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The Unexplored Jewel of Desert: Prospective Role of Thar Desert in Ecological and Socio-Economic Development of Pakistan

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***Abstract*— The Thar Desert is a large, arid region in the northwestern part of the Indian subcontinent and forms a natural boundary running along the border between India and Pakistan. The purpose of this study is to analyze and present favorable and viable conditions for formulating and implementing afforestation plan in Thar Desert of Pakistan. Afforestation of Thar Desert apart from provision of employment, wood and charcoal supply, habitats for wildlife, and ecotourism opportunities, may also play a significant role in overcoming ecological, environmental, and other soil related issues. The 'prospective desert' could also serve as home for medicinal plants and in protecting form further desertification as well as soil erosion.**

Keywords— Thar Desert, afforestation, soil erosion, desertification, socio-economic development, ecology, Pakistan

1. INTRODUCTION

The surface of planet earth consists of water, forests, arable land, arid land, mountains, and deserts. Apart from the area covered by oceans, approximately 29 percent of the earth's surface is land. This land is not of same type from North Pole to that of South. Mountain ranges, forests, arid/semi-arid land, and deserts represent this 29% (Geographic, 2013). Every part of land stated above plays its role in unique ecological, social, and/or economics progress of a particular geographic area. Located in South Asia, Pakistan is also characterized by these different types of land. Moving from North to south, one can see mighty mountains of Karakoram, Hindu Kush in Giglit-Baltistan, planes in some areas of Khyber Pakhtunkha, Punjab, Sindh, and Baluchistan accompanied by several big and small rivers. Nature has also beautified this country with forests as well as deserts in different geographic areas thus providing diverse ecoregions.

Total area of Pakistan is 796,095 KM^2 out which 2.87% is water and rest of this is land. However, the only 26% of land area is arable since Pakistan's land is also characterized by mountains, forests (3%), and desert (21%). Given that, Pakistan is an agrarian economy and about 65% of its population is living rural area, about 45% of its labor force is engaged in agriculture and contributing 25% in GDP (CIA, 2014).

Despite the fact that economy of Pakistan is growing (3.6% GDP growth rate for 2013) the country is still victim to various political, social, geographical, ecological, environmental, energy, and economic problems. Increasing rate of people living under poverty line, electricity and gas load shedding, stock market and currency fluctuations, poor transportation and logistics infrastructure, terrorism, drought, flood, and collapse of tourism industry are few examples that picture the consequence of the problems stated above. If we have a look on recent economic, social, environmental, and political trends it is clear that a country rich in natural resources is unable to prevent itself from such shocks because of either negligence or un-realization of its resources (Karakıkçık, 2004, 191). For instance, more than 24 districts of four provinces has been drowning every year into water for last few years in rainy season causing a loss of more than 50 billion dollars each year. These floods affect about 20 million people by destruction of infrastructure, damage of crops and property. The interesting thing is that these areas also suffer from insufficient water supply for agriculture in other days of the year; presenting a good example of bad governance. Construction of dams and barrages, and plantation of forest can not only become a solution to flood management but also be benefitted for other purposes such as electricity production and water supply to the industry and agriculture.

Contrary to it, south eastern region situated in Thar Desert and Cholistan, and considerable area of Baluchistan suffers from monster of drought. A recent crisis in Tharparker district (located in Thar Desert) began when hundreds of animals died few months ago followed by subsequent death of children because of food scarcity. This drought is not a new thing for the habitants of the desert as they have been experiencing similar conditions for several years. Droughts do not come across instantly rather a "creeping phenomenon" resulting from deficiency in water level either on surface or underground. Causing from persistent below average precipitation, drought substantially affects ecosystems and agriculture thus bringing harm to local community and economy (Karakıkçık & Erkul, 2002, 32). Now, here are two

opposite situations in different parts of Pakistan one is characterized by flood and other by drought. Both are extremely dangerous for any territory and need a wise log-term policy to cope with.

The purpose of this study is not to address contemporary problems of Pakistan but to analyze and present favorable and viable conditions for formulating and implementing afforestation plan in Thar Desert of Pakistan. Afforestation apart from provision of employment, wood and charcoal supply, habitats for wildlife, and ecotourism opportunities, it would also play a significant role in overcoming ecological, environmental and soil related issues. The prospective desert could also serve as home for medicinal plants and in protecting form further desertification as well as soil erosion. The study is structured as follows. Next section describes a brief history, geological and ecological facts. Following section discusses the plants and trees and their characteristics that are feasible to be cultivated in particular regions of Thar Desert. Next section is on potential benefits of afforestation which it possibly would bring to the region. Last section summarizes the study and also discusses study limitations.

2. THE THAR DESERT

The Thar Desert is a large, arid region in the northwestern part of the Indian subcontinent and forms a natural boundary running along the border between India and Pakistan. With an area of more than 200,000 KM2, it is the world's 17th largest subtropical desert (Britannica, 2014). Thar Desert extends from the Sutlej River, surrounded by the Aravalli Ranges on the east, on the south by the salt marsh known as the Great Rann of Kutch (parts of which are sometimes included in the Thar), and on the west by the Indus River. Its boundary to the large thorny steppe to the north is ill-defined. It lies mostly in the Indian state of Rajasthan, and extends into the southern portion of Haryana and Punjab states and into northern Gujarat state.

