

## Review

# Nature and causes of land degradation and desertification in Libya: Need for sustainable land management

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In this article, the characteristics of desertification, causative factors and efforts to combat desertification in Libya are presented. Also, the need to mainstream sustainable land management into land use planning is highlighted which could provide a firm basis for future policy decisions to combat desertification. Libya is characterized by a desert type environment and more than 95% of the country is desert or semi-desert. The processes of desertification have been aggravated by human activities coupled with climatic conditions. This intensification of desertification is believed to affect regional as well as global climate. Currently, desertification is one of the main environmental issues in Libya affecting environment and its resources. Among others, overexploitation of natural resources, inappropriate land use planning, insufficient water resources etc. are the main factors escalating the process of desertification and deteriorating environmental quality. Mainstreaming sustainable land management into land use planning has been considered a viable solution to moderate the effects of desertification and rampant usages of natural resources. However, this requires quantifying the severity of desertification by means of identified causative factor. Development of indicators of desertification process by means of using time-series satellite data coupled with ancillary data need to be attempted to establish a monitoring system to manage desertification in more sensitive areas. Moreover, environmental and livelihood implications of increasing desertification need to be addressed in order to promote regional economic sustainable development.

**Key words:** Desertification, human impacts, Libya, natural resources, sustainable development, remote sensing, monitoring.

## INTRODUCTION

Desertification is a serious environmental problem, involving the degradation of land in arid, semiarid, and dry sub-humid areas. It is caused primarily by human activities and climatic variations (UNEP, 1991; Zhang et al., 2008). According to MEA (2005), desertification is caused by a combination of factors that change over time and vary by location. Due to its particular geographical position and extreme climatic variations, Libya is experiencing a serious problem of land degradation and

desertification. Climate change predictions for North Africa including Libya shows rising temperatures with potentially grim impact on the regions already stressed resources including water and food (IPCC, 2007). Importantly, the rate of dryland degradation and possible desertification may be further exacerbated by global climate change (MEA, 2005). Urbanization coupled with the loss of fertile soils, overexploitation of water resources, overgrazing, destruction of natural vegetation and rapid land use change are important reasons for the environmental problems in Libya. Despite the vast area of the country, most of this area lies within the warm desert climate that prevails in most of the northern part of the African continent where the desert covers 98% of its

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territory (Bin-Khayal, 1995). The only exception is a narrow coastal strip extends along the Mediterranean Sea and some mountainous areas in the north and south, where rainfall in sufficient quantities is enough for the growth of natural vegetation and cultivation of certain crops and fruit trees.

In spite of the small population of the country, the concentration in the northern region caused mankind pressure on the area, especially in marginal areas which resulted in serious environmental problems such as degradation and lowering of the groundwater table, seawater intrusion into fresh water, degradation of agricultural land and low productivity in many crops (El-Tantawi, 2005). All these factors largely contribute to the problem of desertification in Libya. It is pointed out that desertification; land degradation and drought deprive people of food and water and force millions to leave their homes. Agricultural areas have a potentially huge significance for food security as well as sustaining livelihood. Desertification of agriculture areas or pushing agriculture from non-desert to desert, not only agriculture itself may be doomed, but also alternative uses of the desert, such as controlled grazing, conservation of biodiversity, recreation, eco-tourism and tourism, are excluded (Portnov and Safriel, 2004). Impairment of agricultural ecosystems due to desertification often leaves behind an ecosystem that ceased to provide environmental services, and sometime is even impossible to rehabilitate. In Libya, agricultural practices are reported opportunistic mainly due to the country's harsh terrain, climatic conditions and limited irrigation which pose stern constraint to agricultural production. The Government of Libya has also instituted a number of agricultural research projects to promote agricultural development in the country. Researchers have also warned that the temperature increases and shifting precipitation patterns due to climate change may lead to further nitrogen losses in arid ecosystems and make arid soils even more infertile and unable to support most plant life (McCalley and Sparks, 2009). Assessment of the current global status of desertification has shown that accurate hard data, which would allow it to be stated with some precision as to which degree and with what rate of desertification is taking place in various parts of the world, are still lacking (Mamdouh, 1999). In this article, the characteristics of desertification causes and efforts to combat desertification in Libya are discussed. The need to mainstream sustainable land management into land use planning is also highlighted which could provide a firm basis for future policy decisions to combat desertification.

