WORLD ENVIRONMENT DAY
JUNE 2017

On the Theme of

"Connecting People to Nature; in the Cities, on the Land; from the Poles, to the Equator"

Celebrated by

PAKISTAN ENGINEERING CONGRESS

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Engr. Ch. Ghulam Hussain
President
74th Session

INTRODUCTORY REMARKS

By

Engr. Ch. Ghulam Hussain

President

PAKISTAN ENGINEERING CONGRESS

ON

WORLD ENVIRONMENT DAY

(Monday 5th June 2017)

Fellow Engineers, Members of Pakistan Engineering Congress, Participants, Ladies and Gentlemen!

اَلسَّلَامُ عَلَيْكُمْ وَ رَحْمَةُ اللّٰهِ وَبَرَكَاتُهٗ

I take this opportunity on behalf of Pakistan Engineering Congress in general and on my own in particular to welcome you all to this gathering for observing World Environment Day 2017. Significance of marking this day is directly linked with the vital importance of environment in the life of the peoples and the nations. Consequently, United Nations Conference on Environment Development in 1992 declared 5th June as "World Environment Day"

Regarding usage of resources, both natural and financial, there are injunctions in the Holy Quran, for guidance of the humanity and I quote: *"Eat and drink, but do not waste; indeed He does not like the wasteful".*

Every year, the theme of World Environment Day is carefully selected to cover various aspects: relating to Environmental issues facing the humanity; affecting the lives of the people: and the surroundings of their habitats. UN suggested theme for this year is:

"Connecting People to Nature: in the Cities; on the Land; from the Poles to the Equator"

This theme invites you to think about how we are part of nature and how intimately we depend on it? It challenges us to find fun and exciting ways to experience and cherish this vital relationship.

In recent decades scientific advances as well as growing environmental problems such as global warming, are helping us to understand the countless ways in which natural systems support our own prosperity and well-being. For example, world's oceans, forests and soils act as vast stores for greenhouse gases such as carbon dioxide and methane; farmers and fisher folk harness nature on land and under water to provide us with food; scientists develop medicines using genetic material drawn from the millions of species that make up Earth's astounding biological diversity.

Billions of rural people around the world spend every working day 'connected to nature' and appreciate full well their dependence on natural water supplies and how nature provides their livelihoods in the form of fertile soil? They are among the first to suffer

when ecosystems are threatened, whether by pollution, climate change or over-exploitation.

Nature's gifts are often hard to value in monetary terms. Like clean air, they are often taken for granted, at least until they become scarce. However, economists are developing ways to measure the multi-trillion-dollar worth of many so-called ecosystem services from insects pollinating fruit trees in the orchards of California to the leisure health and spiritual benefits of hike up into a Himalayan / Karakoram valley.

In the present age of asphalt and smart phones and among the distractions of modern life, connections with nature can be fleeting. This commemoration of World Environment Day 2017 can make clearer than ever that we need harmony between humanity and nature so that both are able to thrive.

World Environment Day is a day for everyone, everywhere, since it began in 1992, global citizens have organized many thousands of events, from neighborhood clean-ups to action against wildlife crime to replanting forests.

Connecting People to Nature, the theme for World Environment Day 2017 implores to get outdoors and into nature to appreciate its beauty and its importance.

بقول شاعر مشرق

فطرت کے مقاصد کی کرتا ہے نگہبانی
یا بندۂ صحرائی یا مردِ کہستانی

Ladies & Gentlemen!

This year's World Environment Day is an ideal occasion to go out and enjoy your country's national parks and other wilderness areas. Park authorities in some countries may follow Canada's example and waive or reduce park entry fees on June 5 or for a longer period. We request Government to allow free entry to all citizens to the national parks of Pakistan.

With this prologue, I conclude my introductory remarks and once again thank you all for participating in this event.

Pakistan Paindabad

A BRIEF ON FORESTRY RESOURCES OF CHOLISTAN DESERT AND A FUTURE POTENTIAL OPPORTUNITY

Fatima Tanveer[1] & Tayyaba Seemab[2]

ABSTRACT

Cholistan desert was declared as protected Forest in 1950. The Cholistan Development Authority is the caretaker of entire land of Cholistan desert. The Forest department has the responsibility for the management of its natural vegetation which is known as Tropical Thorne Forest. In Cholistan, Forests are used for many purposes. Out of total 95 identified plant species, at least 20 species are used for human food in various forms. The most important use of grasses is their medicinal usage. Forests and rangelands provide forage for livestock heads. Continued reduction in vegetation cover has increased its surface temperature resulting in increased evaporation rate of limited rainfall, recognized as self-reinforcing feature for desertification. However, while forest resources are declining the gap between demand and supply of timber and fuel wood is rising. There are more peculiar socioeconomic problems in the area related to Forestry of which water scarcity is a major issue. Due to the lack of water, Forestry in Cholistan is facing worst conditions. Forestry development is believed to cause a major change in Cholistan. According to the feasibility studies regarding Irrigated agricultural development in Cholistan, it has been shown that water availability would offer many opportunities to integrate trees as part of mixed farming as well as agro-forestry practices. Their role in fixing atmospheric carbon has not yet been fully understood and needs a comprehensive scientific investigation to assess carbon fixing capacity of different plant species. Therefore, planned afforestation can optimize carbon sequestration with the production of food and fiber and accrue many environmental benefits to such areas.

Key Words: forest resources, services, Cholistan, forestry development projects, carbon forests

INTRODUCTION

Forests provide variety of ecosystem services including food, fiber, wildlife habitat, water, recreation, aesthetic values, cultural heritage, and ecological and socioeconomic benefits. Forests are considered as the backbone of a country's economy. Forests form the basis of a variety of industries including timber,

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processed wood and paper, rubber, and fruits. However, they also contain products that are necessary to the viability of rural agricultural communities. These products include fuel and fodder, game, fruits, building materials, medicines and herbs. Additionally, grazing occurs within forests, and local woodlands are used to satisfy basic needs. Rural people also grow crops on temporary plots within the forest, often on a rotational basis. These forest products contribute to a diverse rural economy and security when times are difficult. Therefore, the loss of these resources undermines the viability of agricultural practices in the developing world. Forests are home to millions of people world-wide, and many of these people are dependent on the forests for their survival (Sousson et al., 1995). In addition, many people have strong cultural and spiritual attachments to the forests. Therefore, forest destruction undermines the capacities of these people to survive economically, culturally and spiritually.

Cholistan is an extension of the Great Indian Desert, which includes the Thar Desert in Sindh province of Pakistan and the Rajasthan Desert in India. Cholistan desert is located in Southern Punjab, covering about 2.6 million ha. It has length of 480 km and width varies from 32 to 192 km (Khan, 1987). Based on topography, parent material, soil and vegetation, the Cholistan desert can be divided into two geomorphic regions; the northern region is called Lesser Cholistan bordering canal irrigated areas covering about 7,770 km and the southern region is called Greater Cholistan and covers about 18,130 km (R. Akhter and M. Arshad, 2006).

Majority of the land comprises of sandy and clay patches. The Lesser Cholistan consists of large saline compact areas (‘Dahars’) alternating with low sandy ridges. Sand dunes are stabilized, semi-stabilized or shifting, while the valleys are mostly covered with sand. The soils of desert are categorized as either saline or saline sodic; with pH vary from 8.2 to 8.5 and 8.9 to 9.7 respectively (R. Akhter and M. Arshad, 2006). The Greater Cholistan is a wind sorted sandy desert and consist of river terraces, large sand dunes and a lesser amount of interdunal areas (Naureen et al., 2008; Arshad et al., 2008).

The climate of Cholistan is a hyper hot arid sandy desert type. Ecologically, it is tropical arid sandy desert. Precipitation is erratic and ranges from 100 to 200 mm. Mean minimum and maximum temperature are 20°C and 40°C respectively. Mean annual precipitation varies from less than 100 mm in the West to 200 mm in the East, mainly falling during monsoon (July to September). Precipitation is very inconsistent in quantity and duration and prolonged droughts are common once every 10 years (R. Akhter and M. Arshad, 2006).

Cholistan was declared as protected Forest in 1950. The Forest ACT 1927 made applicable to this area during 1964. The area of Cholistan was transferred to Forest Department for Range management during 1966. The Cholistan Development Authority take cares of complete land of Cholistan desert. The Forest department has the responsibility for the management of its natural vegetation which is known as Tropical Thorne Forest, consisting of mainly of xerophytic species viz; Prosopis cineraria, Salavador oleiodies and Cappairs aphylla etc.

Presence of archaeological ruins in Cholistan desert indicates that availability of water in this area was higher a few centuries before. However, continued reduction in vegetation cover has considerably increased its surface temperature. As a result, high temperature has increased the evaporation rate of limited rainfall during the last decades; this ultimately has reduced the effective rainfall available for range and groundwater recharge, a characteristic feature of accelerated desertification (Mughal MR. 1997).

APPROACH OF STUDY

The approach adopted for this study includes collection of secondary data to establish a brief on existing forestry resources of Cholistan desert including ecology, forestry services and related issues. In addition, recent feasibility studies by PIAIP Consultants for Punjab Irrigation Department regarding water resources development projects in Cholistan desert lay the base to conduct a future growth potential study in the area regarding forestry sector and assess its environmental significances.

METHODOLOGY

The modus operandi adopted for this study includes;

- Situational analysis of existing forestry resources
- Identification of related issues
- Literature Review of secondary data consisting of country reports, national statistical reports and organizational reports
- Calculation of area available for plantation, volume of plantation and wood production comprising the future growth potential study, where; the area has been calculated using the proposed canal right of way, the volume of plantation has been calculated using a standard layout (spacing 6x10') of the irrigated plantations of Punjab and wood production has been calculated using Yield Table of irrigated plantations

RESULTS AND DISCUSSION

The findings of the present study are presented and discussed under forestry resources of Cholistan desert and future growth potential sections, as follows.

FORESTRY RESOURCES OF CHOLISTAN DESERT

Ecology and Vegetation

The vegetation of Cholistan desert belongs to the Nubo-Sindhian Province of the Sudanian Region and is typical of arid regions (FAO, 1993). Cholistan is a semi-desert, having sparse to moderate vegetative cover in the form of xerophytic trees, shrubs and grasses, which are adapted to a variety of environmental stresses, particularly to extreme aridity, high salinity, high temperature and low nutrient availability. The sparse vegetation is dominated by bush forming perennial shrubs

with scattered small trees. Most of the shrubs and trees are leafless or have reduced and modified leaf like structures. Several members of Chenopodiaceae like Haloxylon, Suaeda, and Salsola form the dominant species along with the enduring grasses of rangelands. The three major plant communities found in Cholistan are *Lasiurus-sindicus/ Haloxylon-salicornicum*; *Eleusine compressa/Haloxylon salicornicum*; *Haloxylon recurum/Salsola foetida* and *Suaeda fruticosa* (Govt. of the Punjab, 1974).

A large number of annual and ephemeral species appear after rains, complete their life cycle in a short span and dry up after dispersing seeds. Most of the species have a remarkable capacity to regenerate even in minimum rainfall. The seeds are also tough enough to withstand severe high temperature, aridity and multiple years of drought. Precipitation is generally confined to few showers in the months of July to September. The rainfall makes the desert green with vegetation cover up to 50% in some areas (R. Akhter and M. Arshad, 2006).

The Greater Cholistan is dominated by Phog (*Calligonum polygonoides* and *Haloxylon salicornicum*) on the sand ridges, with the former predominating progressively up the ridges. In inter-dunal valleys the shrubs *Haloxylon salicornicum*, *Diperygium glaucum* and *Aerva javanica* occur, as well as the grasses *Lasiurus sindicus, Cenchris cillaris, Cymbopogon jwarancusa*, and some forbs. Occasional groves of the trees *Prosopis cineraria* or *Tamarix aphylla* are to be found (R. Akhter and M. Arshad, 2006).

Lesser Cholistan is dominated by several species of shrubs and perennial grasses dotted by few species of small trees. Vegetation cover is poor on sand dunes and unstable sand dunes are devoid of any vegetation. Some inter-dunal areas have better vegetation depending on the water retention capacity of the soil. The ground water table is very low and in most of the cases it is brackish, neither fit for drinking purposes nor for raising trees and agriculture crops (R. Akhter and M. Arshad, 2006). In saline/sodic old Hakra beds the shrub Haloxylon recurvum (Khar) is dominant; as the salanity decreases and the soil becomes loamier, the shrub *Suaeda fruticosa* and *Salsola foetida* come in together with some annual grasses such as Aristida and Sporobolus species. The large sandy ridges support the shrub *Calligonoum polygonoides* while the smaller, sandy mounds support the shrub *Haloxylon salicornicum*. The unstable barchans dunes are colonized by pioneer shrubs *Dipterygium glaucum* and the *Aerva javanica*. The stable dunes are characterized by the shrubs Calligonoum polygonoides and *Haloxylon salicornicum* with patchy occurrence of perennial grasses Lasiurus sindicus and Cenchrus cillaris. In some area Cymbopogon jwarancusa forms the dominant stands. A wide range of nutritious and drought-tolerant plant species (128 species belonging to 33 families) of grasses, herbs, shrubs and trees occupy this desert. Hardy species adapted to high temperature and low soil moisture includes *Lasiurus scindicus, Sporobolus iocladus, Aeluropus lagopoides* and *Cyperus onglomerates*.

The predominant tree species, shrubs and grasses are given in the Table 1 as follows.

Table 1: Important Flora of Cholistan Desert

Sr. No.	Vernacular Names	Scientific Names	Family
Tree Species			
1.	Jand	*Prosopis cineraria*	Mimosaceae
2.	Frash	*Tamarix aphylla*	Tamariceae
3.	Wan	*Salvadora oleoides*	Salvadoraceae
4.	Mallah	*Zizyphus nummularia*	Rhamnaceae
5.	Ber	*Zizyphus jujuba*	Rhamnaceae
6.	Kiker	*Acacia nilotica*	Mimosaceae
7.	Kikari	*Acacia jacquemontii*	Mimosaceae
8.	Mesquite	*Prosopis juliflora*	Mimosaceae
Common Shrubs			
1.	Khar	*Haloxylon recurvum*	Chenopodiaceae
2.	Lana	*Haloxylon salincoricum*	Chenopodiaceae
3.	Lani	*Saueda fruticose*	Chenopodiaceae
4.	Karir	*Capparis aphylla*	Capparidaceae
5.	Phog	*Calligonum polygonoides*	Polygonaceae
6.	Khip	*Leptadenia pyrotechnica*	Asclepiadacea
7.	Chag	*Crotolaria burhia*	Papilionaceae
8.	Ak	*Calotropis procera*	Asclepiadaceae
9.	Danda Thor	*Euphorbia caducifolia*	Euphorbiaceae
Dominant Grasses			
1.	Dhaman	*Cenchrus cilliaris*	Poaceae
2.	Khabbal	*Cynodon dactylon*	Poaceae
3.	Chhimber	*Eleusine flagellifera*	Poaceae
4.	Chhimber	*Ochthochloa compressa*	Poaceae
5.	Murgha	*Dicanthium annulatum*	Poaceae
6.	Lumb	*Aristida adscensionis*	Poaceae
7.	Lumb	*Aristida depressa*	Poaceae
8.	Gorkha	*Lasiurus sindicus*	Poaceae
9.	Bansi Grass	*Panicum antidotale*	Poaceae
10.	Khawvi	*Cymbopogon jwarancusa*	Poaceae
11.	-	*Sporobolus iocladus*	Poaceae
12.	-	*Eragrostis cilliaris*	Poaceae

(Source: FAO, 1993)

Forestry Services

In Cholistan, Forests are used for many purposes like for; vegetation for livestock, wood as a source of energy and construction of mud houses. Pertaining to sandy soil and lack of water resources options for nomads to use naturally grown shrubs and plants are limited. Use of plants as food for livestock is common practice in Cholistan. Nomads use wood for domestic fuel and energy purposes, where 53.74 percent households use woods and dung cakes, 43.13 percent use only woods and 3.13 percent use kerosene Oil to meet their fuel/energy requirement.

Cholistan desert is poor in tree-resources. The most common ones that are used as fuel wood by the local inhabitants are *Prosopis cineraria, Tamarix aphylla*, and *Salvadora oleoides*. Depending upon the size of the settlement, large amount of wood is extracted from the nearby area. *Capparis decidua, Zizyphus species, Calligonum polygonoides, Acacia nilotica, Salsola baryosma* and *Capparis decidua* are the main fatalities to be used as firewood. The nomads not only use the wood for cooking their own food, but large numbers of plants are dug up to sell in the nearby cities as fuelwood. The tree-species may assume the shrubby or even prostrate growth habit. The studies shows that large stands of Acacia nilotica and Prosopis cineraria, once present at various localities in the Cholistan desert, has now vanished due to continued cutting by the coal-making industry (Chaudhry et al., 2004).

Forests and rangelands provide forage to 90 million head of livestock. Out of total 95 identified plant species, at least 20 species are used for human food in various forms. Some native plants of Cholistan have very good food potential. The nutritional value of some of these plants is even greater, having high amounts of protein, fats, carbohydrates, minerals and vitamins than cultivated plant food. For example, local people use the seeds of Acacia species for making pickles and other food dishes, which are superior to rice and wheat in energy, protein and fats (Muhammad and Jawed, 1999).