In Pakistan, the desert covers eastern Sindh Province and the southeastern portion of Punjab Province, where it joins the Cholistan Desert near Bahawalpur. The Tharparkar District is one of the major parts of the desert area. Tharparkar consists of two words: Thar means 'desert' while Parkar stands for 'the other side'.

2.1. Origin of the Desert

The origin of the Thar Desert is a controversial subject. Some consider it to be 4000 to 10,000 years old, whereas others state that aridity started in this region much earlier. Another theory states that area turned to desert relatively recently: perhaps around 2000 - 1500 BC. Around this time the Ghaggar-Hakra ceased to be a major river. It now terminates in the desert but at one time was a water source for the Indus Valley Civilization center of Mohenjo-daro. It has been observed through remote sensing techniques that Late Quaternary climatic changes and neotectonics have played a significant role in modifying the drainage courses in this part and a large number of palaeochannels exist.

Most studies did not share the opinion that the palaeochannels of the Sarasvati River coincide with the bed of the present-day Ghaggar and believe that the Sutlej along with the Yamuna once flowed into the present riverbed. It has been postulated that the Sutlej was the main tributary of the Ghaggar and that subsequently the tectonic movements might have forced the Sutlej westwards, the Yamuna eastwards and thus dried up the Ghaggar-Hakra.

Studies on Kalibangan in the desert region by Robert Raikes indicate that it was abandoned because the river dried up. Prof. B. B. Lal (retd. Director General of Archaeological Survey of India) supports this view by asserting: "Radiocarbon dating indicates that the Mature Harappan settlement at Kalibangan had to be abandoned around 2000-1900 BCE. And, as the hydrological evidence indicates, this abandonment took place on account of the drying up of the Ghaggar-Hakra. This latter part is duly established by the work of Raikes, an Italian hydrologist, and of his Indian collaborators".

2.2. Climate

The district has a tropical desert climate. In summer, it is extremely hot during the day, but nights are remarkably cooler. April, May and June are the hottest months during the day; December, January and February are the coldest months. The mean maximum and minimum temperature during this period are 28°C and 9°C, respectively. There are wide fluctuations in the amount of rainfall from year to year and the yearly average for some areas is as low as 100 mm. Most of the rain falls between July and September, during the south-west monsoon, and is often concentrated in a period of two to three days.

The climate of Thar Desert is dry hot with little rain. The mean annual rainfall over the Thar is 150 -250 mm (Times, 2013). However the Indian part of the desert receives up to 500 mm rain in some regions. The pattern and scale of the rainfall in Tharparkar can be described in the framework of two parameters; the intensity and the frequency of rain. The rainfall in Tharparkar mostly occurs in monsoon season between June and September and varies between 50 to 300 mm. The main crops in the area are sown immediately after the rain mature in a spell of two to three months. Harvesting, stocking and marketing the crops along with feeding the animals in the grazing lands with dry grass for the rest of the year characterize the post monsoon season. Such a pattern of rainfall in that context also supports the range lands of the arid zone to grow seasonal grasses for the whole year. In addition, it also recharges the thin fresh-water layers and provides an opportunity for collecting the surface water in open ponds. Thus, such a pattern of seasonal calendar offers sole opportunity to the people of Thar for securing their subsistence of the whole year only in four months.

This crucial period determines the economic security and social credibility for the people in the arid zone. The unpredictable rains normally vary with in frequency and intensity in terms of area and time. The pattern in the consecutive four years in the central part of Thar has varied between 50 to 186 mm in intensity and 1-5 in frequency (Shaikh, 2003). The winter rains are insignificant. Dust storms are common, with winds of 140 to 150 km/hr from April to June in the desert. The maximum temperature rises to over 45C during the hot months of April, May and June. The mean maximum and minimum temperatures average 35C and 19C, respectively, over the year (Nayyer Alam Zaigham, 2003).

2.3. Geographic Area of Thar

The Thar region forms part of the bigger desert of the same name that sprawls over a vast area of Pakistan and India from Cholistan to Nagarparkar in Pakistan and from the south of Haryana down to Rajasthan in India.

The Tharparkar district is mostly desert and consist of barren tracts of sand dunes covered with thorny bushes. The ridges are irregular and roughly parallel, that they often enclosed sheltered valleys, above which they rise to a height of some 46 meters. These valleys are moist enough to admit cultivation and when not cultivated they yield luxuriant crops of rank grass. But the extraordinary salinity of the subsoil and consequent shortage of potable water renders many tracts quite uninhabitable. In many of the valleys the subsoil water collects and forms large and picturesque salt lakes, which rarely dry up.

The only hills in the district are at Nagarparkar on the northern edge of the Rann of Kutch, which belongs to quite a different geological series. It consists of granite rocks, probably an outlying mass of the crystalline rocks of the Aravalli Range. The Aravalli series belongs to Archean system which constitutes the oldest rocks of the earth's crust. This is a small area quite different from the desert. The tract is flat and level except close to Nagarparkar itself. The principal range, Karoonjhar Mountains, is 19 km in length and attains a height of 305 m. Smaller hills rise in the east, which are covered with sparse jungle and pasturage and give rise to two perennial springs named Achleshwar and Sardharo as well as temporary streams called Bhetiani and Gordhro, after the rains.