## LIBYA: A BRIEF OVERVIEW

Libya occupies a large area of the northern part of the African continent (Figure 1) with an area of about

1,600,000 km<sup>2</sup> (Libyan General Planning Council, 2003). Libya is located between 18 and 33° north of the latitude and 9 and 25° east of the longitude. Its climate is mainly determined by contrasting Mediterranean and Sahara climates (El-Tantawi, 2005). The Mediterranean Sea is regarded as the border from the north with a coast that has a length of 1900 km stretching from east to west (Abu Luqmah, 1995). The population of Libya in 2006 is about 5,657,692 million people according to the general census of population (Libyan General Agency of Information and Documentation, 2006). The vast area of the country and the difficult natural environment makes it impossible to develop the bulk of the area. On top of that desert conditions, water scarcity, and harsh climatic conditions have created barriers which impeded the expansion of human activity and development. As a result, the cultivated and populated areas are small and limited in comparison with the total area of the country. The desert climate prevails in the largest part of the country, with the exception of only a narrow strip extends along the Mediterranean which includes the coastal plains and the Northern highlands where the Mediterranean relative cold and rainy in winter with two transitional seasons which are spring and autumn. However, most of Libya experiences long periods of aridity and very few humid periods. Temperature ranges between high to very high in the summer and moderate to cooler in the winter and reaches the highest during the summer in August, while the lowest is recorded during the winter season in January. The climate of Libya is dry and the rainfall is almost limited to a few months of the year (that is, October to March). About 90% of the annual rainfall occurs during the cold half of the year, and nearly half of the amount falls during the months of January and February (Emgaili, 1995). Rainfall is the main feature of precipitation in Libya; nonetheless, it is very erratic and limited (El-Tantawi, 2005). Given this sporadic rainfall pattern, agriculture production in Libya is highly reliant on irrigation. Rainfall in Libya is very infrequent, thus limited dependence on rainfall for agricultural production. For example, only 32% of wheat, 38% of barleys, 25% of dates, 29% of pulses, 34% of vegetables and 24% of olives are produced under rain-fed conditions (FAO AQUASTAT, 2005). Hence, climatic conditions severely limit agricultural production in Libya. Average annual rainfall distribution in Libyan territory is presented in Table 1.

Libya like many Mediterranean regions, also experiences more drought and water deficits that play a major role in the process of desertification. Moreover, Abufayeda and El-Ghuelb (2001) reported that this deficit will undoubtedly increase in the future in response to the continuous population growth and corresponding increase in water requirements for domestic, industrial and agricultural purposes. Currently, the water demand exceeds the conventional water resources capacities markedly creating an urgent need for integrated water