The most important use of grasses is their medicinal usage. Local people of Cholistan desert have always used medicinal plants for their common health problems by traditional methods. Many of the plants has been found to be administered in combination with milk or some specialized foods and various plant species have been found to cure such illness across different ethnic communities (Ismail and Nisar, 2010; Nisar et al., 2011; Arshad et al., 2011). Cymbopogon jwarancusa is an aromatic grass which is locally used for the treatment of burning, cough, cholera, vomiting, thirst, and unconsciousness fever and blood and skin diseases. Cynodon dactylon is used for the treatment of thirst, biliousness, leprosy, scabies, skin diseases, dysentery and extracted juice of this plant is used for hysteria and epilepsy. Sporobolus iocladus after crushing is added to a cup of tea to cure malaria. Panicum antidotale and Lasiurus scindicus are also used for controlling the high fever (Hameed et al., 2011).

Forestry Constraints/Problem

Pakistan is a forest deficit country. In Punjab, the forests crisis is further deepened. There are more peculiar socioeconomic problems in the area related to the Forestry. Only 3.74% of the total area of the province is under forests (Wildlife and Fisheries Department, 1999). Gap between demand and supply of timber and fuel wood is rising, while forest resources are declining. Forestry's share in the GDP and in agriculture is 0.15 and 0.62 per cent respectively, which is not satisfactory and is a clear manifestation of forestry being a neglected sector (Ashraf et al., 1989).

In Cholistan, water scarcity is a major issue for both humans as well as for livestock. Due to the lack of water, Forestry in Cholistan is facing worst conditions. There are two main sources of water in Cholistan desert, sub-soil and the surface water. The sub soil-water is mostly found at the depth of 30 – 40 meters and in most of the cases, it is highly brackish, containing 9000 – 24000 ppm salts. The surface water is the primary source and is received only from rain. Rainwater is collected in Tobas (ponds) and Kunds, while the subsoil water is obtained through dug wells and tube wells (Chaudhry et al., 2004).

In the Cholistan desert, rain is the only source of fresh water. Rain water can play an important role as a source of water development. During rainy season, the rainwater is collected in natural depressions or man-made ponds, locally called "Tobas". According to an estimate compiled by the Pakistan Council Research in Water Resources, Regional Office, Bahawalpur (PCRWR), there are more than fifteen hundred tobas in the Cholistan area. However, due to the hyper and arid temperature of Cholistan, rains are not very often.

Water in the tobas lasts for maximum four months. When there is no water in the tobas then groundwater of open wells is used, although this water is brackish and not feasible for health. Regional Office Bahawalpur of Pakistan Council of Research in Water Resources (PCRWR) conducted a survey of 32 wells in different areas of Cholistan to check the water quality from available sources as given in Table 2. The results indicated that the available water quality was not satisfactory.

Table 2: Ground Water Quality of Open Wells in Cholistan

Location of Wells	No. of Wells	Water Quality			
		Salts (ppm)	pH	Specified Absorption Rate (SAR)	Thermally Stimulated Current (TSC)
Dingarh	6	4200-8000	7.2-7.6	14-32	5.6-14.49
Bariwala	1	11000	7.6	43	5.2
Bhambowala	1	12400	8.0	73.30	11.8

Location of Wells	No. of Wells	Water Quality			
		Salts (ppm)	pH	Specified Absorption Rate (SAR)	Thermally Stimulated Current (TSC)
Chak No. 81	3	3700-8600	7.6-8.4	21.62-43.47	6.4-13.7
Balouchniwala	1	22000	8.3	88.5	10.5
Channanpir	1	29800	8.8	207.85	54.0
Nagarwala	1	3900	7.9	30.12	12.2
Malkamnwala	1	3600	7.6	30.94	8.8
Maujgarh	4	300-16500	8.2-8.9	4.45-67.0	12-13.4
Fortabbas	3	620-2500	7.7-8.5	3.40-5.16	1.7-6.87
Islamgarh	3	2400-5000	7.2-7.8	7.2-7.8	0.97-1.36
Bahikhanwala	5	4400-6000	7.3-7.8	2.0-2.7	5.2-22.0
Kalarwala	2	5700-5900	6.5-6.7	1.61-1.73	4.2-4.6

Source: PCRWR, Regional Office Bahawalpur

As the time passes, if there is no sky shower in the coming months, high evaporation rate, high seepage and consumption of water by the human and livestock reduce the water in Tobas. Many small size tobas dry out up to the month of October and nomads move to the larger tobas where the water and fodder is available. With the onset of time, (after four to five months) the water in the larger tobas begins to foul, becomes thicker with microbial population and finally dries out. Resultantly, nomads shift to the desert fringes near cities with their livestock for livelihoods and fodder for their livestock.

Grazing is the main land use of the Cholistan area. Extreme aridity, pre-dominantly sandy nature of the soils, dune topography and extreme deficiency of drinking water are the main factors which inhabit the use of the area as an arable land. Due to these climatic and environmental characteristics, the area is being used as a natural grazing land. A large number of camels, sheep, goats and cattle are the beneficiaries of the area. However, overgrazing, cutting of shrubs and trees for fuel have caused great changes in the composition of natural vegetation and proliferated wind erosion. The problem is very severe near habitations where once stabilized sand dunes have been converted into actively moving sand. Soil compaction is severe where soils are strongly saline-sodic clayey. Moreover, The parameters controlling vegetation growth such as low rainfall, higher evapo-transpiration rates, brackish sub-soil water and extreme type of prevailing climatic conditions, limit tree planting to only ecologically adapted tree species. Thus, without the irrigation supply, raising of compact blocks of forest trees or farm forestry planting is not possible.

Farmers are desired to grow trees on their farms. However, governmental policies and academic literature is not supporting agro-forestry, therefore, uptake has been lower. Focus of forestry research and education is on the technical forestry and forestry services in which staff needs are fulfilled. In projects there is lack of

farmers' participation. To improve agro-forestry we should make possible the participation of people for growing trees on their farmlands (Hasan et al., 2014). Government should take serious actions for the betterment of water quality as well as for development, management and reservation of water resources.

FUTURE GROWTH POTENTIAL

Pakistan's economy has major concern with forests as they play a vital role in its development. Fuel wood, fodder, timber and shelter for livestock are the output obtained from forests. During the recent past the significance of wood produced on farmlands has increased sharply (Nouman et al., 2006). In Pakistan requirements of wood are greater than the total wood production per annum. Farmland contributes 60% in timber production and 90% in fuel wood. Thus, farm forestry plays a very important role in fulfilling our wood requirements. Only 2% of the area is under forest cover with agricultural crops. It has been estimated that without harming agricultural crops, 10% area of our farmland can be easily used for forest cover. Thus, our growing needs of wood products can be fulfilled only by practicing agro forestry (Qureshi, 2002).

As a forest deficit country (only 3% forested land) that has placed a low priority of forestry programs, its fuel wood consumption of 25 million cu m in 1993 exerts a heavy stress on its limited forest resources. According to Supply and Demand Survey, the consumption of wood is expected to increase from 43.761million m^3 in 2003 to 58.377 million m^3 by the year 2018 (UNDP, 1992). Pakistan will have to further expand the wood producing roles of its non forest areas to fill this huge gap.

The Pakistan Forestry Master Plan 1993-2018 envisages the enlargement of agro-forestry areas to 1.75 million ha to produce about 26 million cu m by 2018. There is also the policy goal to expand the forest base by about seven times, from 3% of the total land (2.02 million ha) to 20% (15.4 million ha) over the same period. In another approach, the National Conservation Strategy of 1992 has prescribed the planting of 100 trees per ha along farm boundaries. Under the Social Forestry Program, there is another plan to establish some 2600 ha of block plantations in woodlots and 14800 ha equivalent of linear planting. Pakistan has the political will, technological skills and human resources to carry out large undertaking such as the planned forestry programs (Forestry Sector Master Plan, 1992).

Forestry development is believed to cause a major change in Cholistan and the livelihood of its residents. Bukhari A. S. (1997) has reported that there are many advantages in adopting agro-forestry as trees help in improving soil fertility. Plants are major cause of rains and betterment of environmental quality. Forests provide timber for fire and fodder for cattle as well as control soil erosion and removal of ozone layer. Trees also help by protecting watersheds which contribute to economic development.

Recently, Punjab Irrigated Agriculture Investment Program (PIAIP) Consultants has carried out feasibility studies on the behest of Punjab Irrigation Department regarding Water Resource Development in Cholistan. The gross area of 626,819

acres in Smaller Cholistan has been planned to be irrigated with flood supplies to be brought form Jhelum Chenab command using the water transfer facilities provided by existing link canal system viz. Rasul Qadirabad (RQ), Qadirabad Balloki (QB) and Balloki Suleimanki (BS). Another irrigation project of irrigating additional areas of 192,018 acres of Greater Cholistan has recently been studied by PIAIP consultants. It proposes to use flood flows of Panjnad Barrage via Abbasia Link Canal to irrigate a part of Greater Cholistan through flood canal at Abbasia Link Canal, feeder canals and distributaries. With the availability of irrigation water through this project the area along the entire proposed irrigation channels can be planted with trees for economical uses. With the flood supplies for 70 days, mainly the fodder crops such as Sorghum, Bajra, Guar, Pulses and some kharif fodders will be grown due to limiting factors. It would be possible to develop some silvi-pastoral models in the project area related for irrigation development. Moreover, with perennial water supply, the Kharif and Rabi crops would be cultivated due to availability of sufficient quantities of irrigation water. Under this project forestry would be very encouraging and growing high value timber species such as Shisham, Kiker, Sirus, Simul and Eucalyptues would be favorable.

In early fifties, irrigation system was introduced in the Thal Desert and converted to irrigated farmlands; mass scale planting of the leguminous trees species such as Shisham (*Dalbergia sissoo*), Kiker (*Acacia nilotica*), and Sirus (*Albezzia lebbek*) etc. was carried out along the irrigation channels. In a similar manner with the introduction of canal water supplies to Cholistan under the project mentioned above, planting of timber tree species can be done along the canals, distributaries, minors and water courses. The plantation along the canals, distributaries and minors, can be undertaken by Irrigation department through contract to Forest department or in collaboration with Forest department in the canal right of way through any of the following types.

Linear Plantation along Canals System

The details of area available and number of plants to be planted and wood produced from the area of linear strips of the main irrigation channels for the Project in Smaller Cholistan are presented in Table 3. Since these strips will be along the irrigation channels where there will be plenty of irrigation water available, therefore, high value timber species should be preferred. The area along the main feeder canals can be planted with seedlings of Shishum while Kiker seedlings can be planted along the distributaries. The area has been calculated using the proposed canal right of way.

Table 3: Linear Plantations along Irrigation system and wood Production in Smaller Cholistan

Sr. No.	Name of Canals	Land Acquisition		Plantation[1] (million)	Wood[2] Production (million CM)
		Acre (Ac)	Hectare (ha)		
1.	Cholistan Flood Feeder	5303	2146.96	3.84	0.439
2.	Fateh feeder	769	311.33	0.56	0.064
3.	Haran feeder	211	85.42	0.15	0.017
Sub total		6283	2543.72	4.55	0.520
New Canal Systems					
1.	New Fateh canal system	2431	984.21	1.76	0.065
2.	New Murad canal system	1515	613.36	1.099	0.040
3.	New Hakra canal system	2886	1168.42	2.095	0.0768
4.	New Haran canal system	2890	1170.04	2.098	0.0769
Sub total		9722	3936.03	7.06	0.258
Total land acquisition		**16005**	**6479.75**	**11.62**	**0.778**

(1 = Planting at 6x10' Spacing, 2= Rotation 20 years for Shishum and 10 years for Kiker)

Above table which shows that there will be 6479.75 ha of land available for planting along the entire irrigation channels and 11.62 million plants would be planted at a standard layout (spacing 6x10') of the irrigated plantations of Punjab. Wood production has been calculated using Yield Table of irrigated plantations (Shishum: 204.47 CM/ha; Kiker: 65.76 CM/ha; Eucalyptus= 441.82 CM/ha). The details of linear plantation and wood production in Project area of Greater Cholistan are presented in Table 4 below.

Table 4: Linear Plantations along Irrigation system and wood Production in Greater Cholistan

Sr. No.	Name of Canals	Acre (Ac)	Hectare (ha)	Plantation[1] (million)	Wood[2] Production (million CM)
1	Abbasia Flood Canal	146	59	0.106	0.0121
Distribution System					
1	1L Disty	36	15	0.026	0.0030
2	Tail Left Disty	230	93	0.167	0.0191
3	Tail Front Disty	236	96	0.172	0.0196
Total		**648**	**262**	**0.471**	**0.0538**

(1 = Planting at 6x10' Spacing, 2= Rotation 20 years for Shishum and 10 years for Kiker)

As indicated in Table above there will be 271 ha of land available for linear plantation along the entire irrigation channels proposed in the project area. The area along the main feeder canals can be planted with 0. 106 million seedlings of Shishum while 0.365 million Kiker seedlings can be planted along the distributaries of the irrigation system. The wood from this plantation can be harvested at 20 years rotation for Shishum trees and 10 years rotation for Kiker trees producing 0.012 million cubic meters and 0.042 million cubic meters of wood from Shishum and Kiker, respectively. Thus, the available land would allow nourishing a total of 0.485 million trees producing 0.0555 million cubic meters of wood.

Agro-Forestry; Forest as an integral part of Agriculture

Agro-forestry is the growing of trees along with agriculture crops. In agro-forestry system, the trees are an integral part of agriculture; in other words the Agro-forestry is the integration of trees into farming systems. In the harsh and extreme type of climate the trees would be an essential part of farms and play an important role in checking wind erosion. The trees will help in improving farm productivity and increase crop yields. The trees will also make farms more profitable while helping to protect the biological environment. By growing trees with agriculture crops, forage and livestock the farmers would have additional advantages due to the following:

- Improve yield of agriculture crops
- Reduce soil loss by wind and water erosion
- Conserve soil moisture by having mulching effect
- Recycle nutrients from the deeper layers of soil profile
- Reduce the effects of agriculture on soil fertility

Therefore, the agro-forestry practices should be encouraged and the trees compatible with the agriculture crops should be planted, which will have significant positive impact on the farm production**.** The farmers in the project area can be encouraged to plant at least 50 trees per hectare (20 trees /Ac) for multipurpose uses. The soils of Cholistan are saline and saline sodic, containing salt contents of carbonates of Calcium and Sodium therefore; out of this total area under agro-forestry system 50 percent should be planted with Kiker species and the remaining 50 percent with the Eucalyptus plants.

Under the proposed project the net area under irrigation command in Smaller Cholistan Project will be 96600 ha (161000 - 64400 ha). Thus 4.83 million trees (on the basis of 50 trees/ha) can be planted under the Agro-Forestry system along the entire irrigated farmlands. Accordingly, the wood production from these plantations would be, for Kiker plantation 3.2 million cubic meters and for Eucalyptus 21.33 million cubic meters. Thus, the total wood production from agro-forestry system would be 24.53 million cubic meters.

The gross command area of Greater Cholistan project is proposed to be 77706.9 ha. A collective plantation of about 3.108 million trees of Kiker and Eucalyptus in the cultivable command area of 62164.57 ha can yield 2.06 million cubic meters of

wood from Kiker and 13.725 million cubic meters of Eucalyptus wood in the project area. Thus, total wood production from agro-forestry in Greater Cholistan would be 15.785 million cubic meter.

Compact Plantation and Woodlots on Farmlands

While developing the Thal Desert in early fifties, the Thal Development Authority (TDA) made allotments for setting up villages along the canal system and for each Chak having area of 1250 acres (50 squares of land) an area of 50 acres was reserved for raising of irrigated forest plantation in the districts of Khushab, Mianwali, Bhakkar and Muzaffar Garh. These areas were transferred to the Forest Department for raising irrigated plantation and for timber and firewood productions. In a similar manner the farmers in Cholistan can also be encouraged to raise compact or block plantation on their farms to meet their timber and wood energy requirements. The farmers can be advised to keep block planting or woodlots on their farms and at least 5 percent of the total area of the farm must be reserved for the trees.

The entire area of Smaller Cholistan is a State owned waste land, hence, 50 acres of land can be earmarked for chak plantation in Smaller Cholistan. If we take it as standard then there will be 178 chaks in the entire project area and the total plantation area would be 8900 acres (3617 ha). The total no of seedling planted here would be 6.46 million, in compact blocks of irrigated plantation in all the villages and the wood production from these plantations would be 0.238 million cubic meters. Likewise, total area available for plantation in Greater Cholistan Project area would be 3,116 ha (154 chaks) which can be planted with 5.59 million plants producing at 0.206 million cubic meter wood.

Environmental Significance

Wood Production

The wood production from these three types of plantations, carried out under the proposed projects has been summarized in Table 5 as follows. The table shows that plantation from all types will allow planting a total of 22.91 million plants in the area. The Shishum plantation can be carried out along the irrigation channels, as it the most fertile land having plenty of irrigation water. The Kiker plantation and other halophytes tree species can be planted under the Agro-Forestry and compact blocks as well as in the chak plantations. Thus the total wood production from all types of plantation will be 25.54 million cubic meter after completion of rotation age.

Table 5: Type of Plantation and wood production (million cubic meters) in Smaller Cholistan

Sr. No.	Type of Plantation	Area (ha)	No. of Plants (million)	Wood Production million (CM)
1.	Linear Plantation	6,479.75	11.62	0.778
2.	Agro-Forestry	96,600	4.83	24.53
3.	Compact blocks and woodlots	3,617	6.46	0.238
	Grand Total	**1,06,696.75**	**22.91**	**25.54**

(Source: Yield Eucalyptus of irrigated plantations, Shishum: 204.47 CM/ha; Kiker: 65.76 CM/ha; Euc= 441.82 CM/ha)

At present, the Project area in Smaller Cholistan has very saline and saline sodic soil; therefore, initially the halophytes such as Kiker (*Acacia nilotica*), Eucalyptus (*Eucalyptus camaldulensis*) and Ipil Ipil (*Leucena lecosophylla*) species should be planted. Over a period of time and with continuous tillage practices and frequent irrigations, the salt contents will either leache down in the deeper soil layers/profile or be taken up by the plant roots. It will pave a way for the non-halophytes and the other valuable timber species to be grown subsequently.