On the south of the district is the great Rann of Kutch, an immense salt lake. It is a flat land, almost at sea level, covered with thick layer of salt which has been left by evaporation of sea water over the centuries. During a monsoon it becomes almost part of the sea owing to influx of sea water at Lakhpat Bander on Kori mouth of the Indus River and other places. During winter it mostly dries up and surface is covered with salt. At places where the land rises up by a few metres, it becomes an island and is thus called "bet". The most important cities are Mithi, Islamkot, Chachro, Nagarparkar, Dano Dandal. While Mithi is noted as one of the most advanced cities of Tharparkar, compared to other cities of world it is tantamount to an African village.

There is no river or stream in the district. However, in Nagarparkar there are two perennial springs named Acbleshwar and Sardharo as well as temporary streams called Bhetiani River and Gordhro River after the rains.

2.4. Religion

It is the only district in Pakistan with significant Hindu population. According to the 1998 census, Muslims constituted 59.53% while the Hindus were 40.47%. At the time of independence of Pakistan in 1947, the Hindus were 80% while the Muslims were 20% of the population. According The significant number of Hindus migrated to India during the 1965 and 1971 wars between Pakistan and India (FindPK, 2014).

2.5. Rivers and Streams

There is no river or stream in the area. However, in Nagar Parkar there are two perennial springs named Acbleshwar and Sardharo as well as temporary streams called Bhetiani River and Gordhro River after the rains.

2.6. Plants of the Thar Desert

The climatic conditions in Thar are not as harsh as in the other deserts. It has diverse ecosystem and hence even though it is arid it is rich in comparison to other deserts. Natural vegetation includes shrubs, herbs and thorny trees such as acacia.

2.7. Animals of the Thar Desert

The Black buck (Antilope cervicapra), the Indian wild ass (Equus hemionus khur) and the Indian gazelle (Gazella bennettii) are found in large numbers in the desert. Other varities include the wild cat and the red fox. About 141 species of resident and migratory birds are found in this desert. Eagles, falcons, vultures, buzzards, harriers and kestrels are some of them. Besides all these desert wild animals, inhabitants of the desert also keep animals like camel, sheep, goats, and cows. Peacock is pride of Thar Desert, and eternal enemy of snakes. Thus peacocks are found to be more than one hundred thousand in Thar Desert of Pakistan.

3. THAR GEOGRAPHY

The Thar Desert lies in the southeastern part of Pakistan, on the western edge of the stable Indian Peninsula. The whole area is covered with extensive & thick cover of dune sands, extending down to an average depth of 80m. Surface rock exposures are almost absent, except limited outcrops of granitic basement in Nagarparkar. A few scattered outcrops of Mesozoic and Tertiary strata are exposed across the Indo-Pakistan border in the Jaisalmer and Rann of Kutch areas of India. Due to lack of surface-exposures of the prevailing subsurface geological sequences, the

geology of the Thar Desert has been poorly understood. Mainly, geophysical and drilling data have provided subsurface geology. The interpretation of seismic-data (Zaigham & Ahmad, 1996) shows that the Thar Desert rests upon a structural platform where granitic basement is at shallower depths. The granite basement has pre-Jurassic rifting, which caused flexure and the ultimate development of the Thar basin. The basement shows rise towards southeast and deepening towards northwest, as a result of Paleozoic-Mesozoic divergent tectonics.

The consistent depositional trends of the stratigraphic sequences from Mesozoic to Tertiary periods indicate that the incipient rifting of the basement was pre-depositional. The younger formations are preserved and overlie the older in the northwestern part, where geological sequences are well developed. The older formations may be encountered at greater depths towards the basin and shallower on the continental shelf area towards southeast.

Results of the geo-electric, drilling and geophysical/geological log data (Rehman et al., 1993) indicate four major divisions of lithological sequences almost throughout the Thar Desert.

3.1. Dune Zone

This zone consists of well-sorted eolian sand. The soils of the desert contain about 8 % clay and silt, near the surface and about 15 % clay and silt in the subsoil (Kazmi, 1985). The thickness of this sand-zone varies from north to south. It is thinner in the northern part of the desert, about 5 to 15 m thick in Gadro-Khokhrapar area. The thickness increases from about 40 to 93 m in the central and southern Thar in Chachro-Islamkot-Mithi area.

3.2. Oxidized Zone

It consists of compact and loose clays, silts and sands with ironstone concretions and siderite nodules. This litho-unit is distinguished from other subsurface units by its iron oxide and limonite staining. The thickness of this zone ranges from 11 to 209 m. The age of this unit is considered Sub-Recent (Fassett & Durrani, 1994). This oxidized zone lies uncomfortably over the coal-bearing formation.

3.3. Coal-Bearing Formations

The coal-bearing sequence consists of clay stones, siltstones, sandstones and lignite, with intercalations of siderite bands, nodules and granite-wash at places. The thickness of this sequence ranges from zero to 185 m, hosting lignite beds with a cumulative thickness ranging from 0.5 to about 34 m.