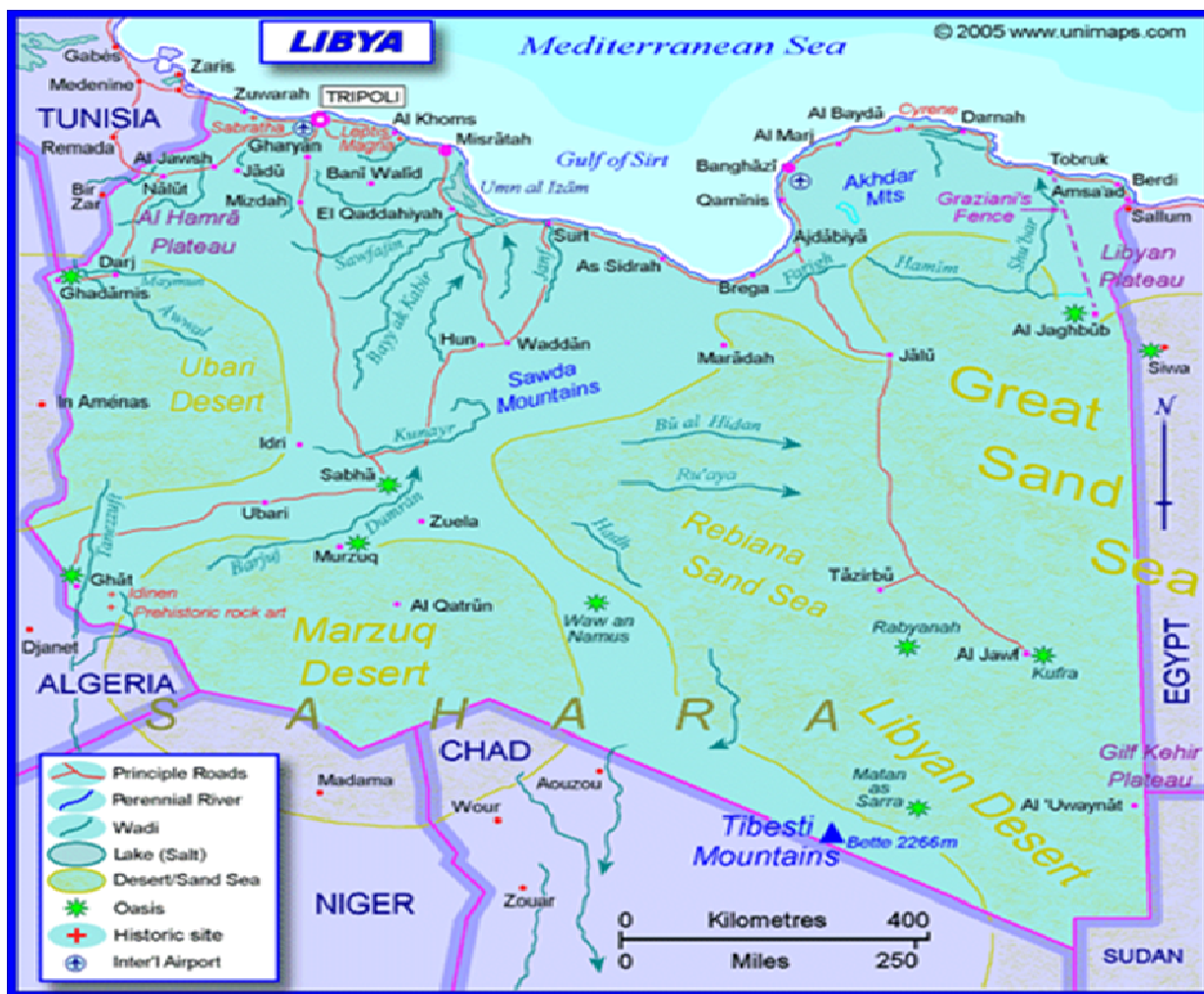


Figure 1. Distribution of desert in Libya.

Table 1. Area as per Aridity zones of Libya.

Aridity zone	Average annual rainfall (mm)	Land area (000' km <sup>2</sup> )	% Total area
Very dry	< 50	1589	90.8
Dry	50 – 200	130	7.4
Semi-arid	200 – 400	26	1.5
Sub-humid	>400	5	0.3
Total		1750	100

Source: ACSAD (2004).

resources management with special focus on non-conventional water resources namely; sea water desalination and wastewater reuse (Wheida and Verhoeven, 2007). This situation of water deficit is becoming more problematic with rapidly increasing population and low rainfall. The high temperatures and low precipitation resulted in low vegetation cover, increased soil erosion

and land degradation at large scale and put the region on highest desertification risk. The annual rate of evaporation is about 1700 mm near the sea and 6000 mm in the central and southern regions (Libyan General Planning Council, 2003). Groundwater is the main source of water supply in Libya, and represents more than 97% of the total water consumed for different purposes. Groundwater

**Table 2.** The water situation in Libya (1990 to 2025).

<b>Sector-wise demand</b>	<b>1990</b>	<b>2000</b>	<b>2010</b>	<b>2020</b>	<b>2025</b>
Required (million m <sup>3</sup> )					
Agriculture	4275	4800	5325	5850	6640
Drinking	408	647	1015	1512	1759
Industry	74	132	236	422	566
Total	4757	5579	6576	7784	8965
Available					
Renewable water	500	500	500	500	500
Non-traditional sources	105	127	155	188	208
Artificial river	-	1642	2226	2226	2226
Total	605	2269	2881	2914	2934
Deficit	4152	3310	3695	4870	6031

Source: Fadel et al. (1995); Abu Luqma (1995).

in Libya is classified into renewable groundwater and non-renewable underground water. Safe water extraction is estimated about 3000 million cubic meters per year (Libyan General Planning Council, 2003) and located in five major water basins. Table 2 shows water situation in Libya from 1990 to 2025. In general, Libya is regarded as one of the areas with low density of natural vegetation due to lower annual rates and irregular distribution of rainfall. Additionally, overgrazing has also increased the process of destroying natural vegetation cover and land degradation in many parts of the country. Eventually, this has increased the severity of desertification problem and environmental degradation.