Plantation carried out in the same manner in Greater Cholistan Project area will benefit both economically and environmentally. As shown in Table 6, a total of 9.169 million plants will constitute linear, agro-forest and compact plantation. The total wood production from all types of plantation in Greater Cholistan Project area will be 16.045 million cubic meter after completion of rotation age.

Table 6: Type of Plantation and wood production (million cubic meters) in Greater Cholistan

Sr. No.	Type of Plantation	Area (ha)	No. of Plants (million)	Wood Production million(CM)
1.	Linear Plantation	207.73	0.471	0.054
2.	Agro-Forestry	62,164.57	3.108	15.785
3.	Compact blocks and woodlots	3,6116	5.59	0.206
	Grand Total	**65,488.3**	**9.169**	**16.045**

(Source: Yield Table of irrigated plantations, Shishum: 204.47 CM/ha; Kiker: 65.76 CM/ha; Eucalyptus= 441.82 CM/ha)

Desert Reclamation

"Desertification is the diminution or destruction of biological potential of the land which can ultimately lead to desert like conditions", (United Nations, 1977). With the supplies of irrigation water to areas in Cholistan, there would be sufficient availability of water for cultivation of agriculture crop and raising of trees such as

shelterbelts, windbreaks and compact blocks. Afforestation in the newly irrigated areas, can serve many purposes. The establishment of green belts of the native trees, ecologically adapted to the desert conditions can play an important role in checking wind erosion and sand dune stabilization. In Cholistan people protect trees of Jand (*Prosopis cineraria*) and Ber (*Zizyphus mauritiana*) to increase soil productivity and land sustainability.

The scorching winds not only damage the agriculture crops but also decrease the crop yield significantly. It is of immense importance to plant tree rows along the agriculture fields to protect the agriculture crops. Under flood water supplies for 70 days only, it will be technically feasible to plant trees rows along the agriculture fields with 1-2 times of watering till the plants gets established. Tree species like *Tamarix aphylla*, *Zizyphus mauritiana*, *Acacia modesta*, *Acacia tortalis*, *Prosopis cineraria* and *Prosopis juliflora* are recommended for planting as windbreaks.

Besides agro-forestry practices, compact plantation of valuable trees can also be established on the cultivated farmlands. All these project interventions will increase the vegetative cover and play an important role in combating desertification and changing the ecology of Cholistan. Furthermore, overgrazing of rangelands which is the main cause of desertification would also be mitigated as there would be surplus quantities of fodder and fodder reserves (hay and silage) available to meet the forage requirements of livestock during dry season. Hence, irrigation development in Cholistan would go a long way in uplifting the socio-economic conditions of the local people.

Afforestation and Carbon Sequestration

Irrigated agricultural development in Cholistan would offer many opportunities to integrate trees as part of mixed farming. It has been revealed through scientific studies that 2 million hectares could sequester around 20 million tons (Mt) of CO2-e per hectare per year; on average 9-10 tons of carbon dioxide equivalent per hectare per year (Cleugh et.al, 2011). However, this depends on many local and external factors, which lead to a variation in storage amount over a 40-year cycle but it would have to be as carbon forest and remain un-harvested. To reduce significantly greenhouse gas emissions, it presents great challenges such as sufficient suitable land must be spared, large quantities of seed is needed, and the trees must survive 100 percent and fully establish. Furthermore, to achieve the full benefits of carbon storage, carbon forests need to be managed according to natural cycles of death and decay of the tree species (Sheikh M. I., 1986).

Irrigation water availability could be an important factor particularly in the arid zone; therefore, carbon forests are likely to have an impact on irrigation water supplies where a large plantation would have to be established in a continuous blocks such as the existing irrigated plantations of Lal Suhenra National Park, Changa Manga and Chichawatni etc. which are already suffering due to shortage of water supplies. In Cholistan, carbon forests can be scattered throughout the newly developed irrigated areas in the form of small blocks to minimize negative impact on irrigation water supplies. It would be feasible, if approximately 5 percent of the farm or any

appropriate size depending upon the size of land holding, may be reserved for planting as Carbon forest which can also be used for multiple benefits such as shelter for livestock, wind breaks, for controlling salinity and enhancing native biodiversity. Therefore, planned afforestation can optimize carbon sequestration with the production of food and fiber and accrue many environmental benefits to such areas.

Carbon Forests and Carbon Credits

It has been revealed through analysis that, at even a modest carbon price (Rs.1000–2000 per ton of CO2-e), forestry could be a competitive land use across large areas, with many tens of millions of tones of abatement generated. However, many factors, awareness of farmers and attitudes of land owners, particularly those having bigger units of lands will govern where carbon forests can be planted. In reality forests contribute to Pakistan's carbon account through the carbon storage in soils and in woody vegetation. Although carbon storage per unit area is low, the extent of forests and rangelands means that they hold a significant total carbon store. Planting of trees in blocks and under agro-forestry systems, would be the most straight forward way to sequester carbon in the newly cultivated areas in Cholistan. It will provide the most immediate, significant, and realizable carbon sequestration opportunity to the local people. They will be eligible for carbon credits under existing climate change agreements, they are effective as (they store significant quantities of CO2 per hectare), and carbon sequestration is easily verifiable. At the present time, to qualify as a 'carbon forest', both reforestation and afforestation need to meet the requirements of Article 3.3 of the Kyoto Protocol, for example, forests would need to be planted after 1990 on agricultural land cleared before 1990.

CONCLUSION AND RECOMMENDATIONS

From the above discussion it can be concluded that;

- ✓ Forests form the basis of a variety of industries including timber, processed wood and paper, rubber, and fruits and are the backbone of a country's economy. They also contain products that are necessary to the viability of rural agricultural communities and are home to millions of people world-wide. Hence, loss of these resources undermines the capacities of people to survive economically, culturally and spiritually and intimidate viability of agricultural practices in the developing world.
- ✓ In Cholistan continued reduction in vegetation cover due to various reasons is indicative of declining forest resources and is a feature of self-reinforcing desertification. In time and immediate policy reform and planning for forestry development and management is considered necessary. Appropriate forest management ensures that the harvest of timber and non-timber forestry products maintains the forest biodiversity, productivity and ecological processes.

- ✓ In Cholistan, water scarcity is a major issue governing the worst conditions of Forestry. Without the availability of irrigation supply, raising of compact blocks of forest trees or farm forestry planting is not possible. Therefore, irrigated agricultural development in Cholistan would offer many opportunities to integrate trees as part of mixed farming.
- ✓ In harsh and extreme type of climate the trees are an essential part of farms as these help in improving farm productivity and increasing crop yields. Therefore, the agro-forestry practices should be encouraged and the trees compatible with the agriculture crops should be planted.
- ✓ Beside agro-forestry farmers should also be encouraged to raise compact or block plantation on their farms to meet their timber and wood energy requirements for which they could be advised to reserve at least 5 percent of the total area of the farm for the woodlots etc.
- ✓ Forestry development is believed to cause a major change in Cholistan and its people. Planting of trees in blocks and under agro-forestry systems, would be the most straight forward way to provide the most immediate, significant, and realizable carbon sequestration opportunity to the local people.
- ✓ Any appropriate size, depending upon the size of land holding, may be reserved for planting as Carbon forest which could also be used for multiple benefits such as shelter for livestock, wind breaks, for controlling salinity and enhancing native biodiversity. Thus, planned afforestation can optimize carbon sequestration with the production of food and fiber and accrue many environmental benefits to such areas.

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GLOBAL WARMING, CLIMATE CHANGE (CAUSES, IMPACTS, MITIGATION, ADAPTATION) AND CARBON-DI-OXIDE MEASUREMENT; A REVIEW

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Abstract: Climate change is posing serious threats to countries across the globe. According to Global Change Vulnerability Index (CCVI) 2010-2011, Pakistan is ranked as the 16th most vulnerable country, owing to its unique topography and scarcity of resources leaving it susceptible to large number of Hazards including but not limited to food insecurity, floods, landslides and droughts. Greenhouse gases in general and carbon dioxide gas in particular is the key driver of the climate change, hence, stress should be laid to limit its concentration to a tolerable level. Scientists employ many methodologies like analysis of ice cores, pollen grains, stable isotopic, lake and ocean sediments to find Carbon dioxide concentration in past climate. Currently, scientists are using different physical and chemical methods such as application of Infra-red, molecular, photoacoustic, and mass spectrograph to measure carbon dioxide levels. We have interpreted that this present concentration is at higher end as compared to the pre-industrial era, calling for a dire need to address its elevated concentration through various means of mitigation in order to safeguard planet Earth.

1 Introduction

Carbon dioxide is colorless, trace atmospheric gas, which despite of its low concentrations, still plays a decisive role in the global climate and Earth life cycle (Houghton, Ding et al. 2001, Ghommem, Hajj et al. 2012, Shakerian, Kim et al. 2015). The atmosphere and its global warming phenomenon (capturing the ultra violet radiations by the greenhouse gases i.e. carbon dioxide, water vapor, methane, nitrous oxide, and chlorofluorocarbons) is what makes planet earth livable by helping it in maintaining enough warm climate (Sabine, Feely et al. 2004). CO_2, methane, nitrous oxide, hydro-fluorocarbon, per fluorocarbons and sulfur hexafluoride have been mentioned in Kyoto Protocol 1998 as greenhouse gases (Nations 1998, Lee, Lee et al. 2012, Lee, Sethupathi et al. 2013). This automatic balance has helped mankind to survive but more recently a significant change has been recorded in the atmospheric chemistry. In result, the concentrations of greenhouse gases in general and CO_2 in particular have increased to an alarming level. There is a strong consensus among the climate and environmental scientists, that these changes have been triggered by human activities such as fossil fuel burning, deforestation during post industrial revolution, in order to meet the needs of over populated planet. This could be inferred from the fact that over the past one and half century has recorded the drastic 40% increase in CO_2 emissions i.e. from 280 to 392 ppm in 2012 (Boden, Marland et al. 2009). Moreover, it is coupled with the global mean surface temperature of between 0.65 and 1.06 degrees centigrade. However, this rate of increase is quite

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different from the average values over the last 22000 years. This is supported by ice core records, which suggest the consistency in the CO_2 concentrations over last ten centuries prior to the industrial revolution i.e. 280ppm. With advent of more sophisticated technology, the CO_2 emissions are now monitored and well documented since the second half of last century by direct atmospheric measurements in locations such as Mauna Loa, Hawaii, being the distant sites from primary sources of carbon dioxide **(**Shakerian, Kim et al. 2015**).**

If we continue consuming planet resources in present fashion, the CO2 concentrations are expected to rise to an alarming level within few next decades, the rate of which however will still be dependent on the natural development, social, economic, technological factors and mitigation of CO2 through reduction and sequestration strategies but this level is expected to increase significantly over the next few decades due to the burning of fossil fuels and land use changes. The rate of this increase will depend on yet uncertain economic, sociological, technological, and natural developments, but may ultimately be limited by the reduced availability of fossil fuels or CO_2 reduction strategies (Nakicenovic and Swart 2000). Performance of the natural reservoirs and sinks for carbon dioxide gas (oceans and land) depends upon the complex chemical reactions and it compromised and reduced as a result of increased global warming (Cramer, Bondeau et al. 2001).

2 Global warming

Global Warming is the inclination of rising average temperature of the planet Earth. It is the cause and Climate change is the effect, which is the changing in the wind direction, precipitation rate, length of seasons, and extreme climatic events. Climate change is no more a hoax; its effects are now felt around the Globe (Budyko, 1982). Climate Change is a consequence of Global warming and Greenhouse gasses are reason behind the Global warming (Budyko, 1982). Pakistan being a Developing country just contributed 0.47% of Global GHG emissions, and in a recent GHG emission study (2011-2015) Our country has been ranked 137th, however, Pakistan is prone to the consequences of Climate Change, like the extreme climatic events. (Rasul, Zahid, Bukhari, & Afzal, 2012). Pakistan is among one of the five nations that were severely affected by the climate change in 2014. (Khan, 2001) Clean Development Mechanism (CDM) where India approved about 3600 projects as actually reduced carbon emissions and earned much capital resources as well, in contrast Pakistan however only approved 9 projects (Chandler, Schaeffer, Dadi, Shukla, Tudela, & Davidson, 2002). In order to be resilient towards aftermath of climate change in Pakistan, the policy makers should ponder on the ways to incorporate it in the policy making and initiate green Projects (UNEP, 2013).

3 Measuring level of carbon-di-oxide in paleoclimate

There are many complex reasons that are responsible for climate change but there are some major factors that includes; changes in Earth's orbit around the Sun, changes in solar output, change in the concentration of greenhouse gases in

atmosphere and changes in the position of continents with time. When we are interpreting climate change time scale is very important there are 4 major time scales; modern term (hundreds of years), short term that comprises 160,000 years, medium term (one million years) and long term (hundreds of million years) (Cronin, 2009).

In long term trends in climate change we see major shift like ice ages and warming periods after it very clearly it basically provides a “big picture” of climate change. (Gilbert, 2016) In order to study past climate, scientists use climate proxies to reconstruct past climate over longer fraction of Earth’s history. Consistent records are only available after 1880s and proxies only provide approximate data about ancient climate (Cronin, 2009). Ice cores, sub fossil pollens, lake and ocean sediments, are the proxies used by scientists. Two factors of the proxies usually get influenced by changes in climate one is the rate of growth and other is the composition of material at the time they were deposited or grew. Ice core provides relatively a direct conc. of atmospheric gases (e.g., CO_2 and methane) at the time ice was formed. Others are less direct like stable isotopes of oxygen. Data from many proxies can be combined for reconstruction of data longer than instrumental records (Gilbert, 2016).

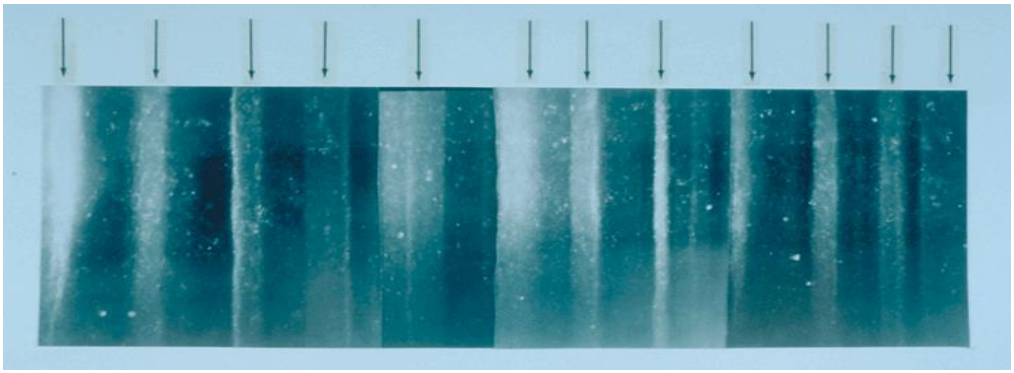
3.1 Physical proxies

Physical proxies comprise of features like texture, color, magnetic properties, sediment composition, density and structure (F. Sirocko, 2007). Scientists infer the past climate owing to the fact that change in conditions by environmental, orbital and human activities, the physical properties of sediments are altered in predictable way. Thus, by understanding these relations one can easily guess the weather conditions at the time of these sediments deposition (Fritz S. , 2007). Scientists use the layered structure, shape and size of sediment particles to figure out how if sediments were transported or not, from how far they are brought here, and lastly how energetic the environmental conditions like wind, water were. For example, if we see a layered structure of a rock with mud stone alternate with sand and fine clay from a lake lading we can predict the climate conditions at the time it was formed through analyzing its size and shape of its particles. Let us take another example when waves crashes on a beach or sea shore it will deposit coarse sand particles and for the deposition of silt or small grains very still conditions are required like a slow-moving river or Dam (Fritz S. , 2007). A lot of information was provided by the thickness and shape of sediment layer like pattern of deposition, weather they were deposited under water or on land, was condition were optimum for biological activity, local seismic activity like a crack or deformation in layered structure, and the direction of water and wind flowing (DRUFFEL, 1997). Color of sediments is another very important factor which can be measured like the rust color of sediments is because of oxidation of tor layer of rock when exposed to high level of oxygen after a period of low oxygen, green color is because of photosynthetic activity, white color is because of bleaching (DRUFFEL, 1997).Thus, they can provide hints about the different sources of sediments layer. For instance, change in sea level exposed the sea floor to high

oxygen conc. and the deposited layers of sediments on Florida Bay which are of light gray color (estuarine mud) changes to reddish brown color (peat) (F. Sirocko, 2007). Density is basically defined as the mass of sediments per unit volume and in turn depends upon three factors; amount of sediments, pore spaces, and the filling of the pore spaces (PÄTZOLD, 2004). Scientists can easily identify the source of sediments by measuring its ease of magnetization if it gets easily magnetize it is from a volcanic eruption or from some special geological unit. Minerals that trend to align by applying magnetic field allow scientists to date them and other older sediments that are deposited at the time of reversal of Earth's magnetic field (Budyko, 1982)**.**

3.2 Glaciological proxies

Glaciers are located high above the mountains or in the form of ice caps in Green land or Antarctica and this snow had been accumulated here after snow fall from many hundreds of centuries. Glacial ice comprises of isotopes of oxygen, dust, air bubbles and all these can be used to predict the climatic conditions when the snow was fallen. Scientists drill deep holes deep into these ice sheets and provide a summary of past climate changes by examining the air bubbles trapped inside the ice layers (F. Sirocko, 2007) (Pitman, 2006). Many projects are being launched but two most important are the Vostok Ice Core Project in Antarctica and Greenland Ice Core Project and these projects provide data up to tens to thousands of years (Pitman, 2006).