3.4. Basement Complex

Granitic basement is encountered at depths ranging from 112 to 279 m in holes drilled in the east and southeast of Chachro (Fassett & Durrani, 1994). On the other hand, rhyolitic/basaltic basement was reported in other hand, results of the deep vertical electric soundings (VES) indicate two trends of apparent resistivity values at different sites in the area south of Chachro. One trend indicates massive granitic basement and the other trend reveals the presence of layered Archean metasediment was reported in a well near Pabban locality, about 8 km south of Gadro. Further south along the border with India, the dioritic basement was reported, encountered at 253 m depth in a drill hole. Based on the geo-electrical resistivity survey, this basement complex, having high resistivity of 50 to 150 Ωm, was interpreted to be a deep fissured sandstone aquifer, bearing fresh water, by Schildknecht & others (1991) under the WAPDABGR Groundwater Exploration Project. On the other hand, results of the deep vertical electric soundings (VES) indicate two trends of apparent resistivity values at different sites in the area south of Chachro. One trend indicates massive granitic basement and the other trend reveals the presence of layered Archean metasediments.

3.5. Hydro-Geological Conditions

There is no surface perennial water available in the Thar. Based on the results of dug wells' inventories, covering about 8500 km2 area between Gadro and Virawah in the eastern Thar along the Pakistan border, it is observed that the perched aquifers are hosted in friable sandy/salty layers sealed underneath by clay layers. The depth to water-table varies from 5 to 15 m in and around Gadro area, 30 m to 45 m in Chachro area and goes even deeper in areas west of Chachro. Their thickness and lateral extent are limited. The majority of the dug wells have a depth to groundwater ranging from 20 to 80 m. In general, the quality of groundwater ranges from saline to brackish.

3.6. Groundwater Quality

In Thar Desert, the ground water tapped by 83% of dug wells has an electrical conductivity (EC) value ranging from 2000 µS/cm to more than 10,000 µS/cm. Thus, under normal standard, such quality of water is unfit for human consumption, but the water with EC of 5,000 µS/cm is considered drinkable under duress for the arid region. As such, 48 % of the water in the dug wells may be considered fit for human consumption in the area. Figure-9 shows the distribution of electrical conductivity (EC) of groundwater in the Thar Desert. The distribution-pattern indicates three prominent good-quality groundwater zones. In the northern part, EC values less than 3000 µS/cm prevail, exclusively associated with the perched aquifers encountered in the shallow dug-wells. The perched aquifers contain mostly fairly good to brackish groundwater, but show extreme lateral variation in ground-water salinity over small distances.

The area between Gadro/Khokrapar and Chachro is dominated by EC values greater than 10,000 µS/cm, indicating poor groundwater prospects. In the central part, south and southeast of Chachro extending from Pakistan-India border to Islamkot, EC values between 2,000 and 5,000 µS/cm are found, particularly in the relatively deeper aquifer(s). The

hydrogeological data indicate good groundwater prospects, particularly associated with deep-seated sedimentary aquifers. Another good prospective area is reflected by the EC values ranging from less than 2,000 to 3,000 µS/cm, in and around Nagarparkar, where the basement units are exposed. In the area between the central zone and Nagarparkar, EC measurements of the dug well water (values mainly range from 5,000 to 10,000 µS/cm) indicate brackish to saline water- quality. In this area, deep sedimentary aquifers have not been explored in detail.

Occurrences of better groundwater (EC: < 2000 µs/cm) are associated only with the exposed granite unit in Nagarparkar area, where basement is exposed otherwise no good-quality groundwater is so far exploited, associated with the basement at deeper depths throughout the Thar region. At places, vertical electric soundings have indicated good prospects for the good quality groundwater associated with the basement complex.

4. AFFORESTATION

Afforestation is the establishment of a forest or stand of trees in an area where there was no forest. Afforestation refers to the conversion of wasteland into a woodland or forest. It is essentially the transformation of land which has not been forested for a period of more than 40 year to woodland through seeding and planting. Afforestation is the best technique used to minimize the greenhouse effect. Therefore, there is constant necessity to develop afforestation programs in order to preserve and protect the forestry including the wasteland. A massive afforestation program is required to meet the increasing demand of fuel wood, timber and fodder. Afforestation is also essential to prevent the earth from environmental hazards resulting in form of greenhouse effect, global warming, flood, soil erosion, and desertification. Rapid increase in population and industrialization made inevitable need of oxygen.

4.1. Afforestation in Thar Desert

Like rest of world Pakistan is also victim to environmental pollution, desertification, rapid soil erosion, and deforestation. Afforestation not only prevents a geographic region from hazards discussed above but also sources for economic development. Woods could be used for domestic use as well as for commercial purposes. Commercial purposes could be use of trees as paper pulp, timber, coal, and other energy resources. The herbs cultivated in these forests could be used for medical purposes thus provision of a rich source of medicines.