## CAUSES AND CONSEQUENCES OF DESERTIFICATION

In recent decades, Libya has witnessed enormous development in various fields, particularly in the sectors of agriculture and industry. However, such development has put negative effects on local ecosystems, especially in sensitive and fragile areas due to change in production patterns, and the need to provide food requirements for the growing population. Consequently, this lead to the intensification of pressure on already limited natural resources, and thus escalating land degradation and desertification problems. There are several natural and human factors that cause land degradation in Libya (Ben-Mahmoud et al., 2003). The natural factors include changes in climate, mainly rain, wind and temperature. Climate varies from one setting to another in response to changes in external and internal influences in the air system (Emgaili, 1993). There have been significant climate changes through geologic time on the African continent, in which wet and dry ages succeeded. Dry

ages led to the emergence of the Sahara, and the current climate of the area is a continuation of the dry climate, which began since the emergence of the Sahara, with a general tendency towards more droughts in the past years. Therefore, the frequent wind and water erosion are symptom of land degradation and desertification in Libya (Emgaili, 2003). Although, climatic factors play an important role in the spread of the phenomenon of desertification, human activity causes the deepening of the effects of drought on environmental resources and human beings. Many human factors are combined contributing to the deterioration of environmental conditions and the occurrence of desertification in Libya. The increasing pressure of population on natural resources (example water, soil, vegetation), poor management and over exploitation of natural resources by entities or individuals, mainly led to desertification. Anthropogenic factors causing deterioration of soil and vegetation in Libya include: (i) overexploitation of water resources (ii) rangeland conversion cropland (iii) deforestation and the removal of natural vegetation (iv) over-grazing in marginal areas (v) misuse of the soil on arable land, and urbanization (El-Tantawi, 2005; Emgaili, 2003; Libya General Planning Council, 2003).

Desertification results in a variety of negative environmental, economic and social impacts, directly or indirectly (Nahal, 1987). Consequently, the productivity of natural pastures, forest and agricultural land is decreasing. In periods of successive drought, the problem is considered acute and a significant decrease in the production per hectare of grain in the dry and marginal areas in the Arab world is observed. Moreover, deterioration of the pastoral environment causes a decline in the productivity of live-stock and thus, reduces the productivity of meat and milk. Desertification is accompanied by deterioration in soil fertility, change in its physical and chemical properties

and vulnerability to water erosion (Arab League, 2003). This may cause a decrease in the volume of agricultural resources loss and decrease of the area of arable land, which ultimately has negative socio-economic consequences. The shrinking of forest lands and natural pastures due to deforestation leads to a vicious circle in which there is an increase in the number of animals beyond the carrying capacity, leading to the importing of animal feeding from abroad, and severe economic losses. That impacts on national income (Nahal, 1987). Desertification also leads to many environmental impacts. A major consequence of desertification at the local and global level is the reduction in biodiversity, since it contributes to the destruction of the habitats of animal and plant species and micro-organisms (Abahussain et al., 2002). Biodiversity loss is also expected to encourage the genetic erosion of local livestock and plant varieties and species living in fragile ecosystems. Libya is no exception.