Source: (Pitman, 2006)

Figure 1: Picture of Ice Core Sheet depicting Annual Ice Layers

Determining the depth-age relationship is one of the major problems in the study of ice cores. Many methods can be used to determine this relationship and the accurate data has been produced up to 10,000 years beyond this the level of uncertainty increases. This is because of the fact that the relationship between the age-depth is exponential and ice flow models are used to determine the age of deepest section of ice cores. For instance, the first 1000m indicates the 50,000 years and the next 50 meters may indicate 100,000 years because of immense compaction and deformation of ice sheets (Pitman, 2006) (F. Sirocko, 2007). Isotopes of different elements like hydrogen and oxygen are sometimes instable

and emit different particles like alpha and beta and decay into their daughter elements and the rate at which it decays into its daughter elements is constant and thus this forms the basis of radio-isotope dating methods, and these methods are then used to age ice cores (Cronin, 2009). Melt feature in the upper layer of glaciers is among one of the most important feature in predicting past climate. This feature includes vertical and horizontal ice glands and ice lenses respectively and these structures are formed as a result of refreezing of percolating water (SACHON, 2007). The deficiency of air bubbles is the identifying feature of these structures. The relative frequency of melting down will give us the peak summer temperatures. Other physical features of ice are crystallographic axis, crystal size and air bubbles (F. Sirocko, 2007). Ice cores provide vital information about volcanic activity, wind patterns, precipitation, temperature and atmospheric composition (Pitman, 2006). There are some chronostratigraphic markers, and other dating methods can be verified by comparing them with these markers. There markers are generated because of major volcanic eruptions that are so explosive that they added large quantities of ash and gases in to the atmosphere. (Cronin, 2009) These gases turn in to aerosols before precipitation and when snow falls they significantly reduces the pH of snow and making these layers highly acidic and this acidity can be measured by electrical conductivity method. (Gilbert, 2016)

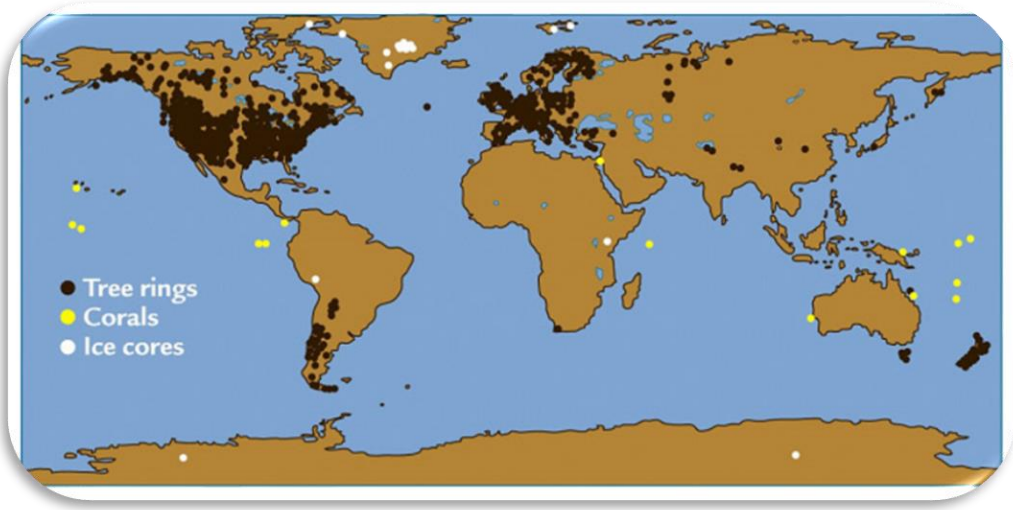
3.3 Geological proxies

Most of the techniques we use for climate reconstruction provide accurate data up to a limited time scale. Most tree rings and ice cores provide data up to 10,000 years. Ocean sediments are among those proxies that provide data up to the ages of dinosaurs i.e., 100 million years ago. But we are unable to reach further because of tectonic plates subduction due to continental drift. So, scientists have to find another way to look for evidences older than that (FELIS & PÄTZOLD, 2004). Sediments are laid down progressively by debris transported by wind, water, gravity etc. During tectonic movement, sometimes they are lifted upward and get exposed, then scientists study these and reconstruct past climate (Fritz S. , 2007). Many techniques are used for paleoclimate reconstruction, however, primarily; rock type and rock composition provides valuable insight of the time at which the sediments were deposited. This deposition not only get influenced by climate but also due to a second factor that is continental drift e.g., the carboniferous coal and lime stone of northern England (which provide evidence of humid and warm climate) was deposited when Britain was present near the equator and in the southern hemisphere large scale glaciation was occurring which is the evidence of cold climate (FELIS & PÄTZOLD, 2004). So, in order to reconstruct past climate from sediments scientists have to keep in mind both these factors. In geology facies analysis is the study of changes in rock type over time. For example, we have a sedimentary rock formation consisting of a layer of shale interstratified between the sandstone layers (Cronin, 2009). This change from fine-grained mudstone (shale) to coarse grain sand stone provide evidence of changing sea level as sand stone is deposited in coastal areas where water is shallow and shale or mud stone is deposited in deep water of continental shelf. And this shifting in

sea level is because of epeirogenesis of ice formation. Other major rock type markers include coal (is a lithified organic matter provide information about humid and warm climate), evaporates (provide information about the arid, dry conditions and is a lithified salt deposit), reef lime stone (is a cemented coral reef and provide evidence of warm surface condition of ocean) and phosphates (lithified siliceous and phosphate material and evidence of ocean upwelling due to active surface trade winds) (Cronin, 2009) (Fritz S. C., 2007) (Gilbert, 2016). Other techniques include chemical composition, sediments grain morphology, and sedimentation rates. Fossil bearing rocks also provide valuable paleoclimatic information.

3.4 Biological proxies

Seed plants have special sperm caring reproductive body called pollen grain and it has a unique shape depends upon its plant and its walls are thick and are made up of a substance called spooropollenin making it strong and stable (Sadori & Koutsodendris, 2016). Pollen grains when get blown or washed into a water body their outer wall which is tough allow them to get preserved in the layer of sediment that are normally present at the bottom of lakes, oceans and pounds. Due to this novel characteristic of pollens, researchers normally take the core sample, analyze it and by measuring the abundance of specific type of pollen they determine the type of plants that existed at the time when sediments were deposited. By knowing this, they could easily predict the climate of deposition period by comparing the knowledge about historical and modern distribution of plants and their connection to climate (Timothy J. Pfeiffer, 2011). By using both chemical and physical methods scientists are able to separate spores and pollens from sediments only by taking the core sample. As we know that spores and pollens are very small typically in the order of 10-200 microns so for thorough examination they must be mounted on a slide and examined under microscope (Sadori & Koutsodendris, 2016). After examination scientists identify type, count, draw diagram, and at last the abundance of specific pollens in that particular core sample. Researchers by analyzing the data obtained from the well-dated core samples are able to get information about the vegetation and plant species of the time at which sediments are deposited i.e. up to millions of years ago. This proxy not only tell us about the past climate but also the impact of human activities on climate and how we are altering it. This can be done by comparing the vegetation of thousands of years ago and now (Sadori & Koutsodendris, 2016) (Cronin, 2009). National climate data center has launched a paleoclimatology program that organize and collect data about pollen records around the globe. Tree rings can also serve as climate proxy because of isotopic composition, tree growth, density, tree ring width and all these factors depends upon different climatic conditions. Trees add one tree ring along its waist every year so, by counting the numbers we could not only comment about the age of the plant but also the climatic conditions (Yasmin E. Bushby).



Source: (Sadori & Koutsodendris, 2016)

Figure 2: Picture representing the geographical distribution of sources of prehistoric carbon dioxide concentration measurement.

First of all, scientists hike to the site of tree growth, and ensure that it is not affected by human activities, after that individual trees are selected. The trees that are oldest provide longest climate data. Then they use a tree core that is basically a hollow bit drill that works like an Apple corer. They generally put the corer into the tree and then move it to the center by twisting and turning and when it reach at the center they withdraw it without harming the tree (Gilbert, 2016) (SACHON, 2007). After collecting the samples scientists transfer the samples that are usually in large number to lab and with the help of sand paper they smooth them to make every tree ring visible and distinct. They also cross date of the results obtained from the living trees with that of the dead plants so, that no tree ring could be misidentified and this reduces the uncertainty in the end results. Tree rings collected from different regions of the worlds help us to construct the global past climate (Timothy J. Pfeiffer, 2011). Plant macrofossils are basically those parts of plants that are big enough to be seen with naked eye like cones, flowers, leaves, seeds and other plant fragments. Firstly, they identify the specie. Liverworts are the oldest known macrofossils to be identified in the middle Ordovician rock dating back to about 475 million years. In Ireland, the oldest vascular land plant macrofossil is of Cooksonia found in the Silurian rocks dating back to about 425 million years. They interpreted the results by comparing the environmental requirements that a particular plant taxa demands (Budyko, 1982) (DRUFFEL, 1997). Normally charcoal from different sediments is used by scientists to investigate fire history. Charcoal is basically the carbon residue that is left behind when plant material is burnt down. They use it to reconstruct past climate by measuring the magnitude, frequency, area and intensity of fire. As the vegetation cover changes and temperature variate all these factors also change (Yasmin E. Bushby). They are microscopic, unicellular organisms that have an external shell and lives in marine

environment. As they have characteristic shell shapes and specific environmental requirements so, by studying the composition of their shell scientists are able to infer the changes in the water quality and temperature (Fritz S. C., 2007). They exist in two different forms depending upon the depth at which they live in ocean. One is Benthic that lives on the ocean floor and founds in the early Cambrian rocks about 500 million years ago. Other is the planktonic form, it lives in the shallow water above the ocean floor and present in the mid-Jurassic rocks about 145.5 million years ago. They are valuable climate proxies because of their rapid diversification (PÄTZOLD, 2004). They are basically tiny members of the family named shrimp and their habitat is usually aquatic and prominent feature is that they are enclosed in two shells. The features that make them important temperature proxies are their sensitivity to salinity, change in temperature, water quality, and oxygen level (DRUFFEL, 1997) (Timothy J. Pfeiffer, 2011). They are golden brown, photosynthetic algae and have skeleton formed of silica. They are important because they are delicate to change in salinity, nutrients, temperature in both fresh and marine environment. The oldest diatoms found are in the Jurassic period dating back to 190 million years (Fritz S. C., 2007) (Sadori & Koutsodendris, 2016). They are single celled and have a whip-lash flagellum, most of them live in marine environment. Under unfavorable conditions they form a cyst called as Dino-cyst that is dormant and have resistant cell wall and because of this character they are found preserved in the rocks of Triassic period dating back to 235 million years and they provide us vital information about the nutrient status and salinity of water in which they are living (DRUFFEL, 1997). Sediments in large quantities are accumulated in lake and in the ocean basin per year and these sediments contain chemical and biological material that due to absence of oxygen get preserved in the form of tiny fossils and this is due to high pressure (Fritz S. C., 2007). (Gilbert, 2016). Generally, scientists drill cores in the sediment and get the sediment sample to study the sequence of climate changes occur during the formation of sediments. The most important features are the shells of Diatoms because when these tiny creatures die their shell sinks to the bottom of sea and they tell different environmental factors that are described earlier. The ratio between the carbon content and isotopes of the shell tell us about the composition of atmosphere or climate at that particular time when shells are formed (Timothy J. Pfeiffer, 2011). They are the colonies formed by many tiny animals called Coral Polyps. These polyps form the reefs hard structure and it is composed of a mineral called calcite i.e., $CaCO_3$. With the passage of time the older polyps goes beneath the newer polyps and make the coral reef expand. (DRUFFEL, 1997)The animals that lives in the coral polyps are in symbiotic relationship with the photosynthetic algae so, they require sunlight (FELIS & PÄTZOLD, 2004). They grow in a very narrow range i.e., in which there are less fluctuation in temperature, acidity, salinity, sunlight etc. They only bloom in the area where temperature is warm (not very warm), subtropical or tropical, water is shallow and clear so that enough light penetrates and reach the reef (PÄTZOLD, 2004). This delicacy to environmental conditions make them good measure of local climate. As they only flourish in low altitude areas so they very beautifully compliment the data obtained from tree rings

(moderate altitude) and from ice cores (high altitudes). Corals have layered structure like lake sediments, tree rings and ice cores. The texture of mineral (calcite) varies seasonally, with darker bands appearing in the winter season when growth is slow and lighter bands appear in the summer season when growth is fast. Corals can live up to centuries and like tree rings we can do cross dating of corals by comparing the data obtained from living corals with that of dead (Fritz S. C., 2007). Unlike tree rings it is not the thickness or width of calcite layers that help scientists to use it as a climate indicator but instead it is the composition of the layers that actually help scientists to predict past climate whereas layered structure help scientists to accurately date the change they found. (DRUFFEL, 1997)Corals not only tell us about the past temperature but also the change in sea level as they grow in shallower regions and due to shrinking of ice cap sea level get higher and the area become less shallow and result in death of corals. Other factors that kill corals includes too warm and too cold or muddy water. To gather the reef core samples SCUBA divers, dive down and take the sample out by drilling. Sometimes visual inspection is sufficient but in some cases x-ray imaging is done to make the bands clearly visible and identifiable. After that they extract samples for isotopic and chemical analysis (FELIS & PÄTZOLD, 2004) (Fritz S. C., 2007). One other important paleoclimatic study of coral reef indicated that along with annual banding pattern there is a secondary banding pattern and it is because of the monthly variation in tides. The frequency of tides at any particular place depends upon two factors one is the Earth's rotation and other is the orbital motion of moon. If we examine the corals 440 million years ago it was evident that there were more cycles per year than now. (Cronin, 2009) And this support the view of astronomer that is Earth spun more quickly on its axis in past as compared with now. And these findings tell us that Earth spuns 11% faster than current rate.

3.5 Chemical proxies spun

Stable isotopes can be used as a basis of interpretation of paleoclimate. As we know that oxygen have 3 stable isotopes i.e., ${}^{16}_{8}O$, ${}^{17}_{8}O$, and ${}^{18}_{8}O$, and their natural abundance is 99.76%, 0.04% and 0.2% respectively. Whereas 16, 17, 18 represent the nucleon number of atom. This means that number of proton in each atom is same (8 protons) but it is the number of neutrons varies. As a result, ${}^{18}_{8}O$, is heavier than ${}^{17}_{8}O$, and it in return is heavier than ${}^{16}_{8}O$. water molecule with ${}^{16}_{8}O$ have higher vapor pressure than water with ${}^{18}_{8}O$. Thus, during evaporation vapors are rich in ${}^{16}_{8}O$ molecule and remaining water is enriched ${}^{18}_{8}O$. During condensation ${}^{18}_{8}O$ condenses first due to lower water pressure (Budyko, 1982). Water becomes increasingly depleted in heavier isotope as the poleward transportation continues. Condensation is because of cooling, and there is greater decrease in temperature and lower is the conc. of heavier isotope. The concentration of isotope in condensate will determine the temperature at which condensation occurs. And thus, we concluded that snow at poles is depleted in heavier isotope of oxygen (F. Sirocko, 2007). This temperature dependency allows the oxygen isotope content of an ice core to provide a proxy climate record. (Pitman, 2006) The relative

proportions of $^{16}_{8}O$ and $^{18}_{8}O$in an ice core are expressed in terms of departures, $d^{18}_{8}O$, from the Standard Mean Ocean Water (SMOW) standard, such that:

$D^{18}_{8}O = (\frac{^{18}_{8}O}{^{16}_{8}O}$ sample) - $(^{18}_{8}O/^{16}_{8}O$SMOW) x 103 ‰

4 Present methods used for carbon dioxide measurement

Now a days many methods are used for carbon dioxide measurement from atmosphere i.e. physical and chemical. This type of spectrograph uses Raman scattering for carbon-di-oxide measurement. First of all, gas sample is aspired into an analyzer and then this sample is illuminated by using an argon laser beam which should be of high intensity and monochromatic. This light is absorbed by the gas molecules and then they get excited or become unstable (SACHON, 2007). The Raman scattering signals are measure at specific angle to laser beam and are of low intensity. This scattering method help us to identify all types of molecules present in gas sample. This technique can be coupled with the latest technology that will not only help to identify but also quantify the carbon-di-oxide (Yasmin E. Bushby) (T. M. L. Wigley, 1985). Mass Spectrograph technique separates the gas or sample molecules upon the difference in their charge to mass ratio. The gas sample is aspired into a chamber with high vacuum 10-5mmHg and there an electron beam hit the sample, fragments and ionizes the sample components. Then they are accelerated by the help of an electric field in to a final chamber, here magnetic field is made perpendicular on sample. And the sample molecules both fragments or ions follow a curvature and this curvature depends upon the charge to mass ratio of that particular molecule. Then at the end of the tube a detector is placed that detects the ions fall and generate an electric current which is then amplified and measured and processed in an analog system (Klaus S. Lackner). Photoacoustic Spectrograph work on the principle of IR-gas analyzers, the only difference is that photoacoustic use acoustic techniques while IR method uses optical methods. When gas is subjected to IR light it absorbs it, expands and as it expands its pressure increases and if the IR light is provided in pulses then the pressure produced is also pulsatile and results in pressure fluctuation. If the frequency of pulsation is within the audible frequency range, then it is detected by a microphone (SACHON, 2007). This microphone is then connected to an analogue system which interpret the results. The potential advantages of PAS over IR are better reliability, less frequent need of calibration, higher accuracy, less need for maintenance, and PAS is able to directly measure the amount the IR light absorbed and no reference cell is required for calibration. When there is no gas in chamber zero is reached. Despite of its great accuracy and reliability this method was unable to get much importance than IR spectrograph. (T. M. L. Wigley, 1985) (Budyko, 1982)

5 Chemical method of CO2 measurement

In this method, a pH sensitive chemical is used which change color when exposed to carbon-di-oxide. This chemical is enclosed or entrapped in a plastic casing and is connected to the gas stream that is directly sucked from atmosphere. Color

changes from purple to yellow when carbon-di-oxide concentration decreases (SACHON, 2007).