Pakistan is already facing problem of deforestation, as Pakistan is using forests for energy production and paper production. Forestry in Pakistan is facing a 3% decline for last one decade. Increase in population is also a cause to replace forest land with agri-land. It is a critical situation for Pakistan and needs prompt action in due course. Since 21% of Pakistani land comprises of deserts, Pakistan can make proper use of these desert lands for afforestation. Of particular, the region of Thar Desert and Cholistan could be best for the purpose because these deserts are arid and semi-arid and world's most populated desert. Moreover, ground water is far away from surface and not good enough in most area to be used for agriculture. Thar region of Pakistan and Cholistan's agriculture is dependent on monsoon rain. If it rains these regions become green but if there is no rain these regions victim to drought and famine. If some initiative are taken to make deserts green, as India did and faced huge success, the future of these deserts and their inhabitants could be changed forever only within few decades.

Although afforestation in deserts is not as easier as in arable region abundant in water but still there are variety of flora that has proved compatible and consistent with Thar Desert's climate and other related conditions. Thus promoting plantation of these species of trees and plants could play a vital role in greening of Thar Desert as well as Cholistan. The description of these plants and trees is discussed in lines below.

4.2. Trees and Plants for Afforestation

Here is detailed discussion about some important trees and plants that could be grown as a part of afforestation and bring green revolution in the deserts.

4.2.1. Jojoba

Jojoba has very promising scope for cultivation in the desert even in the relatively hot weather. Its nature withstands the hot weather in summer, warm weather in winter, low fertility of soil and low water resources. It needs less than one quarter the amount of water needed for olives with great ability to withstand the high salt in the soil. The payback for planting Jojoba is encouraging. To be used as fuel it needs to be cultivated in huge amounts which are easy in desert land in many countries. Soil texture is important as jojoba grows best in sandy or decomposed granite or rocky soils and slowest in heavy clay soils such as adobe. Even if the fertility of the soil is marginal, jojoba is still able to produce well without the use of fertilizers. However, jojoba plants kept in containers seem to do better with some fertilization. However, it is also used only to prevent desertification (Sharma, 2000).

Jojoba grows, to 1–2 meters (3.3–6.6 ft) tall, with a broad, dense crown, but there have been reports of plants as tall as 3 meters (9.8 ft). The leaves are opposite, oval in shape, 2–4 centimeters (0.79–1.57 in) long and 1.5–3 centimeters (0.59–1.18 in) broad, thick waxy glaucous gray-green in color. The flowers are small, greenish-yellow, with 5–6 sepals and no petals. It tolerates lack of water, salinity and poor-nutrient soils.

Jojoba foliage provides year-round food opportunity for many animals, including deer, javelina, bighorn sheep, and livestock. The nuts are eaten by

squirrels, rabbits, other rodents, and larger birds. Only Bailey's Pocket Mouse, however, is known to be able to digest the wax found inside the jojoba nut.

Jojoba is grown for the liquid wax (commonly called jojoba oil) in its seeds. This oil is rare in that it's an extremely long (C36–C46) straight-chain wax ester and not a triglyceride, making jojoba and its derivative jojoba esters more similar to human sebum and whale oil than to traditional vegetable oils. Farmers in Thar Desert of India are earning up to 10 USD for refined 100 ml jojoba oil.

4.2.2. Khejri/Jand Tree

The Khejri, Prosopis cineraria, will give any wilderness survival expert a run for his money. In an environment that endures as little as 100mm rainfall each year, competition for water is the game. For Khejri, winning is easy. It is capable of lodging roots 30 metres into the ground and accessing water obscured from the grasps of animals and other plants alike. Withstanding great variation in temperatures, it easily copes with summer heat in the 50 □C range and winter nights that can bottom at around 0 □C. Almost evergreen and thriving in the harshest of conditions, it is a super species, with all the stamina, vigor and resilience of a great warrior.

The wood of P. cineraria is a good fuel source, and provides excellent charcoal. Its leaves are best food for animals. Khejari fruits or pods are locally called sangar or sangri. The dried pods locally called Kho-Kha are eaten. Dried pods also form rich animal feed, which is liked by all livestock. Green pods also form rich animal feed, which is liked by drying the young boiled pods. The dried green sangri is used as a delicious dried vegetable which is very costly. Many Rajasthani families use the green and unripe pods (sangri) in preparation of curries and pickles.

4.2.3. Ber/Ziziphus mauritiana

Ber (Indian Jujube) is hardy tree that copes with extreme temperatures and thrives under rather dry conditions with an annual rainfall of 6 to 88.5 in (15–225 cm). The tree has a high tolerance to both water-logging and drought and can grow where annual rainfall ranges from 125 to 2,225 mm, but is more widespread in areas with an annual rainfall of 300 to 500 mm. In China and India, wild trees are found up to an elevation of 5,400 ft (1,650 m). In India, the minimum shade temperature for survival is 7–13° and the maximum temperature is 50 °C. Studies report that this species flourishes in alkaline soils with a pH as high as 9.2. However, deep sandy loam to loamy soils with neutral or slightly alkaline pH are considered optimum for growth. In India, the tree grows best on sandy loam, neutral or slightly alkaline (Kirkbride & Wiersema, 2006).