#### **EFFORTS TO COMBAT DESERTIFICATION**

Since the early sixties, serious measures have been taken to combat desertification in Libya at the best possible way (Bin Mahmoud, 2000). These measures were part of a broad policy in the framework of National Plan for Agricultural Development which takes into account the objectives of local development on the one hand, and harsh environmental conditions prevailing in the country on the other. These measures include curbing sand dunes, establishment of windbreaks, reforestation of fallow forest land, establishment of terraces to combat soil erosion, preservation of rain water on sloping agricultural land, and follow the special agricultural cycle to maintain soil fertility, especially in the areas of cultivation of grain, as well as the protection and improvement of natural pastures (Nahal, 1987). Literature shows that in spite of the success of some attempts to achieve the desired objectives, others did not meet the same success due to the lack of relevant laws and legislations concerning the protection of the environment (Libyan Department of Urban Planning, 2005). However, adopting better land use management practices could slow down the desertification process. Libya has adopted a lot of measures and actions to reduce the desertification during the past four decades. Major desertification controlling strategies can be summarized in the implementation of a range of diverse projects by government in many areas (that is, forest, pastures, sand dune fixation, soil and water conservation, resistance to erosion and integrated agricultural development). Libya has given a great attention to development and conservation of water resources by adopting a short term and long term strict policy to prevent a serious drain of water resources. There are many other actions that contribute to the

protection of soil and maintain soil fertility, such as, following the method of crop rotations to maintain soil fertility, especially in the areas of expansion in the cultivation of grain; reforestation of waste lands; protecting and improvement of natural pastures; the creation of economic non-agricultural activities, especially in areas threatened by agricultural depletion or degradation of quality (Libyan Department of Urban Planning, 2005). Libya has paid a great attention for pastures improvement and development as well as the establishment of pastoral projects based on scientific methods to ensure the preservation of ecological balance. Wise attempts have been made to regulate grazing and rehabilitation of degraded lands by a number of programs. Considerable efforts are made to reforest lands threatened by erosion and desert encroachment in order to maintain the natural ecological balance. These include protecting land and soil, and providing some of the requirements of forest products, combating unjust cutting of forests and developing the existing forests to increase their productivity, establishment of nurseries to meet the needs of the citizens for seedlings, supporting small forest planting, windbreaks, and protective barriers, as well as meeting the needs of public projects when establishing new forests, and filling the requirements of afforestation and roads are amongst the important efforts. Moreover, determining access rights, and preventing the cutting of some species, protecting them from insect damage, and the organization of grazing in natural forests are among significant initiatives (Libyan General Planning Council, 2003). For reforestation of degraded and deforested areas to compensate the losses, the country has witnessed campaigns of tree planting from the 1990s onwards, including most of the desertified and degraded lands for the purpose of balancing natural ecosystem, land rehabilitation establishment of national parks and wildlife reserves to maintain biodiversity and prevent extinction of rare animals and plants, and issuing legislations and laws for the protection, development and investment of forests. Failures of resource management policies are aggravated by overgrazing, overexploitation of water and land resources, over-cultivation of marginal lands, deforestation, and the use of inappropriate technologies.

#### **ESTABLISHMENT OF LEGAL PRINCIPLES**

Establishment of a global network of national, regional and international institutional and technical facilities for current operational assessment and continuous monitoring of desertification has been effectively debated in many environmental research forums. A pressing and constant need was felt to develop laws and legislative enactments to serve as an appropriate framework for the efforts made to combat desertification and achieve the

**Table 3.** Important Law and Legislations regarding environment and natural resources in Libya.

<b>Law and Legislation</b>	<b>Main objective</b>
Law 15 of 1992	Protection of agricultural lands, pastures and forests and converting them to irrigated agricultural lands.
Law 72 of 1988	Establishment of the Arab Center for Desert Research and development of desert communities.
Law 15 of 1984	Protection of animals and trees, and to prevent hunting wild animals, and the prevention of trees cutting because of urban expansion.
Law 1 of 1983	Agricultural inspection.
Law 790 of 1982	Organization of drilling operations and the preservation of water sources.
Law 7 of 1982	Protection of the environment.
Law 5 of 1982	Protection of pastures and forests.
Law 827 of 1980	The establishment of the General Authority for Scientific Research and its bodies specialized in various fields.
Law 46 of 1972	Protection of shrub land.
Law 26 of 1972	The establishment of a public board of water responsible for proposing public policies and legislations concerning water, and follow up their implementation, as well as overseeing the follow-up projects related to water abstraction, digging wells and methods of using them.