6 Impacts of climate change

Refers to the condition of low rainfall and water over a specific area and specific time. This drought has been a prominent feature of Pakistan in recent years. The Baluchistan and Sindh mostly suffers from the drought conditions, mainly results in the decrease of water in river flows. (Rasul, Zahid, Bukhari, & Afzal, 2012)Drought further causes the agriculture deprivation. It is also a cause to animal and poultry loss which in return leads to mal-nutrition (Chandler, Schaeffer, Dadi, Shukla, Tudela, & Davidson, 2002). Climate change could affect coastal areas in a variety of ways. The coasts are sensitive to temperature, increase in sea level, storms and frequency of rainfall. Due to the increased amount of Carbon dioxide in the atmosphere, oceans are absorbing are absorbing more CO2 and are getting more acidified. This rising acidity will have significant impacts on coastal and marine ecosystems (Khan, 2001). Coastal flooding, Shoreline erosion, and water pollution affect manufactured infrastructure and coastal ecosystems (UNEP, 2013). Tropical cyclones are Characteristics of climate change in Pakistan. The Global warming is causing more cyclone over the Arabian sea, hence it is anticipated that frequent cyclones will hit the coastal areas like Karachi (Rasul, Zahid, Bukhari, & Afzal, 2012). The increase in Temperature leads many new vectors invasion and diseases, Like Dengue Infectious Diseases are expected to be more prevalent as their reach increases and seasonality expands. Warmer temperatures can enhance the amount of air pollutants and water pollutants. The consequences of extreme events will lead to widespread of disease (Chandler, Schaeffer, Dadi, Shukla, Tudela, & Davidson, 2002) (Golomb, 2004). The areas of Pakistan which lies in the active zone enjoys upto200mm rainfall annually. But this much rain often leads to destruction when happens for a prolonged time and in the lower half in province Sindh and Baluchistan, the precipitation is only few millimeters. And it occurs mainly during summer in 15-20 days (Khan, 2001). Occasionally during the monsoon season heavy rainfall results in a very destructive Floods. The shift in the monsoon season due to climate change and also the intensity of rainfall. Last year 1400 died in floods, 130,000 people displaced (Rasul, Zahid, Bukhari, & Afzal, 2012). As the temperature of the globe is increasing due to Global warming, the trend of thinning of ice sheets and the glacier retreat is increasing at alarming rate (Budyko, 1982) (F. Sirocko, 2007). Recently by, remote sensing technique it was recorded that the decay of Siachen Glacier has reduced by 5.9km in longitudinal extent from 1989 to 2009. The recent mishap of Giyari sector is also due to global warming and it took away life of 100 of people. Thinning of ice mass is evaluated 17%. The continent of Antarctica has been losing more than 100 cubic kilometers of ice per year since 2002 since 2010; the Antarctic ice melt rate has doubled. (NASA, 2016) Pakistan Metrological department recently took sample of ice and confirmed the presence of black carbon deposits in it. The black carbon increased the amount of absorbed solar radiation, hence melting the ice sheets at faster rate (F. Sirocko, 2007). The data

of 100 years of temperature showed that the trend of increase in temperature is more in Northern Areas as compared to other areas of Pakistan. The two main Mountains Hindukush and Karakorum which are source of fresh water to 70% of population of Pakistan are also melting which is not a very good sign for the future. The continent of Antarctica has been losing more than 100 cubic kilometers of ice per year since 2002 since 2010; the Antarctic ice melt rate has doubled (NASA, 2016). The melting of glaciers due to Global warming is leading to the increase in the sea level. This happened in two ways; Firstly, Thermal Expansion, which is the expansion of sea due to the increased temperature and secondly due to the melting of ice sheets and glaciers which leads to the rise in the sea level. (Rasul, Zahid, Bukhari, & Afzal, 2012) (Khan, 2001) Karachi Tidal Station an increase in 1.1mm/year of sea level has been recorded. (UNEP, 2013) (Rasul, Zahid, Bukhari, & Afzal, 2012)The sea continuously submerges to the surface and about 80 acres of land on average is taken away. Six subdivisions of Thatta, which were once so richer in agricultural production are now considered as poor due to the rise in sea level and the ultimate consequences of it (T. M. L. Wigley, 1985) (Budyko, 1982). The Earth's sea level has risen by 21 cm (8 inches) since 1880 (DRUFFEL, 1997).

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GLOBAL WARMING, CLIMATE CHANGE, CARBON CAPTURING, AND STORAGE – A REVIEW

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ABSTRACT

Due to our industrial revolution, intensive farming, land clearing and use of non-renewable resources such as, natural gas, oil and coal, there is an abrupt rise in the temperature globally. People now-a-days feel less threat by the phenomenon of terrorism than to the devastating effects of climate change. This global rise in temperature is also causing many problems in Pakistan such as, Flooding, droughts, food insecurity, sea level rise and many others. There are certain mitigations to overcome this issue, most important we have to reduce our use of fossil fuel and try to fulfill our energy needs by non-renewable resources such as solar power, geothermal energy, wind energy, hydropower and by the use of biomass. Not only this, our Government should have a deep interest in the issues regarding this and should also give a bird's eye view on the technique of carbon capturing and storage. This is virtually one of the efficient methods for the capturing and storage of carbon for many decades. There are several methods for it, such as, post combustion capturing, pre-combustion and oxy fuel capturing. Carbon is liquefied after capturing and stored at a particular site. Site for the storage of carbon should be properly selected. Pakistan should introduce these methods to reduce the problems regarding the emission of carbon dioxide from industries.

1. INTRODUCTION

The word Climate comes from Ancient Greek word "klima", meaning "inclination". Generally, it can be defined as the average weather condition of a place over a long period of time. Usually the period of 30 years is the normal standard averaging period. Other statistics are also included other than average like magnitudes of variations from day to day, week to week, month to month and year to year (Ghommen, 2012). There are three major climate classifications; Spatial Synoptic climate classification, Koppen climate classification and Thornthwaite. Records show two types of data based on previous observations and one on present observations i.e. Modern and Paleoclimatology. Climate change is the variation in global or regional climates over time. It reflects changes in the variability or average state of the atmosphere over time scales ranging from decades to billions of years. These changes can be caused by internal processes of Earth, external forces or, more recently, human activities. In latest usage, especially in the framework of environmental policy, the term "climate change" often refers only to changes in modern climate, including the increase in average surface temperature known as global warming.

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2. SOURCES AND IMPACTS OF CLIMATE CHANGE

"Climate change" is defined as the change in the climate state that is identified by the variability's in its properties and proceeds for long times. The change may be caused by the natural disasters including plate tectonics and volcanic eruptions, by the biotic processes or by the human beings that are causing the most significant effect on the climate, referred to as 'Global Warming'. The scientists around the world are actively working for understanding the climate changes extending deep into the Earth's history by the studies on the evidences provided by borehole temperature profiles, cores removed from deep accumulations of ice, floral and faunal records, records of the past sea levels, sediment studies and the comparisons between the glacial and per glacial processes. Moreover, the general circulation models to match the past climate data and the future projections are also an efficient approach by the scientists (Montzka, 2011).The most general trend in the climate change is by the analysis of its statistical properties over short and long periods. The change in climate is referred specifically to the "global warming" which can be sometimes called as the "anthropogenic global warming" due to the intense increase in the greenhouse gases level. In 1996, the World Meteorological Organization (WMO) proposed the climate change scale to be greater than 10 years. Also, the climate change was incorporated in the Intergovernmental Panel on Climate Change (IPCC) and the UN Framework Convention on Climate Change (UNFCCC). On the broadest level the rate at which the energy is received by the Sun and the rate at which it is lost determine the equilibrium temperature. The climate shaping mechanisms include the variations in solar radiations in the albedo, mountain building, continental drift and the changes in the greenhouse gas concentrations. The oceans and ice caps respond more slowly to the climatic forcing. But the Arctic sea loss both in extent and thickness over the recent years is an authentic evidence of the rapid climate change (Khan, 2012). The oceans and the atmosphere can work together to spontaneously generate internal climate variability including the Pacific decadal oscillations, the Atlantic Multi-decadal Oscillations. The main causes are shown in the figure.

They are the most concerned factors about the climate change crisis due to rapid rise in CO_2 levels. The main reason for it is the emissions produced from the fossil fuel combustion followed by aerosols (particulate matter) and the CO_2 released by the cement manufacture. Other factors include land use, "Ozone depletion", animal husbandry releasing CH_4 and deforestation. According to the IPCC Fourth Assessment Report global temperature has increased by 1.8^{o}C by the end of 21st century. For the highest emission estimate for the global mean temperature is 4.0 ^{o}C within a likely range of 2.4-6.4^{o}C. This range in the temperature partly reflects the "climate sensitivity" reflecting the uncertainty in the response of the climate system to past and the future greenhouse gases. According to a study on temperature variation, temperature variation from 1850 to 2000 is shown in figure 2.

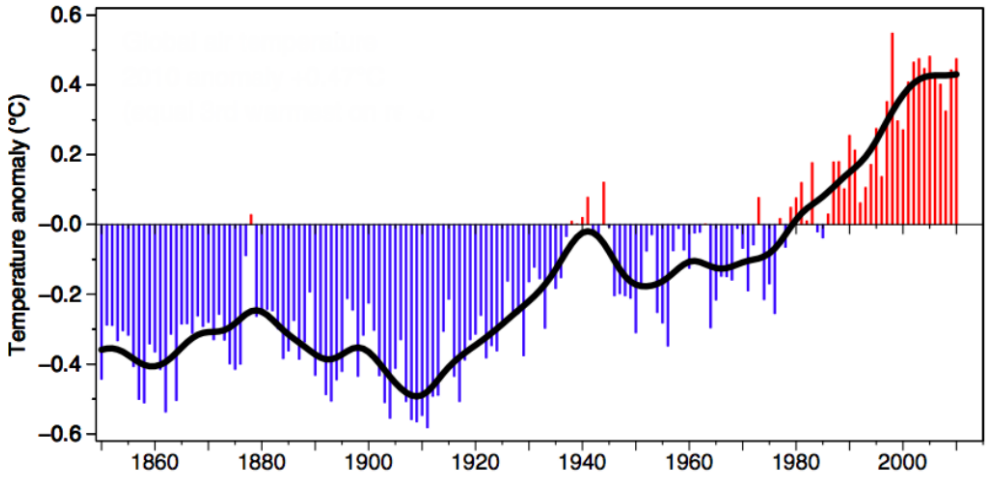


Figure 2: Graph Showing Temperature Variation

Over the next several decades it is thought that the global warming could be 'irreversible'. But even if we reduce the emissions to the least level global temperatures would still remain to the highest level for at least 1,000 years projecting an alarming situation for the human beings. Climate change is a major problem these days. The whole world is warming; sea level is rising globally and some of the extreme events are becoming more severe and frequent. These changes have resulted in the worldwide impacts all across the countries affecting almost every sector of the economy. Today, there is a need of reliable scientific information about the present and the future responses, impacts and effects of the change in the climatic conditions. The most affective role here is being played by the U.S Global Change Research Program (USGCRP) which has released the 3rd National Climate assessment in May 2014 playing its part at the center of the Federal Government's efforts to accomplish this critical need. The evidences gathered from the studies from the atmosphere's top to the very depths of the oceans, gathered by the engineers and the scientists around the globe explains that 'the planet is warming and since the last half of the century the cause behind this immense increase is primarily due to the activities of the humans, the worst due to the "burning of the fossil fuels". Moreover, the impacts of the climate change are seen across the regions in almost every sector of the human society including human health, agriculture and food security, transportation, energy, water supply, ecosystems and others are in the list of the increasing disruptions throughout the centuries. The situation of the emission of greenhouse gases is becoming more worse and now many people are suffering from many diseases because of the contact with these emissions(Montzka, 2011).Here the scientific information can play their effective part for creating economic opportunities and actively taking part in managing the risks that can reduce these impacts (Walmsley, 2010). Climate change mitigation includes the actions that reduce the rate or intensity of the long-term climate change. The term actually implies to the reduction in the

anthropogenic activities releasing GHG's. Mitigation may be increase by the increase in the carbon sinks capacity. Many mitigation policies are there that are associated with the reduction of risks associated with human-induced global warming. The reports assessed by the IPCC's portray 'mitigation' as a public good and the 'change in climate' as the tragedy of commons. The effective results would only be obtained if every individual will put his best foot forward for mitigating the impacts of climate change. These include; Switching to low carbon energy sources (renewable energy), Expanding forestation (major Carbon sinks), Improving energy efficiency (insulating buildings), Climate engineering. The renewable energy use has grown rapidly in the recent decades. The Intergovernmental Panel on Climate Change explains that some of the fundamental technologies are quite enough to meet the increasing demand of the growing energy crisis. More than 20% of the 30 nations utilize the renewable energy. Geothermal energy in Iceland, Hydroelectric power in Brazil, Austria and New Zealand, Wind power in the U.S and the solar water heating in China contributes to more than 50% of the total economy of these nations. The World Nuclear Association has reported that the nuclear electricity generation in 2012 was at its lowest level since 1999. It shares second largest share to electricity generation as low carbon power but there is a need of better security managements for nuclear accidents. The studies have proved that by implementing more heat pumps the greenhouse gas emissions could be controlled. This is a single technology with a market share of 30% cleaner electricity. Moreover, heat pumps could reduce CO_2 to 8% annually. The best way to phase out the fossil fuels is to replace it with "carbon neutral and carbon negative" pipelines and replacing the power to gas and gas to liquid transportation fuels. The flue gas generating CO_2 could be replaced by plastic lumber which allows the plastic reforestation. By reducing the amount the energy required to produce the products and services such as by insulating the house by building it to less heating and cooling. Similarly installing the natural skylights or the fluorescent lights by the traditional incandescent light bulbs use almost less than 2-3 times of the energy and are 6 to 10 times longer lasting. According to the IPCC Fifth Assessment Report lifestyle behavior and cultural change plays a very important role in the high mitigation potential in the sectors of technological and structural change. Food alone Accounts for 20% of the global carbon footprint due to its largest share of consumption based GHG emissions. So, by controlling the food and services significantly in poor countries and the manufacturing and the mobility of goods in rich countries climate change consequences could be managed. Almost (Nigam, 2011)about one ton of carbon dioxide emissions had been reduced in 2007 by the decrease in the rate of deforestation. Thus, reforestation could save at least another 1 Gt CO_2/ year. For this, there is a need to conserve forests by transferring the rights from public domains to its native inhabitants. This could only be achieved by protecting the existing loss such as Forests Rights Act entitled for this purpose. China and Brazil have played their best parts in maintaining the forest covered by protecting the greenery and prohibiting the clearing of it, which ultimately leads to greater economic, social and environmental returns(Walmsley, 2010).Carbon capturing and storage is a very

effective technique involved to mitigate the climate change, involving the capture of CO_2 from point sources such as power plants, storing it away safely instead of releasing it into the atmosphere. The Inter-Governmental Panel on Climate Change says that CCS could mitigate carbon from 10% to 55% over the next 90 years. This is the single new technology that could take the place of the regular coal plant and could cut emissions of CO_2 to almost millions of tons a year, ultimately maintaining the natural climate balance (Herzog, 1997). Climate has thoroughly changed due to manmade technologies and his activities all across the world. Major factors for change in climate are these; The major change is considered the industrial revolution; numbers of industries and factories have been increased so also the greenhouse gas (GHG) emissions in the atmosphere(Montzka, 2011), After increased population and urbanization the number of vehicles have been increased and emissions from these sources are also increased, For increased energy demand and for high economic activities anthropogenic activities have increased, and Fossil fuel is also an important source of Green House Gas emissions. Increase in temperature was estimated 0.76°C in the 20th century. It was 0.6°C increase in first decade (Dr. Ghulam Rasool, 2012).

Pakistan's economy has suffered a lot due to the incidents that happened in it by changed climate pattern. These events were devastating and happened continuously during the past years. Pakistan faced worst conditions of floods in year 2010 and 2011.2010 flood was a major flood emerged in the human history in Pakistan. It affected 20 million people, people were displaced from their houses and villages and left with no help. 2011 flood affected also 5.3 million people and destroyed many villages. 1.2 million villages, 1.8 million houses in Sindh (Dr. Ghulam Rasool, 2012).Drought is known as period of dry weather with no rainfall. It is also associated with decreased water availability and hence no water is available for the people living there. In Pakistan the province of Baluchistan and Sindh faced the drought condition. River embankment also face shortage of water so rivers got dried and no drinking water is available to the people native to that area. Agricultural lands are affected due to drought conditions because Pakistan's agriculture is dependent upon irrigation from water with traditional sources. As a result of climate change number of cyclones has increased. Cyclones are seen in the Arabian Sea during the last 50 years. Metropolis city like Karachi is under its affect (Lemmen DS, 2008).