The fruit is eaten raw, pickled or used in beverages. It is quite nutritious and rich in vitamin C. It is second only to guava and much higher than citrus or apples. The leaves are readily eaten by camels, cattle and goats and are considered nutritious. Ber timber is hard, strong, fine-grained, fine-textured, tough, durable, and reddish in color. It has been used to line wells, to make legs for bedsteads, boat ribs, agricultural implements, tool handles, and other lathe-turned items. The branches are used as framework in house construction and the wood makes good charcoal with a heat content of almost 4,900 kcal per kg.

4.2.4. Calligonum polygonoides/Phog

Calligonum polygonoides, locally known as phog, is a small shrub found in Thar desert areas, usually 4 feet to 6 feet high but occasionally may reach even 10 feet in height with a girth of 1 to 2 ft. This plant is referred to as “orta” in old Arabic poetry. It commonly grows on dry sandy soils and on sand dunes. It is very hardy and being capable of growing under adverse conditions of soil and moisture. It is frost hardy (Tadevosyan, 2007).

It is found from arid and semi-arid areas of Thar Desert, Armenia, Azerbaijan, and Turkey (Aralykh, Igdir). It is becoming increasingly rare due to the demand for its roots, which are used to make charcoal. Overgrazing and sand mining are also having an effect.

4.2.5. Calotropis Procera

Calotropis is a shrub or tree with lavender flowers and cork-like bark. It locally known as “AAK” and “ACRA”. It has ability to endure extreme temperatures and water unavailability. Found in North Africa, Tropical Africa, West and South Asia, Calotropis is native plant of sandy land. This plant also does exist in Thar but not in abundance (Brüschweiler, Stöckel, & Reichstein, 1969).

The wood of the plant yields a fibrous substance that is used for rope, fishing line and thread. It also has tannins, latex, rubber and a dye that are used in industrial practices. The shrub is considered a weed in its native subcontinent but has also been used traditionally as a medicinal plant. It also serves as food to animals.

4.2.6. Crotalaria burhia

Crotalaria burhia is a herb found in north-west India, mainly in the Thar desert region.It is a good soil binder and has medicinal value. It is used to make ropes and sheds for animals in the desert and also used to made jhumpa (desert huts). It is a food for goats.

4.2.7. Aerva javanica

Aerva javanica, the kapok bush or desert cotton, is a species of plant in the Amaranthaceae family. It has a native distribution incorporating much of Africa (including Madagascar), and the south-west and south of Asia.

This herb is deep rooted, and is used as soil binder in desert reclamation. It is used for fuel and for fodder

for goats. In traditional medicine this plant has many uses. It is used externally to remove swelling, relieve inflammation and promote healing of wounds and ulcers. The flowers and roots are used to alleviate kidney problems and rheumatism and the seeds are believed to cure headaches. A gargle is made from the plant to treat toothache (Samejo, Memon, Bhanger, & Khan, 2012).

The plant has naturalized in northern regions of Australia, as an alien introduction, and is cultivated and utilized by the indigenous peoples. The seed-heads are harvested for their soft fibers, rubbed between the palms and used as kapok for pillows.

4.2.8. Leptadenia pyrotechnica

Leptadenia pyrotechnica is the botanical name of a desert herb of the family Asclepiadaceae. It is known as khimp in Hindi and Urdu,"Khipp" in Punjabi.

Being highly drought-resistant, Leptadenia pyrotechnica has played an important role in the desert afforestation programs. The herb khimp is a strong soil-binder and as such is one of the pioneer species in sand dune fixation. Its seed maceration is used as eye lotion and eye bath. The plant sap is rubbed on the skin to treat smallpox and dermatitis. An infusion of the aerial parts is taken as a diuretic to treat kidney disorders, kidney stones and cough. In Sudan a root decoction is taken to treat constipation and indigestion. Its crushed stems are applied to wounds to stop bleeding.

The plant is a potential commercial fiber plant especially for ropes and textile mixtures with wool. It is also potentially useful in cellulose acetate and paper industries. Apart from all these uses, it also serves as food for animals.

4.2.9. Cordia sinensis

Cordia sinensis is a species of flowering tree in the borage family, Boraginaceae. The species' range extends from South Africa, through East Africa Madagascar and the Middle East to the Indian Subcontinent and Eastern Indochina. There is also a disjunct native population in Senegal. The species has become naturalised in Eastern Australia. Common names include grey-leaved saucer berry, grey-leaved cordia, marer, mnya mate and mkamasi.

The fruit are an important food for monkeys and birds. The leaves provide browse for animals such as antelope, giraffe and deer.

The fruits are edible and are eaten in a variety of cuisine. The gum from the tree is also edible. The timber is used as firewood and for making furniture and tools. The leaves are an important source of animal fodder. Both roots and bark are used to treat a variety of disorders in both humans and livestock, including malaria, intestinal disorders and conjunctivitis.

4.2.10. Capparis decidua

Capparis decidua is commonly known as kerda, kair, karir, kirir, karril, Pilu etc. It is a small much branched tree or shrub of arid regions in Africa, Middle East and southern Asia, including the Thar Desert. It bears a mass of slender, leafless branches, the small caducous leaves being found only on young shoots. It rarely exceeds a height of 5 meters (15 feet).

