development;
- It requires the development of standard planning for site-specific management;
- It establishes the Integrated Protected Areas Fund (IPAF), a trust fund which will form the basis of a sustained financing system; and
- It adopts a decentralized system of protected area management.

By 1999, 76 protected areas had been established under the NIPAS Law. The regional offices of DENR, its Community Environment and Natural Resources Offices, and provincial Environment and Natural Resources Offices have also identified 25 old-growth and mossy forests for inclusion in the IPAS.

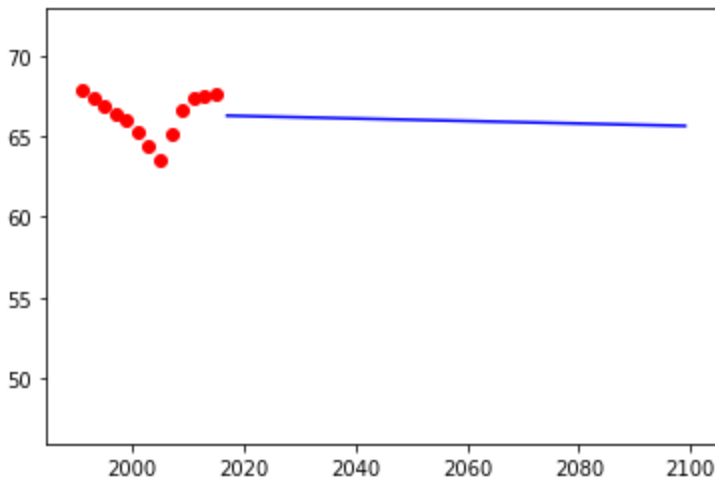
Plus trees are being selected continuously across the Philippine archipelago. The criteria for selection are based on morphology and resistance to pests and diseases, but there have been few attempts to propagate the selected trees in nurseries. In 1991, plus trees from 23 species in eight

administrative regions of the country were selected. Thirty-eight seed production areas (SPA) have been identified and documented. The Forest Management Bureau (FMB) has also identified 61 seed production areas for 19 tree species. Plans to improve the genetic composition of these SPAs are under development. Although seed is being collected from selected plus trees and SPAs, a system to monitor the transfer of germplasm and its performance after planting is not yet in place.

There have been several ex situ conservation projects and programmes in the Philippines. Seed orchards of various species have been established in several parts of the country under both private and government initiatives. In most cases, however, these orchards have been abandoned because of a lack of funds or trained personnel. Financial and technical needs for rehabilitating these orchards are being studied.

A resurgence of efforts to establish more seed orchards has followed implementation of the National Forestation Programme. Nine seed orchards for 12 species were established in 1991 alone. Species and provenance trials have also been used for ex situ conservation purposes in the Philippines. Some provenance and species trials have been conducted.

6. Malaysia



Malaysia has undergone significant economic development since its independence, which can be attributed to its forest resources. This has largely been in part to its abundance of natural resources, which constitutes significant portions of the country's economic sector. Because of this large financial gain from logging, production has been high since initiation, and it was not until 1985 that consequences were first realised.

Malaysia ranks as the 21st most biodiverse country in the world, with 2,199 endemic species. 18% of these species are listed as 'threatened', and because they are endemic, if Malaysia fails to conserve them, extinction will result.

Malaysia has adopted several measures to protect and conserve forest diversity. These include the creation of a network of totally protected areas including national and state parks, wildlife and bird sanctuaries, and the PFEs. Malaysia currently has 2.12 million hectares in legally protected conservation areas. Of this, 1.79 million hectares are located outside the PFEs and the rest within. In the past 2 decades, Malaysia has moved towards diversifying its economy. The Malaysian Nature Society is also active in advocating protection of forest.

Encouragingly, the country has more forest cover than it did a decade and a half ago. That is according to the UN Food and Agriculture Organization's recently published Global Forest Resources Assessment report. The FRA surveys the state of the world's forests every five years

to produce a comprehensive examination of their health and extent while drawing on data from hundreds of sources worldwide. What the report's authors have found is that despite growing urbanization and a heavy reliance on palm oil cultivation across Malaysia (a practice that is often blamed for extensive deforestation), just over two-thirds of the country is still covered in forests.

In fact, with a total forest area of 22.195 million hectares today, Malaysia boasts more forest cover than it did at the turn of the new millennium, when the figure was 21.591 million hectares. In the years between the earlier FRA report in 2010 and the latest one last year, the nation's forest area rose by an annual average of 14,000 hectares.

Such findings may seem counterintuitive, since extensive deforestation has in recent years been frequently highlighted by conservationists as a major cause of environmental degradation in the country. Yet a closer look at the figures reveals a similarly positive picture. Primary forests account for 5.041 million hectares, or almost a forth (22.7%), of all forest area, whereas other naturally regenerated forests account for another 15.188 million hectares (68.4% of the total area). Planted forests, in turn, represent 1.966 million hectares, or 8.9%. According to Global Forest Watch, the figures are even more impressive. This comprehensive World Resources Institute project estimates Malaysia's forest cover to be at around 29 million hectares, or more than of 80% of land area.