3. CARBON CAPTURING AND STORAGE

Now-a-days fossil fuels are playing very significant role in meeting our energy demands and are the main reason in the issue of Global warming (Klaus S. Lackner). 80% of the energy consumption is by fossil fuel and 58% of which is consumed by the sector of transportation (Golomb, 2004). To deal with these issue the release of carbon dioxide in the atmosphere should be avoided. Our carbon sinks like forest and oceans are not much able to absorb the carbon adequately so that is why our carbon emissions should be reduced. 60% of the global emission of carbon dioxide are from power points and the industries. If we consider our present situation, fossil fuels are a very significant source of carbon emissions,

about 85% of our energy needs are met with the help of fossils fuel and rest of the energy need is met though the renewable sources. The reductions in this carbon emission demanded in the Kyoto Protocol is actually very less than that would be ultimately required to control Carbon dioxide levels, and this goal will be much ambitious to accomplish by solely removing emissions from power plants(Klaus S. Lackner). There are various methods to reduce the concentration of the greenhouse gases from the atmosphere such as, to use renewable resources, to expand our carbon sinks and also to use technology regarding carbon capturing and storage (Ghommen, 2012).At present, 15 large-scale facilities are working all around the world to capture 27 million ton of Carbon dioxide every year. (Golomb, 2004) Feasibility of the technologies being used and also about the cost spent is also now reckoned in the various conducted studies (Heal, 2002).The sliepnir oil and gas project working in Norway had about 20 years of excellent operations, and is storing approximately 1 Million ton of carbon dioxide per year. In United States, carbon dioxide has been a major reason to enhanced oil recovery, for several years, aided by the existing network of Carbon dioxide transport pipelines which have a life of more than 6,600 kilometers (Yasmin E. Bushby). Carbon Capturing Technology is important for various reasons, one of them is this technology can also be used for the purification of the biogas. As, biogas can replace natural gas, under the umbrella of energy consumption(Nigam, 2011).Carbon sequestration is basically the process of capturing and storage of carbon that would otherwise be emitted into the atmosphere and will be the source of global warming. The basic purpose of CCS is to empower the utilization of fossil fuels, and to reduce the release of Carbon dioxide to the atmosphere, and then mitigating the problem climate change (Yasmin E. Bushby). Carbon Capturing is usually done from the cement and steel production industries and power plants because they emit a great about of Carbon dioxide (Hu, 2011). Carbon capture has been used for many years to provide Carbon dioxide for different industries, for example those producing carbonated drinks, dry cleaning of clothes or making coffee. The oil industries are also using Carbon dioxide separation process to purify methane gas, and also in refineries where hydrogen gas is produced by the help of natural hydrocarbons. (Yasmin E. Bushby). Carbon Capturing can be done by following methods; Flue gas separation, Oxy-fuel combustion in power plants and Pre-combustion separation.

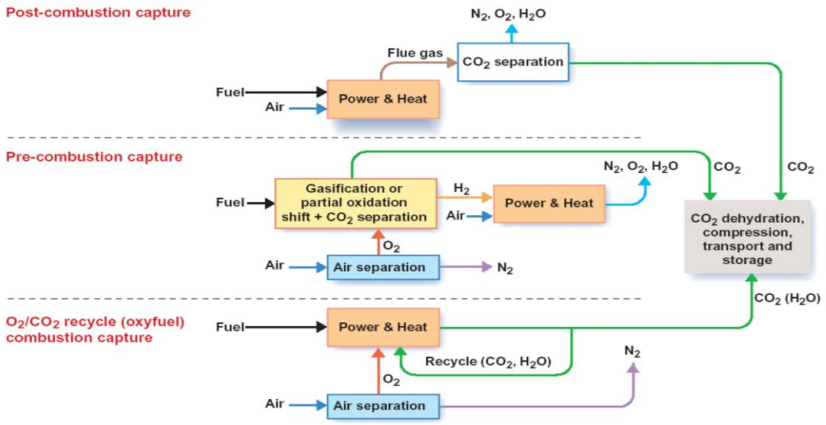


Figure 3: Various methods of Carbon Dioxide Capture and Storage

If we want to collect carbon after the combustion process involving downstream flue gas separation then firstly, a solvent is used for the absorption of carbon dioxide from the flue gas and then de-absorption is done by providing heat and pressure to excite the carbon dioxide absorbed in the loaded solvent. After that, carbon dioxide collected is processed and compressed to store at the particular storage sites (Yasmin E. Bushby). Flue gas separation is one the popular method of carbon storage and is based on chemical absorption. It is working efficiently at the industries and many commercial processes, e.g., carbonated beverages, foam blowing, the production of urea, and dry ice production. Absorption process, proceed from left to right and regeneration from left to right (Golomb, 2004).In order to decrease the size of the columns, capital cost and energy cost, new processes are designed. One of the example is membrane absorption process, in which a membrane composed of poly-tetrafluoroethylene provides greater contacting area in a given volume, but the membrane by itself do not separate Carbon dioxide from the remaining flue gases. Basically, the solvent absorbs the carbon dioxide selectively(G, 2009).The main advantages of this process are its high packing density, high flexibility regarding solvent selection and flow rates, no foaming, no channeling and flooding and prominent savings with respect to weight. It is also good to develop a scrubber to remove carbon dioxide. In this process, no regeneration is needed. We can only remove carbon dioxide from the flue gas by the help of sea water and then can take back the whole solution to the ocean water for storage. In the scrubbing process, for example, the massive volume of water that is required result in developing huge pressure drops in the absorbers and the pipes. In Oxy-fuel combustion burning of hydrocarbon fuel is done, in a chamber that have a large amount of oxygen, instead of air containing 16% oxygen only. By this, water is produced and 80% Carbon dioxide as by-product. In Pre-combustion process of carbon capturing, the capture of Carbon dioxide is done before the fuel is burnt. The fossil fuel is partially burned or gasified in a combustion chamber at a very high pressure and within an adequate amount of oxygen. This in return,

produces hydrogen and a comparatively pure stream of Carbon dioxide about 15-60% that the hydrogen can then be burned to produce heat for electricity generation without producing Carbon dioxide (water vapor is the main by- product). This capture technology is very easy to separate and capture. This technology can be widely use in industrial processes, such as Carbon dioxide production during the generation of hydrogen from the splitting up of hydrocarbon in oil refineries. Though, this methodology has not yet been used in the processes, such as power generation (Yasmin E. Bushby).This process has some important advantages such as, the carbon dioxide is not diluted due to the combustion air and the stream having carbon dioxide is at high pressure. Thus, more effective methods should apply that is the pressure-swing-absorption in the solvents for example polyethylene glycol or methanol. This method is mainly applied in the coal gasification combined cycle power plants (Golomb, 2004).In this process, gasifying of the coal is done for getting synthetic carbon monoxide and hydrogen gas. After that carbon monoxide is reacted with water to get carbon dioxide and hydrogen (Golomb, 2004).

Carbon dioxide is to be stored, so that it can't emit out into the atmosphere. It must be stored under these conditions; Prolonged storage time, i.e. hundred to thousand years, Minimum storage cost, this cost also has the transportation cost from source to storage site, Reduced risk of accidents, Minimum environmental impacts, Storage of carbon dioxide should be according to the national and international laws and regulations. Carbon storage media can be of two types; Geologic sink and Deep Ocean. Geologic Sink can be depleted gas or oil reserves, deep saline formation etc. Deep Ocean Storage is the direct injection of liquid carbon dioxide into the water column at an appropriate depth that is 1000 to 3000 meter, or at depth greater than 3000, at this place liquid carbon dioxide is much heavier than the sea water (Golomb, 2004).

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STAKEHOLDERS' INVOLVEMENT IN NATURAL SUSTAINABILITY OF WAPDA PROJECTS – A STRATEGY PAYING DIVIDENDS

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ABSTRACT:

Mankind since antiquity is aware of importance of nature for its survival. With the passage of time human footprints on natural ecosystems increased manifold. The threat to nature due to anthropogenic activities has reached a threshold, where further onslaughts can jeopardize our very existence. It is high time to formulate strategies for conservation of nature in development sprees. We already realize this scenario of gloom and doom and some spade work has been done at various platforms including conventions and protocols of UN and national strategies, regulations and acts. The way forward in the future is to involve all stakeholders in the stewardship efforts to inculcate the concept of sustainable development. WAPDA as our important national agency is already doing its bit to involve stakeholders in its development ventures to minimize the impacts of hydropower related interventions. The driving force behind this involvement is to connect the concerned stakeholders to the development project to safeguard integrity of nature and people related to it. Various international best practices and National Environmental Quality Standards and social norms are taken as benchmark to carve a niche for natural conservation. WAPDA Environment Cell (WEC) is spearheading such efforts to fine tune construction / operation activities in such a way that their environmental ramifications and impacts on natural systems are reduced and mitigated to the extent possible.

INTRODUCTION:

Since antiquity, man is conscious of the intrinsic and utilization value of biological diversity and its importance in its subsistent living. With the passage of time ecological, genetic, social, economic, scientific, educational, cultural, recreational and aesthetic value of natural systems was also explored by mankind. The UN's World Charter for Nature, 1982, stresses upon need for appropriate measures at the national, international, individual, collective, private & public levels to protect nature and promote international cooperation in this regard. To connect people to nature, it was considered that while planning and implementing social and economic development activities, due account shall be taken of the fact that the conservation of nature is an integral part of these activities. All planning shall include, among its essential elements, the formulation of strategies for conservation of nature, the establishment of inventories of ecosystem and assessments of the effects on nature of proposed policies and activities. All of

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these elements shall be disclosed to the public by appropriate means, in time, to permit effective consultation and participation. The UN Convention on Biological Diversity, 1992, further augmented the concept of conservation and sustainable use of biodiversity.

In the backdrop of these international strives, Pakistan promulgated "National Conservation Strategy" NCS, 1992. NCS is designed as a broad-based policy program aimed at sustainable use of renewable resources, preventive actions against pollution and other adverse impacts of industrial and urban growth / anthropogenic activities, mandatory environmental assessments of new projects and more stringent control on toxic chemicals and hazardous substances. This broad framework alongwith Pakistan Environmental Protection Act, 1997, and other national and international protocols and regulations sets out the basic guidelines for an integral effort at protecting the environmental and natural resources of country. It also provides a comprehensive point of reference for all stakeholders, involved in sustainable development. WAPDA as an important national agency is involved in development of Water & Power sector based on good and sound international environmental practices. The United Nations (UN) Charters, Conventions, protocols and national laws and policies are the building blocks for environmental considerations in WAPDA projects and IFC's guidelines. All the development projects are bound to modify the existing ecosystems in their vicinity. Every development project is a unique entity and has peculiar footprints / ramifications on environment and social setups. The anthropogenic intrusions in natural ecosystem result in disruption of delicate intricacies of interwoven biotic and abiotic components. A holistic approach is required to keep affected ecosystem on the track of survival. To take this task in hand, a strategy is chalked out to prepare inventory of existing biotic and abiotic components of the project's area of influence. This inventory is called baseline and involves physical, chemical, biological, social, economic, aesthetic and archaeological parameters. Man is basic and foremost important entity of baseline studies. Human stakeholders can be project affected persons (directly affected), project implementers, financers, consultants, contractors and a bonanza of others. It is understood that major agent of change will be man both as being impacted and as being enforcer. Both these categories will be major stakeholders for development project. For a hydropower project stakeholders' involve population of watersheds / catchments, site specific personnel and downstream riparians also. WAPDA make environmental and social management programs / plans for all tiers of longitudinal reach of lotic water regimes, ensuring involvement and participation of stakeholders during all stages. This strategy not only mitigates the impacts of project but also enhances the ecological vigor and resilience of biota leading to continuity, viability and future sustainability of natural systems.

METHODOLOGY

Natural integrity of ecosystems ensures the survival of mankind. WAPDA projects are designed in such a way that their ramifications on ecosystems are reduced to bare minimum. The methodology adopted to do so, includes preparation of

inventories of Valued Environmental Components (VECs), their ecological assemblages; assessment of intensity, severity and duration of project impacts on VECs; adoption of mitigation measures to avoid, reduce, rehabilitate, compensate or circumvent the impacts altogether. The social and environmental plans are carved to take this task in hand. During this whole exercise, forging of connectivity among stakeholders and nature is the cornerstone of all activities. Hydropower plants are often constructed in remote and biologically, culturally and socially sensitive areas. Awareness among stakeholders to protect these pristine ecosystems is of paramount importance. Awareness is the most effective tool to connect people to nature, for its sustainability. This whole process is started with scoping process to identify what are likely to be main environmental impacts. Often scoping is carried out through both formal consultation meetings to hear what the concerns of the different groups of stakeholders are and through focus group discussions and individual meetings with relevant people and organizations. A scoping questionnaire is prepared which include questions about important stretches of river for fish spawning, wetlands, protected areas (National Parks, etc.), buffer zones and biodiversity corridors, range of endangered or threatened species, indigenous people, forest and wildlife habitats, d/s water quality and water ecology, sediment trapping and eutrophication in reservoir, sustenance and livelihood patterns of affected people. Furthermore, the participation of project stakeholders in project planning, design and implementation is a norm and WAPDA as per PEPA, 1997 (Section 12(3)) ensures that every review of an EIA is carried out with public participation.

The stakeholders are identified as those who have influence or are influenced by these projects. Stakeholders can be classified as primary and secondary depending on the influence of project activities on them. Stakeholders for WAPDA projects may be project affected persons, Environmental Protection Agency, Project Director and his team, WAPDA top management hierarchy, provincial forest, wildlife and fisheries departments, provincial health, irrigation, agriculture, transport, livestock and district administration, departments, WWF, IUCN, local NGOs, design and construction consultants and contractors, IFCs include the World Bank, ADB, IDB and private banks while donors encompass USAID, KfW, JICA, etc.

The engagement techniques include, focus group discussion, individual meetings, mapping, need assessment, village meetings, workshops, semi-structured interviews, role playing and use of baseline data. Driving force behind this engagement is to connect the concerned humans to the development project to safeguard integrity of nature and people attached to it. The process is summed up as:-

Identify > inform > Engage > Record > Address > Incorporate > Finalize.

These formal consultation meetings are usually properly minuted together with a record of attendance. In case of agreements e.g. on compensation or resettlement process, involvement of Project Affected Persons (PAPs) in agriculture, livestock,

aquaculture extensions, biodiversity management, watershed management, social forestry and forest conservation related ventures. The minutes are duly noted and signed by both the representatives of the employees / developer / WAPDA and local communities or households, with copies held by both.

Directly or indirectly affected persons are enumerated and recorded. Most vulnerable and voiceless are taken care of for special efforts. Most effective / influential persons, whom majority of stakeholders support and trust, are given special importance. All sects and genders are represented. Marginalized and indigenous PAPs like Soniwals of Khaliqabad village in Diamer Basha Dam Project are considered for continuance of their livelihood patterns. A monitoring system is inked to take cognizance of implementation of Environmental & Social Management Plans and Resettlement Action Plan to keep intact not only livelihood and sustenance of PAPs but to protect and sustain natural integrity of impacted ecosystems. In case of any considerable footprint of project implementation process on environmental and social key performance indicators, mitigations are applied and it is always kept in mind that man's role as steward of nature remains intact.

DISCUSSION

The principals of stakeholders' integrated involvement for sustainability of development projects have not yet become a part of any established body of laws and regulations. However, under present environmental protection legislation, respective EPA's in collaboration with project proponent have to arrange a public hearing to take all stakeholders onboard, particularly, project affected persons (PAPs), not only to involve the PAPs in environmental sustainability of proposed project but also to ensure an equitable and uniform treatment of resettlement issues.

The IFC performance standards, the World Bank safeguard procedures and ADB, Safeguard Policies alongwith International Best Practices all render it imperative to follow the concept of environmental and social sustainability during project implementation. WAPDA being the foremost important developer of HPP projects in the country has a sound track record of inculcating such national and international sustainability norms, standards, safeguards in its development sprees. The cornerstone of these strives is the involvement of all stakeholders in this process. While developing Environmental Management Plans and Resettlement Action Plan, detailed consultations are held and agreements are reached with local communities as their cooperation and involvement in effective implementation of sustainable environmental and Social Action Plans is of utmost importance. To connect the PAPs with nature and to ensure natural viability, continuity, integrity, sustainability of AOI and judicious mitigation of any impact of project intervention on VECs. The plans encompassing watershed and wildlife management, biomass removal, resettlement and community development are chalked. Appropriate costs to cover these plans are included in the project budget.

Certain other specific plans are also included depending upon the characteristics of the project such as;

- Stakeholders' involvement Plan
- Livelihood restoration Plan
- Community Development Plan
- Vulnerable Groups Development Plan

These plans has a direct bearing on sustainable outcome of proposed project's implementation.

Equally important is the monitoring and compliance program. The monitoring and compliance program underpinning and recording the practical monitoring of Key Performance Indicators (KPI) make this whole exercise result oriented. Key features of a monitoring program having connection between nature and man for WAPDA development projects include:

- Water quality in river d/s, u/s the reservoir after impoundment.
- Solid waste management.
- Noise, dust and emissions around the construction site.
- Construction practices.
- Fish and fisheries u/s & d/s of reservoir.
- Biodiversity management measures e.g. translocations of species i.e. invasive, predatory, desirable, exotic, etc.
- Resettlement processes, comprehensive payments.
- Public health and safety scenario.
- Changes in landuse and land cover features in the wake of project implementation.
- Effectiveness of livelihood programs e.g. increasing HHs income to reduce dependency on goods and services to be exploited from allied ecosystems.

The monitoring is based on ensuring compliance by stakeholders. The institutional arrangement to implement Environment Management Plan (EMPs); encompass, the linkages with the regulatory Authorities i.e. EPAs. Special Environmental & Social Committees and units are constituted to deal with the issues arising from the project consisting of representative from respective EPA, project proponent, local authorities, local community, labor union, NGOs consultants, Wapda Environment Cell and other stakeholders. Wapda Environment Cell (WEC) works as top supervisory, external monitoring and environmental auditing entity.