The new flush of leaves appears in November–January. Red conspicuous flowers appear in March to April and August–September and ripe by May and October. The pink fleshy berries are readily eaten by birds. It coppices well and produces root suckers freely. It is extremely drought-resistant and tolerates some frost.

This is a useful plant in its marginal habitat. Its spicy fruits are used for preparing vegetables, curry and fine pickles and can attract helpful insectivores; the plant also is used in folk medicine and herbalism. Capparis decidua can be used in landscape gardening, afforestation and reforestation in semi desert and desert areas; it provides assistance against soil erosion.

4.2.11. Vachellia tortilis/ Israeli Babool

Vachellia tortilis tends to grow in areas where temperatures vary from 0 to 50 degree Celsius and rainfall is anywhere from about 100–1,000 mm (3.9–39.4 in) per year. In extremely arid conditions, it may occur as a small, wiry bush. It grows up to 21 m (69 ft) in height. The tree carries leaves that grow to approx. 2.5 cm (1 in) in length with between 4 and 10 pair of pinnae each with up to 15 pairs of leaflets. Flowers are small and white, highly aromatic, and occur in tight clusters. Seeds are produced in pods which are flat and coiled into a springlike structure.

The plant is known to tolerate high alkalinity, drought, high temperatures, sandy & stony soils, strongly sloped rooting surfaces, and sand blasting. Also, plants older than 2 years have been observed to be somewhat frost resistant.

Timber from the tree is used for furniture, wagon wheels, fence posts, cages, and pens. Vachellia wood was also used exclusively by the Israelites in the Old Testament in the building of the tabernacle and the tabernacle furniture, including the Ark of the Covenant. The pods and foliage, which grow prolifically on the tree, are used as fodder for desert grazing animals. The bark is often used as a string medium in Tanganyika, and is a source for tannin. Gum from the tree is edible and can be used as Gum Arabic. Parts of the tree including roots, shoots, and pods are also often used by natives for a vast number of purposes including decorations, weapons, tools, and medicines. The Umbrella thorn is also emerging as an important species in the battle to 'green the deserts', as it is one of few trees to tolerate very harsh, arid environments.

4.2.12. Tecomella undulate/ Rohida

Tecomella undulata is a tree species, locally known as Rohida in Urdu found in Thar Desert regions of India and Pakistan. It is a medium sized tree that produces quality timber and is the main source of timber amongst the indigenous tree species of desert regions of Shekhawati and Marwar in Rajasthan. The trade name of the tree species is Desert teak or Marwar teak. It is also state flower of Rajashtan.

Tecomella undulata is mainly used as a source of timber. Its wood is strong, tough and durable. It takes a fine finish. Heartwood contains quinoid. The wood is excellent for firewood and charcoal. Cattle and goats eat leaves of the tree. Camels, goats and sheep consume flowers and pods. Tecomella undulata plays an important role in ecology. It acts as a soil-binding tree by spreading a network of lateral roots on the top surface of the soil. It acts as a windbreak and helps in stabilizing shifting sand dunes. It is considered as the home of birds and provides shelter for other desert wildlife. Shade of tree crown is shelter for the cattle, goats and sheep during summer days.

Tecomella undulata has got medicinal properties as well. The bark obtained from the stem is used as a remedy for syphilis. It is also used in curing urinary disorders, enlargement of spleen, gonorrhoea, leucoderma and liver diseases. Seeds are used against abscess. Traditionally in Musakhel, Pakistan its flower used for Hepatitis.

5. DISCUSSIONS

A desert is a barren area of land where little precipitation occurs and consequently living conditions are hostile for plant and animal life. The lack of vegetation exposes the unprotected surface of the ground to the processes of denudation. About one third of the land surface of the world is arid or semi-arid. About 20% of Pakistan's area is characterized by deserts, out of which almost half belongs to both Thar and Cholistan. Pakistan's weather is also being influenced by global warming and there could be seen a shift in ecoregions. It is witnessed that monsoon season which would begin in months of May-June now has changed to late June and July. Thar Desert and Cholistan are monsoon deserts bout this global change also affected them and not having as much rain as it used to be earlier. This lack of rain is bringing drought and resulting in famine which could be witnessed in these deserts, of particular Thar Desert is still suffering from drought and famine. When there is enough rain the soil of that region face prosperity but if there is no rain or a little rain then this land becomes barren and shows no sign of life. Since Thar Desert is the most populated desert in the world, the people living here are forced to beg basic needs of the life. This desert region does not only cause a catastrophe but this environmental change could also be seen other regions of the country. Thus, here comes the role of local and central public administration bodies to plan and implement strategies on solid ground.

Besides these key reasons, Pakistan is also facing a rapid decline in forests and rate of deforestation has increased since beginning of twenty first century. This deforestation has many negative effects on the environment. The most dramatic impact is a loss of habitat for millions of species. Hundreds of Earth's land animals and plants live in forests, and many cannot survive the deforestation that destroys their homes. It is also driving climate change. Forest soils are moist, but without protection from sun-blocking tree cover they quickly dry out. Trees also help perpetuate the water cycle by returning water vapor back into the atmosphere. Without trees to fill these roles, many former forest lands can quickly become barren deserts. Removing trees deprives the forest of portions of its canopy, which blocks the sun's rays during the day and holds in heat at night. This disruption leads to more extreme temperatures swings that can be harmful to plants and animals. Trees also play a critical role in absorbing the greenhouse gases that fuel global warming. Fewer forests mean larger amounts of greenhouse gases entering the atmosphere—and increased speed and severity of global warming (Geographic, 2013). This global warming is harming Pakistan severely.