"The focus on sustainable forest management has never been so high: more lands are designated as permanent forest . . . and there is an almost universal legal framework legislating on sustainable forest management," the authors of the FRA survey write apropos Malaysia. "Larger areas are designated for the conservation of biodiversity and simultaneously forests have an increasingly important role in offering products and services."

In other words, Malaysia is a world leader in forest conservation with zero total forest loss over the past quarter century, while overall biodiversity conservation has also been a relative success story in the country. "Malaysia should be lauded," Pierre Bois d'Enghien, an environmental expert, noted apropos the UN findings. "Far from the environmental pariah that some have accused it of being, it is a country that has worked hard to manage its natural resources sustainably."

4. Acknowledgements

Data:

<https://data.worldbank.org/indicator/AG.LND.FRST.ZS?view=chart>

<https://data.worldbank.org/indicator/sp.pop.totl?end=2018&start=1991>

<https://github.com/openclimatedata/edgar-co2-emissions/blob/master/data/edgar-co2-emissions.csv>

5. References:

China:

<https://www.nature.com/articles/d41586-019-02789-w>

<https://www.nature.com/articles/s41598-017-07732-5>

<https://www.downtoearth.org.in/news/forests/surprise-india-and-china-are-greening-faster-than-rest-of-the-world-63213>

<https://news.cgtn.com/news/3d3d514e304d544e31457a6333566d54/share.html>

<https://www.rapidtransition.org/stories/how-china-brought-its-forests-back-to-life-in-a-decade/>

Vietnam:

<https://news.mongabay.com/2005/11/nigeria-has-worst-deforestation-rate-fao-revises-figures/>

<https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1365-2486.2008.01575.x>

<https://www.nrcresearchpress.com/doi/abs/10.1139/er-2016-0050>

<https://news.mongabay.com/2016/12/vietnams-forests-on-the-upswing-after-years-of-recovery/>

Kenya:

Seton Stiebert, Deborah Murphy, Jason Dion and Scott McFartridge (2012). "Chapter 4:

Forestry". Kenya's Climate Change Action Plan: Mitigation

Global Corruption Report 2011: Climate Change, The plunder of Kenya's forests Archived 2015-09-12 at the Wayback Machine Resettling the settlers and holding the loggers accountable Sheila Masinde and Lisa Karanja (Transparency International Kenya) 280-282

https://trees.org/post/ikinu2_graduation/

<https://www.dw.com/en/kenya-biogas-units-running-on-cow-dung-help-farmers/a-48094546>

<https://www.unenvironment.org/news-and-stories/press-release/deforestation-costing-kenyan-economy-millions-dollars-each-year-and>

<http://www.fao.org/3/y2328e/y2328e19.htm>

<https://kenaseka.wordpress.com/2015/06/29/causes-of-deforestation-in-kenya/>

http://www.xinhuanet.com/english/2019-04/12/c_137969522.htm

http://www.xinhuanet.com/english/2018-04/17/c_137118124.htm

<https://www.independent.co.uk/voices/campaigns/GiantsClub/Kenya/how-seed-bombing-could-help-kenyas-dwindling-forests-a8470571.html>

Phillipines:

<https://opinion.inquirer.net/5809/protect-philippine-forests>

<http://www.fao.org/3/ac648e/ac648e09.htm>

India:

"India's forest, tree cover up by 1% in 2 years: Centre". 12 February 2018 – via www.thehindu.com.

"Geographical area and its effective utilization". Retrieved 27 March 2013.

"Wood and Wood Products in India" (PDF). United States Department of Agriculture, Foreign Agricultural Service. 2009.

"India's Forests: Conservation" (PDF). MoEF, Government of India. 2009.

Malaysia:

http://www.monm.edu/cac/students/2007/GP%2007%20Sample%20Essays/Coutts_GP_07.pdf

"Markets for Biodiversity - PERC – The Property and Environment Research Center".

www.perc.org. Archived from the original on 12 December 2009.

"Malaysia Forest Information and Data". [Rainforests.mongabay.com](http://rainforests.mongabay.com).

<http://www.academia.edu/Documents/in/Forestry>

Figures (Given along with results)

Tables:

A subset of our forest cover data

Country Code	Country Name	1990	1991	1992	1993	1994	1995	1996	1997	1998	...	2007	2008	2009
ABW	Aruba	2.333333	2.333333	2.333333	2.333333	2.333333	2.333333	2.333333	2.333333	2.333333	...	2.333333	2.333333	2.333333
AFG	Afghanistan	2.067825	2.067825	2.067825	2.067825	2.067825	2.067825	2.067825	2.067825	2.067825	...	2.067825	2.067825	2.067825
AGO	Angola	48.909922	48.809817	48.709712	48.609611	48.509506	48.409401	48.309296	48.209191	48.109089	...	47.208148	47.108046	47.007942
ALB	Albania	28.788321	28.717152	28.645986	28.574818	28.503650	28.432481	28.361313	28.290147	28.218979	...	28.465694	28.421168	28.376643
AND	Andorra	34.042553	34.042553	34.042553	34.042553	34.042553	34.042553	34.042553	34.042553	34.042553	...	34.042553	34.042553	34.042553