Nature conservation / biodiversity conservation and management plans are prepared in such a way that if a large hydropower project is located near protected

area, additional precautionary measures are taken, earmarking threats to the integrity of the protected area, their mitigation measures are implemented. The significant impacts on biota include, impacts due to construction activities, access roads, transmission lines and area inundated by reservoir, fragmentation of habitats, creation of barriers to free movement of fauna, increase in access to these areas enabling / facilitating illegal logging, hunting and fish poaching. All these impacts lead to degradation of natural resource assets and loss of biodiversity. These impacts and their implication on ecosystem are reduced to bare minimum by adopting nature conservation plans. Endangered, threatened, vulnerable and of less concern species are categorized and, if endangered species are considered to be at risk of virtual extinction, even design parameters of project are changed to minimize the impacts. Certain rare and endemic fish species live high up in the mountain tributaries. In case if project implementation destroys the habitat of these species e.g. fast flowing, rocky streams (as in Kachura Nullah near Gamba Skardu) the habitat may reduce drastically leading to a decline in populations. In such type of cases transplantation of fingerlings of desirable species, and measures of in situ management are adopted.

Today the concept of “stakeholders’ engagement” mean describing a broader, more inclusive and continued process between WAPDA and those potentially impacted or involved persons and encompass a range of activities and approaches, and spans the entire life of a project. The engagement place, a growing emphasis on Corporate Social Responsibility (CSR) and shared nature conservational strategies. However, every proposed project is different entity and engagement of stakeholders is need based and flexible actions and approaches that make the most sense for a particular project, are adopted. Pro-active approach is applied to build trust, mutual respect and understanding among stakeholders which reflects in sustainable implementation of WAPDA projects. This process has evolved with the passage of time, it is working wonders during implementation of T4th Ext. HPP and likely to be further fine-tuned during the implementation of T5th Ext. HPP and Dasu HPP. WAPDA is gradually taking a systematic approach (rather than ad-hoc) that is grounded in project activities and is getting better results in terms of time and resources we invest, and are able to track and manage stakeholders’ issues and risks more effectively. Allocating responsibilities for stakeholders’ engagement to project implementing entities and mainstreaming it into project activities increases its chances of serving the purposes of project sustainability rather than becoming a costly peripheral exercise that is out of touch with ground realities and raises expectations that cannot be met.

The results of mainstreaming of stakeholders concerns and aspirations, keeping in view international best practices while dealing environmental and social ramifications of WAPDA Projects, is stimulating the eco-efficient and resource-efficient implementation and operations.

Results

Water & Power Development Authority is one of the pioneer organizations in Pakistan to inculcate judicious and result oriented involvement of stakeholders in its development projects to make them holistically acceptable and environmentally sustainable. The prime and pioneering example is Ghazi Barotha Hydropower Project, wherein, an ambitious team of bonanza of stakeholders cemented into a cohesive whole, visited every nook and corner of area influenced by the project and every likely affected person and entity was contacted and even at design level the original layout plan / design of power channel was modified to reduce the impacts of project interventions on environmental and social parameters. The guiding principle for GBHP has been to maintain close contact between the engineering and environmental planners, social scientists, local community groups and NGOs right from the feasibility stage to project construction. Not only Ghazi Town was protected but also archaeological mounds and graveyards were salvaged and environment friendly spoil banks were laid alongwith banks of 52 Kms power channel to be developed into agriculturally productive units owned by original affectees. A total of 110 households were affected by Project. Three No. model villages with all necessary amenities were constructed for affectees and through a very effective NGO, Ghazi Barotha Taraqiati Idara (GBTI). The socio-economic uplift of local populace in Ghazi and Chachh plains is being taken care of even today. The safety and security of life was given paramount importance during implementation of project and such measures are still intact to a large extent along 52 Km long Power Channel. To take stock of vigour and vitality of downstream ecosystems in 43 Km Indus reach from Ghazi Barrage to Khairabad Bridge, 29 cumecs environmental flows during lean periods are being released. This vital measure has worked wonders in doing its bit. On the directives of the then Chairman WAPDA, Wapda Environmental Cell (WEC) carried out an Ichthyofauna (population dynamics) related study in 2014-15 and found that release of environmental flows downstream Ghazi Barrage has a positive impact on the fish and fisheries of this Indus reach.

To compensate for disruption of the local community the construction works employed about 13,500 local people and many local companies. For villages on both sides of Power Channel, 46 No. of crossings have been provided over the Power Channel. The World Bank, ADB, JICA, KfW, EIB & IDB all funded the project and declared it environmentally, socially and economically a very viable and sustainable model project.

In Neelum Jhelum Hydropower Project the extensive environmental and social baseline studies were conducted during feasibility study to record existing E&S parameters. While doing so all the stakeholders were earmarked and institutional arrangements for implementation of Environmental Management Plan (EMP) were chalked and same were updated in 2010 after the change in ground realities, as an aftermath of 2005 earthquake.

For mitigation of project's footprints on natural integrity of ecosystems all the stakeholders were taken onboard. Out of 4675 Kanal land required for project, total land awarded / leased till Feb. 2017 is 4612 Kanals. For natural integrity of the WAPDA acquired land "Plantation Development Plan" is being implemented. 15 cumecs environmental flows in Neelum River 40 Kms reach d/s from Nauseri weir to Domail will be ensured during lean flow periods to augment ecological vigor of this reach and dilution of sewage introduced at ingress points. The confidence building measures (CBMs) include employment of 70% of unskilled and semi skilled labor force from local populace.

Construction of RCC Bridge Class-70 on Neelum River at Nauseri, water supply schemes at Chast Nagar Chattar Klas, dispensary and upgradation of water supply scheme at Nausanda and Nausery, rehabilitation of Lohar Gali road and construction of vocational training school at Lower Plate Muzaffarabad and further approval of 24 Nos. water supply schemes and Alikoh Bridge has been funded by WAPDA and implemented by AJK Govt. Such Confidence Building Measures (CBMs) ensure the improvement in quality of life of PAPs and also enable them to depend less on services provided by nearby ecosystems, thereby inculcating resilience in natural habitats. We have cited two case studies of WAPDA projects where WAPDA is trying its best to connect the people to nature while implementing development projects. Another unique example of its kind of connecting people to nature to develop resilience in nature conservation practices is the successful implementation of Mangla watershed program, this covers the land use and soil conservation practices of whole area above reservoir. This includes a bonanza of stakeholders for its implementation. The project was launched in 1960, its success can be gauged by the following outcome.

- The rate of sediment to land into Mangla Reservoir was originally assessed as 42000 AF / annum. The life of reservoir was determined by consultants as 100 to 110 years.
- Average sediment inflow reported by MDO upto 2014 is 27747 AF/annum. The life of Mangla reservoir has enhanced upto 212 years (excluding raising).

WAPDA is seeking to improve further present stakeholders involvement in future projects. This involvement will inculcate resilience in terrestrial ecosystems including; endangered species, viability of protected areas, aquatic ecosystems, aquatic biota in catchment area, area influenced by project and downstream habitats.

RECOMMENDATIONS:

- We as human beings must acknowledge that ecosystems that provides goods and services are not unlimited and need to change our present lavish thinking of consumerism.

- Anthropogenic activities are already edging the natural vitality towards precipice of doom, the pristine natural habitats are vanishing. We need to take the bull of development by horns to make it sustainable.
- The concept of stewardess is to be fed to all and sundry to avoid degradation and unchecked pollution of nature.
- We need to connect the people to nature; in the cities, on the land; from the poles to equator through awareness and education.
- Nothing in nature is isolated and tough enough to fight the human aggressions. The climate change, ozone depletion, environmental degradation are the outcome of collective human hostilities, they need holistic, cohesive and unison strives of all human-beings to tackle all such dreadful outcomes.
- All national and international stakeholders should be on one page to avoid looming danger of likely extinction.

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URBAN HEAT ISLAND IN CHANGING CLIMATE (A CASE STUDY OF KARACHI HEAT WAVE, 2015)

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Abstract

Extreme weather events can lead to disasters. Southern parts of Pakistan have faced climate change and recorded higher surface temperature in summer. Temperature is one of the indicator to detect the climate changes. The heat-wave event of June 17-24, 2015 in Karachi took more than 1200 human lives and is a clear indication of climate and environmental changes. Heatwave is a climate-related hazard and effects on human comforts. Heat wave is an unusual period of hot, humid or dry conditions which prevail from three to five consecutive days during a summer season. The summer heat index is a good descriptive concept utilized to gauge the impacts of a heatwave phenomenon in an urbanized area by combining the overall effect of temperature, air pressure, humidity and wind speed. In Karachi, during the above mentioned event, the maximum temperature recorded was 44.8°C but the heat index was around 66°C on the peak heat wave day i.e. 20th June 2015, because of low air pressure and wind speed and very high humidity. The main causes of deaths identified were heatstroke and dehydration. Karachi is the mega city and financial hub of Pakistan. Cities have a direct impact on the local climate, the rapid urbanization in cities has a direct adverse effect on increasing Land Surface Temperature (LST) and production of heat by anthropogenic activities contributes to the Urban Heat Island (UHI) effect. This local climate phenomenon will be even more dangerous with climate change. Therefore, there is a dire need to monitor this drastic change in temperature and to prevent the formation of Urban Heat Islands (UHIs). In this study, different data sets were used. Geopotential height and wind data were analysed for an atmospheric condition over various parts of the country. The maximum temperature record along with humidity and the wind (speed & direction) data for the month of June for the normal period (1981-2010) and for the period 2013-2015 have been used. Earth observation data LANDSAT 8 OLI/TIRS and &7 ETM+ 2010 and 2015 analysed for monitoring changes in NDVI, land cover, LST and formation of UHI to detect the severity of temperature and causes of a heat wave and their consequences on environments using Remote Sensing & Geospatial Technology.

Keywords: Heatwave, Heat index, Urban Heat Island, Atmospheric condition, LST.

Introduction

May and June are the months of heat waves in Pakistan. The frequency and intensity of heat waves seems to be increased in recent past in the country, which may be attributed to the prevailing global warming and climate change. According to a study conducted by Pakistan Meteorological Department (PMD) yielded that the number of heat waves days has increased in recent decade (Chaudhry et al. 2009). The World Meteorological Organization (WMO) defines heat-wave as

"when the daily maximum temperature of more than five consecutive days exceeds the average maximum temperature by 5 °C, from the normal temperature of an area. The definition in terms of number of days and ambient temperature varies region to region. It is important to know about the region and its climate to understand and further explore the causes of heatwave related factors. The phenomenon of heat wave is observed usually in the areas which experience highly variable summer climate (Chang and Wallace, 1987; Choi and Meentemeyer, 2002; Grumm, 2011; Hunt, 2007; Palecki et al., 2001; Pezza et al., 2012; Zaitchik et al., 2006). The phenomenon is exacerbated and becomes deadly due to two main factors i. e heat index and urban heat island (UHI) effect. Heat Index or The Heat moisture Index (Steadman, 1979 and 1984) is usually simplified as a relationship between ambient temperature and relative humidity versus apparent temperature. The high values of the heat index can pose a health risk to anyone engaged in outdoor activity over a short period of time; a greater general danger to public health exists when the heat index remains high for an extended period of time (Zahid and Rasul, 2010). The urban heat island effect is newly explored environmental phenomenon which has come into existence due to rapid and uncontrolled urbanization.

This study discusses changes in the climate parameter related to heatwaves, particular setting of atmosphere and urban heat island effect by analysing the data using remote sensing and GIS techniques, taking into account the case of historical heatwave in June 2015 in the city of Karachi. Deadliness of the mentioned event was mainly due to high heat index and UHI effect. This event has been chosen to present the case of deteriorating environment in mega cities, which can further aggravate the adverse impacts of warming climate in the country. The effect of heat waves can be felt across many sectors of life, from the general public to government organizations, industries, health, utilities, commerce, agriculture and infrastructure. Therefore, severe heat waves enhanced by UHI effect is an important environmental issue in the mega cities. Initiatives may be taken to mitigate the adverse impacts of such phenomenon in the future global warming and climate change scenario.

Data and Methodology

In this study, two different data sets; observed meteorological data from Pakistan Meteorological Department and NCEP Reanalysis data provided by the NOAA/OAR/ESRL PSD, Boulder, Colorado, USA, from their Web site at http://www.esrl.noaa.gov/psd/ (Kalnay et al. 1996), and satellite observation are used. Landsat 5 TM and 8 OIL/TIRS used for classification. Each pixel of raw satellite data has Digital number values. For quantitative study is necessary that the data must be atmospheric and radiometric calibrated (M. B. Giannini, 2015). The images can be converted to Top of Atmosphere (TOA) radiance by using the following equation.

$$\rho\lambda = MpQcal + Ap \dots\dots\dots Eq1$$

Where

$P\lambda'$ = TOA planetary reflectance, without correction for solar angle.

M_ρ=Band-specific multiplicative rescaling factor from the metadata (REFLECTANCE_MULT_BAND).

A_ρ=Band-specific addiative rescaling factor from the metadata (REFLECTANCE_ADD_BAND)

Q_{cal} = Quantized and calibrated standard product pixel values (DN).

In this study, the only thermal band 10 & band 11 of TIRS used for Land surface temperature located in the atmospheric window between 10 and 12 μm. The spatial resolution of thermal band is 120 meter and the images have been acquired the on 2nd week of July because there is no Landsat observation are available from 19th to 22nd June 2015.the the spectral radiance to TOA brightness temperature by the following equation.

$$TB = \frac{\mathrm{K2}}{\ln\left(\frac{K1}{Lsat}+1\right)-272.15} \ldots\ldots Eq2$$

Where, TB is at-satellite based brightness temperature (K) and multiply with -272.15 for Celsius. L_{sat} is spectral radiance in (W/m^2 * sr* μm) and K1, K2 is calibration constant for band 10,11 in in (W/m^2 * sr* μm).

Normalized Difference Vegetation Index used to retrieve the vegetation cover usually its range from (-1 to +1). NDVI is calculated from the reflectance of Visible and Near Infrared bands by following equation.

$$NDVI = \frac{(\mathrm{NIR}-\mathrm{RED})}{(\mathrm{NIR}+\mathrm{RED})} \ldots\ldots Eq3$$

Surface emissivity is essential for the retrievals of surface temperature from remote sensing measurements. Emissivity computed by following expression.

$$\epsilon = 0.004 * Pv + 0.986 \ldots\ldots Eq4$$

The Jiménez-Muñoz algorithm is used for emissivity calculation. It is a root mean square deviation (rmsd) of 0.009 for emissivity and lower than 1 K for land surface temperature. Pv, represents the vegetation fraction it is derived from NDVI.

The finally, LST is computed by following expression.

$$LST = \frac{\mathrm{TB}}{1+\left(\lambda.\frac{\mathrm{TB}}{\rho}\right).\ln(\varepsilon)} \ldots\ldots Eq5$$

Where, λ is the central band wavelength of emitted radiance (11.45 μm), ρ = h*c/σ (1.438*10-2 m*K) with: σ is the Boltzmann constant (1.38*10-23 J/K), h is the Planck's constant (6.626*10-34 J*s), c is the light velocity (2.998*108 m/s).

Results and Discussion

Heat waves

Plane areas of Pakistan are prone to heat waves in the summer season. Heat wave events occur during the season from May to September. A study revealed that there is a significant increase in apparent temperature in the country in last few decades. A significant rise in the heat index calculated during the season is 2°C, over the period of the study (Figure 1a). The maximum temperature and relative humidity profile for the entire Pakistan is presented in Figure 1(b). There is a significant rising trend of both the factors, which is the ultimate cause of sharp increase in heat index values in Pakistan. The total change in humidity calculated during summer from 1961-2007 for entire Pakistan is 6.2% and total change in maximum temperature is 0.25°C (Zahid and Rasul, 2010).

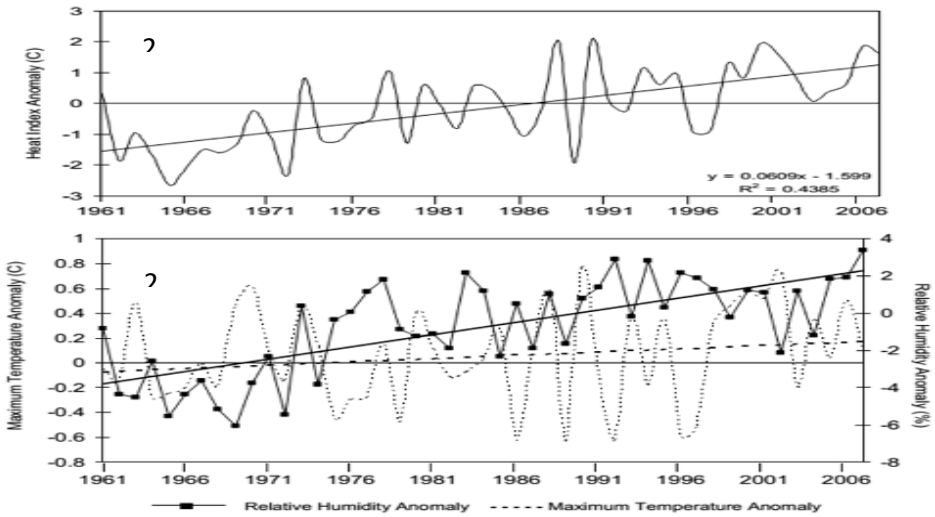


Figure 1: a) Heat Index Anomalies in Pakistan **b)** Maximum Temperature and Relative Humidity Anomalies for the Period 1961-2007

Source: Zahid and Rasul, 2010

Higher temperature recorded in the southern parts of the country ranged from 40 ^{o}C to 49 ^{o}C. Figure 2, show the maximum temperature of Pakistan from 19th to 22th June 2015. The heat wave conditions gradually decreased in the Southern Pakistan, but persisted over Karachi for more days. This hot and humid condition resulted in a deadly heat wave. Daily Maximum temperature exceeded to 45 ^{o}C in the city during the heat wave period.