objectives and requirements of sustainable development. In 1977, the United Nations Conference on Desertification (UNCOD) adopted a Plan of Action to Combat Desertification (PACD). Also, the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992, called upon the United Nations General Assembly to establish an Intergovernmental Negotiating Committee (INCD) and Convention to Combat Desertification in affected countries, particularly in Africa. Libya has ratified important international agreements on environment, like biodiversity, climate change and desertification. There are several pieces of legislation to protect the environment, natural resources including agricultural, pastures, urban development, rationing water and soil use, protection of renewable and non renewable natural resources etc. Few of these legislations are included in Table 3. In light of these and other laws and legislations, it was possible to achieve many of the objectives of combating desertification and halt desert encroachment, and maintaining the ecological balance while conserving biodiversity, both in terms of legislative or operational terms. However, the enactment of policy, laws and legislations need to be assessed properly through appropriate framework.

## CONSTRAINTS AND PROSPECTS

Despite the efforts and achievements made so far, the factors and causes, manifestations and harmful effects of desertification need special attention in Libya. Researchers, natural resources managers and conservationists highlighted a number of obstacles and challenges that need to be confronted by all possible means including: (i) Scarcity of water resources and successive seasons of drought, which limit the success of agricultural projects, land reclamation and cultivation (ii) Increasing the level of food deficit as a result of rapid population growth, and the widening gap between production and consumption rates, and the continued expansion of urban areas which causes damage to agricultural production (iii) Erroneous practices of population and unorganized exploitation of natural resources without paying any attention to preserve them (iv) Incorrect application of the provisions and legal regulations and legislation governing relations between citizens and natural and environmental resources (v) The absence of a comprehensive database of natural resources in terms of importance and restriction for their uses, and (vi) Weakness of skilled manpower and specialized staff in the field of protection of natural

specialized staff in the field of protection of natural resources and combating desertification (Libyan Department of Urban Planning, 2005). Climate change will result in extreme weathers for the region affecting both the intensity and frequency of climate factors such as temperature, precipitation, rainfall and droughts (IPCC, 2007). In Libya, water scarcity is endemic and changes in precipitation could pose a strain to freshwater resources, vegetation and desertification (El-Tantawi, 2005). Currently, many areas became prone to land desertification and the situation even may go worst if climate change and human activities continue to trigger land degradation in the country. Climatic factors contribute to both desertification and the scarcity of water; and no doubt global warming is exacerbating these problems. As far as possible solutions to desertification is considered, many researchers highlighted that these problems can be tackled by re-planting tree in shelter belts as a major afforestation programmes, planting grasses to stabilize the soil and halt wind and water erosion, and obviously adopting proper crop rotation and use of manure as a fertilizer, as a good farming practices. Rehabilitating all of the desertified land in the world is not economically profitable. However, if people stop misusing the land and overexploitation of resources beyond the carrying capacity, desertification can be controlled at large extent and management practices can be implemented more effectively.

## CONCLUSION

Sustainable development and sustainable living includes social, economic and environmental considerations and dimensions. Desertification and climate change modify all these dimensions, and therefore alter potential development goals and efforts (Seely et al., 2008). As the degree and types of desertification varies from one country to another within the region, land management has been acknowledged to be extremely important in desertification prone areas. Understanding the desertification process more explicitly requires detailed knowledge about where desertifications occur, spatial as well as geographic gradients. Climate change is expected to decrease water availability and water quality, increase droughts, floods and salinity leading to decrease in soil fertility and loss of vegetation threatening food security. The increasing pressure on resources by people in addition to the severe climate and low soil fertility has rendered the ecosystems even more fragile, and in some places their renewal is jeopardized. It is reported that the progression of desertification is making the recovery of vegetation on cleared and abandoned land impossible, so human assistance through soil preparation, use of fertilizer and watering during regeneration and careful monitoring is needed. The remote sensing (RS) technology with its multi-temporal,

multi-spectral, synoptic and repetitive coverage can provide valuable information on intensification of desertification, real magnitude of desertification and its changes over time. To date, there are few studies of desertification monitoring in Libya using RS/GIS tools (Abahussain et al., 2002; Emgaili, 2003, El-Tantawi, 2005), but comprehensive studies are still awaited. To provide useful information on the prevailing desertification situations in Libya, areas having exceptionally high magnitude of desertification need to be delineated with the help of RS/GIS tools. These geospatial tools could help in tracking landform changes to create and update maps for managing land utilization effectively and sustainably.

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