The solution to deforestation is reforestation and/or afforestation. Reforestation refers to a mechanism where trees are planted in place trees are cut. Given trees are cut for agriculture, reforestation is nearly impossible in such places. There is need to identify barren places and do afforestation because such lands are not suitable for agriculture but some specific species of trees, plants and herbs could be grown. In our case, Thar Desert and Cholistan are best suitable hosts allowing variety of desert and non-desert trees, plants and/or herbs to grow. Since there are few species of trees exist in these deserts which survived in a very hard, warm, and droughty land over past several years. The plantation of all/few of these species on large scale could provide a best solution as alternate forest to existing ones. This afforestation must consider native trees and plants' species and could also be characterized by agroforestry. This project could be very useful in overcoming several ecological, metrological, environmental, biological, and socio-economic problems of the country, specifically south-eastern region. These benefits are discussed in the following lines.

In their research, Makarieva, Gorshkov, Sheil, Nobre, and Li (2013) advocated that condensation, not temperature, drives winds. They highlighted the importance of the world's forests as the salient driver of precipitation from the coast into a continent's interior. The condensation produced by forests creates zones of low pressure that suck in the air from the surrounding regions. Forests create persistent low pressure zones on land and this causes moist winds to blow from the ocean to land. Afforestation in Thar region could result in higher precipitation because this region is closer to Arabian Sea. As concluded by Hance (2013), forests are key to rainfall and as a

consequence, global ecological restoration. This afforestation project can reap benefits of rain as well as high precipitation resulting in higher rain a decade or half. Following the same inference, Makarieva et al. (2013) also made forests responsible for rain and concluded why there is so little rain in deserts and further posited that if we were to plant enough trees in these zones we could induce rainfall. Thus success in plantation and development of trees in these regions can cause in bringing rain and it is what whole life in these regions depends on.

Subsequent to above mentioned ecological and metrological advantages, the resulting forest could play a vital role in prevention and growth of wild life of the desert. Currently, blackbuck, chinkara, red fox, wildcat, eagles, harriers, falcons, buzzards, kestrel and vultures are living in the desert but facing threats because of lack of trees and grazing plants. Several types of reptiles and their species including snakes and lizards are also found here. Blackbuck, chinkara, wild cow and ostrich could be farmed on commercial grounds and their meat, skin and horns etc. could make contribution in economic and GDP growth.

Apart from wildlife, the prospective forest and plantation of grazing plants would also provide opportunity to the inhabitants for livestock. Of particular, camels (the ship of desert) can play significant role in socio-economic development of the region. The wool of sheep, camel and goats has multiple uses for textile. The leather obtained from camels' skin is one the best leathers to produce expensive and sophisticated leather products such as jackets, purses, table lamps and leather products for fashion industry. Camel's milk has been proved as an alternative to insulin for first and second level diabetic patients. As advocated by Lewis (2013), forests and trees are very essential to food security and agriculture. Thar Desert and Cholistan afforestation certainly play a vital role in development of agricultural productivity in these regions. Last but not least, the deserts could serve a best place to ecotourism with a combination of desert and forest.

6. CONCLUSION

Recent global ecological and metrological changes have brought the world in a critical situation where each country is making efforts to prevent its environment, ecology, biodiversity and geography. Global warming, shift/change in ecoregions, and greenhouse effects brought changes in terms of no/little rain in some regions but in excess in some other regions, deforestation, soil erosion and desertification are causing threats to agriculture, biodiversity as well as food security. International and global organizations are working together to prevent the planet from these severe changes and keep it green. This green revolution is focusing not only to prevent forests but also establishment of new forests in different regions of the world. Changa Manga forest in Pakistan is a good example in South Asia representing afforestation efforts. But this forest was established on arable land.

Nations around the world are trying to transform barren lands and deserts into forests to take double advantage. The nations are using arable land for agriculture and arid/semi-arid land for afforestation. Such examples could be seen from successful plantation and development of trees and plants in Africa, America, Israel, Iran, and India. India has been working successfully for last six decades to transform Thar Desert of India into green land. This study posits on the same idea to use Thar Desert of Pakistan and Cholistan an alternative to arable land for afforestation. Although this is a very long term project but its fruits could be reaped and benefitted by the whole nation, particularly people living in these deserts. Federal government and Sindh government must take collaborative actions in due course and international organizations such as United Nations (UN), Asian Development Bank (ADP), South-Asian Association for Regional Cooperation (SAARC), Organization for Economic Cooperation and Development (OECD) could also prove beneficial in financial and technical assistance for regional development. This project will certainly help Pakistan to provide (self) employment opportunities to that region and a breakthrough development of socio-economic conditions as well as a favorable eco-regions.

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