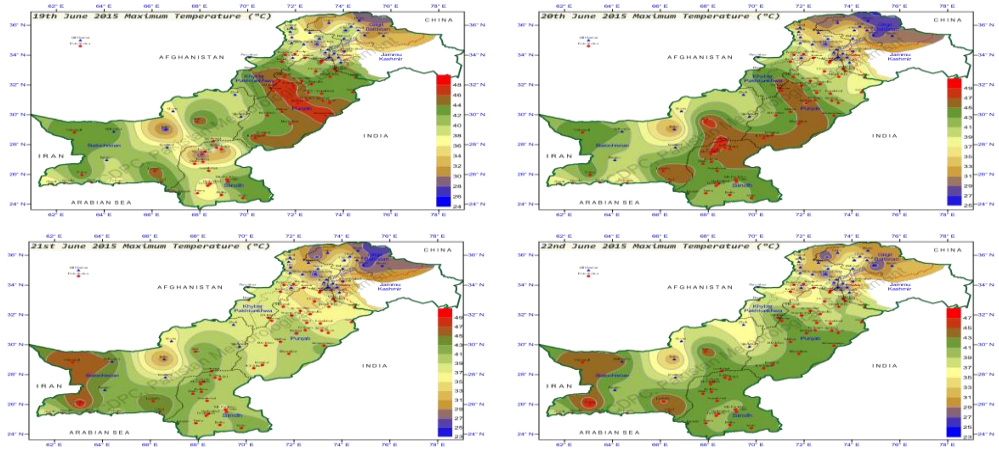


Figure 2: Maximum Temperatures over Pakistan from 19-22 June 2015

Source: Pakistan Meteorological Department (PMD), 2015

Synoptic Situation

A typical normal moisture transport from the Arabian Sea was prevailing across the coast of Karachi on 15-16 June (Figure 3). In the middle atmosphere a ridge prevailed over the country (Figure not shown). With the extension of anomalous ridge towards southeast Sindh including Karachi, the atmospheric conditions went anomalous. The extension of this ridge led to the clear skies and more incoming solar radiation which warmed the atmosphere over the study area. A cyclonic system started to develop over the Sea, near the coast of Karachi, on June 18, 2015. Development of cyclonic system resulted in weak weakening of sea breeze from the Arabian Sea (Figure 4). Prolonged presence of this low pressure system in the vicinity of Sindh-Makran coast further reduced the flow of sea-breeze. The system further strengthened and blocked all the moisture transport and ventilating winds towards Karachi. Due to the presence of low pressure area over northeast Arabian Sea, Karachi received hot and dry air entering from the east during the day time, whereas surface wind in the late afternoon (1200 UTC) remained mostly westerly/southwesterly due to the temperature difference between land and sea. This afternoon light sea breeze brought lot of moisture, ultimately increasing the amount of humidity. Night time temperature also remained higher due to urban heat island effect. Higher day and night time temperatures and humidity increased apparent temperature i. e. heat index during the heatwave days. As a result, the temperature which was already higher has been felt much more than the actual recorded, both for day and night times. The weakening of low pressure system over Arabian Sea on the afternoon of June 24-25 brought the normal sea breeze to Karachi and diminished the adverse effects of heat wave.

In the mentioned atmospheric settings daily temperature anomalies were more than 5°C for consecutive five days. The departure of maximum temperature from the normal ranged between 5.3 to 11ºC during severe heat wave as is evident from figure 5. The highest maximum temperature in Karachi was 44.8 °C on 20th June 2015 with a departure of 11.1ºC from normal. The heat index touched the mark of ~67°C. One should keep in mind that this apparent temperature not the actual temperature of the atmosphere. Even higher than 44.8 °C temperature has been recorded in the history of Karachi, but high death toll reported in this heat wave has never been reported before. This shows that some factors other than meteorological factors also contributed to the severity of heat wave. Satellite data focussing the city of Karachi and vicinity have been analysed for different parameters to explore those factor.

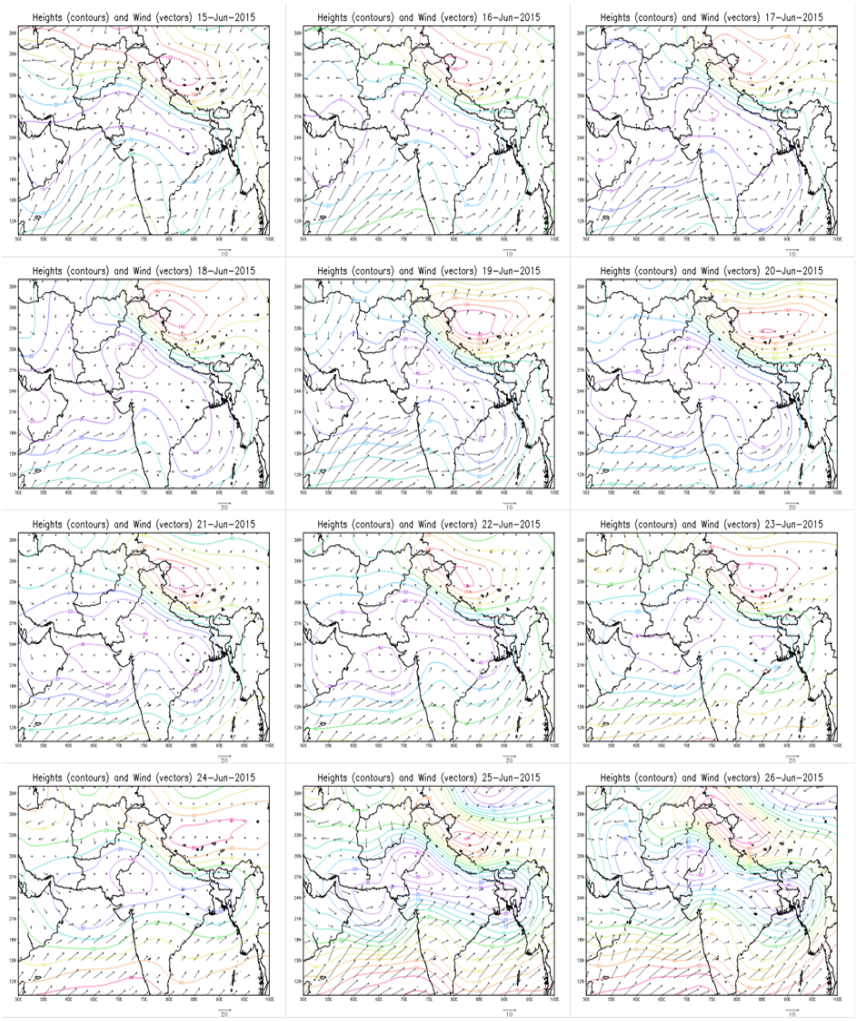


Figure 3: Timeline of Atmospheric Condition showing Geo-potential Heights (m) And Wind Vectors (m/s) at 850mb level. Source: MoCC 2015

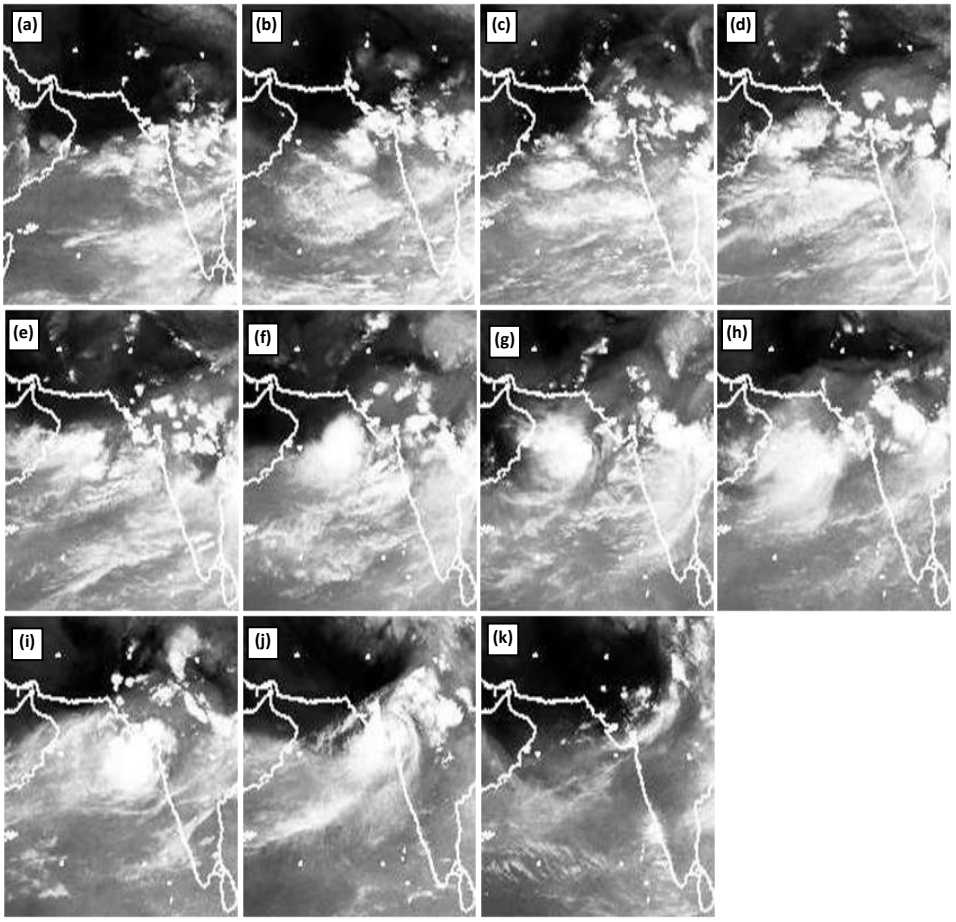


Figure 4: Satellite Images Showing Low Pressure System for the Periods 15- 25 June 2015 (A – K). Source: DSRS, 2015

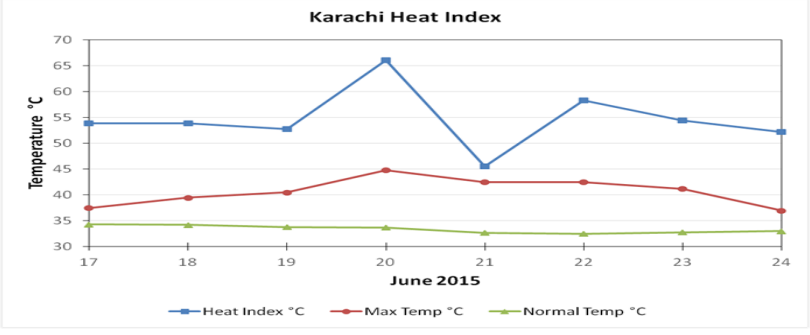


Figure 5: Time Series of Maximum Temperature and Heat Index Observed during the Heat-wave Days in Karachi from 17-24 June 2015
Source: MoCC, 2015

Urban Heat Island

The term "Urban Heat Island" describes built environment that are hotter than nearby natural areas. An urban heat island refers to a city or metropolitan area that is significantly warmer than its surrounding suburban area. Uncontrolled urbanization negatively impacts the local environment. The main cause of the urban heat island effect is from the modification of land surfaces, which use materials that effectively store short-wave radiation. Land surface temperature is very important for UHI. In this study, Landsat 8 images were utilized to observe and understand Urban Heat Island effect.

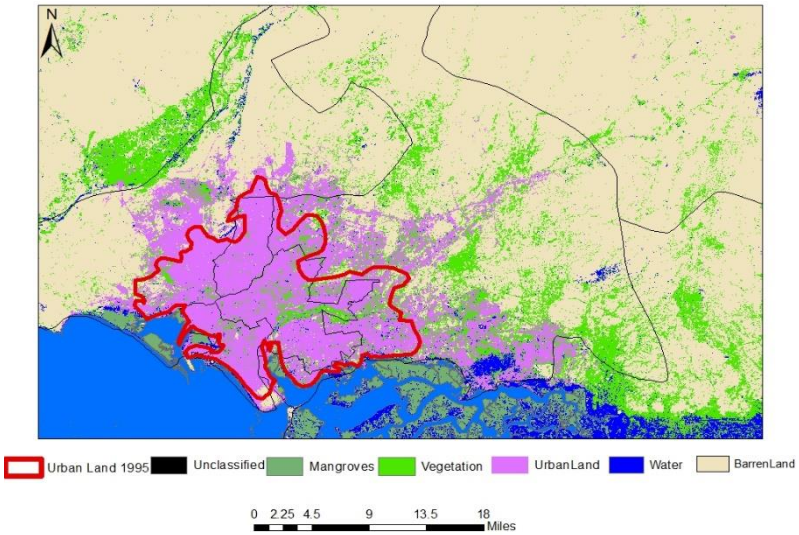


Figure 6, Classification map of Karachi 2015

The land use and land cover information utilized in this study has been derived from LANDSAT data. Land use and land cover (LULC) classification is a well-established technique for satellite image interpretation. Supervised classification method was used to map LULC from LANDSAT satellite images 2015 and urban land of 1995.Study area was classified into urban land, vegetation, barren land and water. Figure 6, shows the urban land of Karachi city rapidly increased from 1995 to 2015. The city expanded in the direction of Malir and Karachi west. The minimum vegetation cover observed in the city in the recent years.

Normalized Difference Vegetation Index (NDVI) is a simple graphical indicator that can be used to analyze remote-sensing measurements, typically but not necessarily from a space platform, and assess whether the target being observed contains live green vegetation or not. The NDVI is calculated from visible (red) and near infrared bands. The tool in the Image Analysis Window calculates how vigorous the vegetation is in an area. But it's not the only index available, although it may be the most widely used. Figure 7 shows the NDVI of Karachi in June 1995 and June 2015. In 1995 the forest cover in Lasbela is higher comparatively 2015. The vegetation along roads and in housing scheme found slightly greater in 2015

compared to that in 1995. NDVI values from 0.009 to 0.2 observed for vegetation along the roads and housing scheme. The higher NDVI values range 0.3 to 1 observed in Karachi East and at few places in Malir and Lasbela.

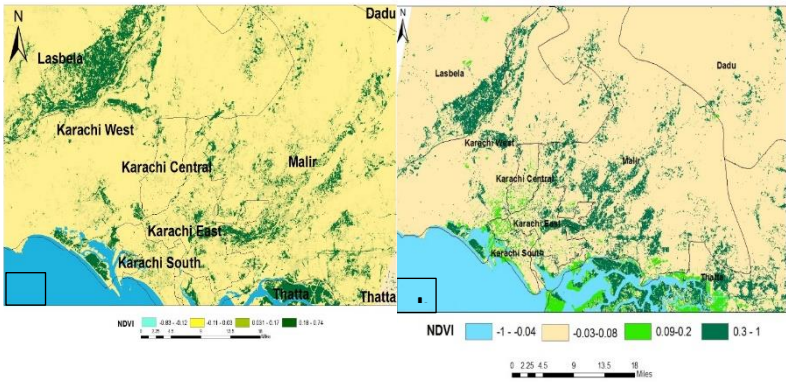


Figure 7, (a) NDVI of 1995and (b) NDVI of June 2015.

Surface emissivity is essential for the retrievals of surface temperature from remote sensing measurements. We have computed the surface emissivity from LANDSAT 5 TM and 8 TIRS data. Emissivity is the ratio of surface ability to emit the long wave radiation to that radiated from a blackbody (a perfect emitter) at the same temperature and wavelength and under the same viewing conditions. It is a dimensionless number between 0 (for a perfect absorber) to 1 (for a perfect emitter). Emissivity values for the study region ranges from 0.986 to 0.99 observed in June 1995 and that in 2015 ranges from 0.986 (water), 0.987 for (Barren Land/ soil) and 0.988 for (vegetation cover). These are shown in Figure 8 a & b. The emissivity value higher where the vegetation cover is higher and in barren land values are lower which means that more heat energy is absorbed in barren land as compared to vegetated land.

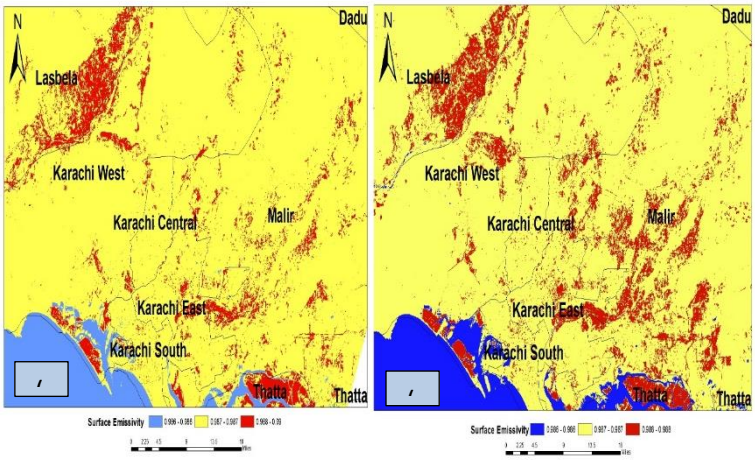


Figure 8, (a) Surface Emissivity of June 1995 and (b) Surface Emissivity of June 2015.

LST mapping has also been done for estimation of land surface temperature and compared with associated environmental condition. LST, NDVI and LULC was calculated in the same period of June. Figure 9, shows the Land Surface Temperature of Karachi and adjoining areas.

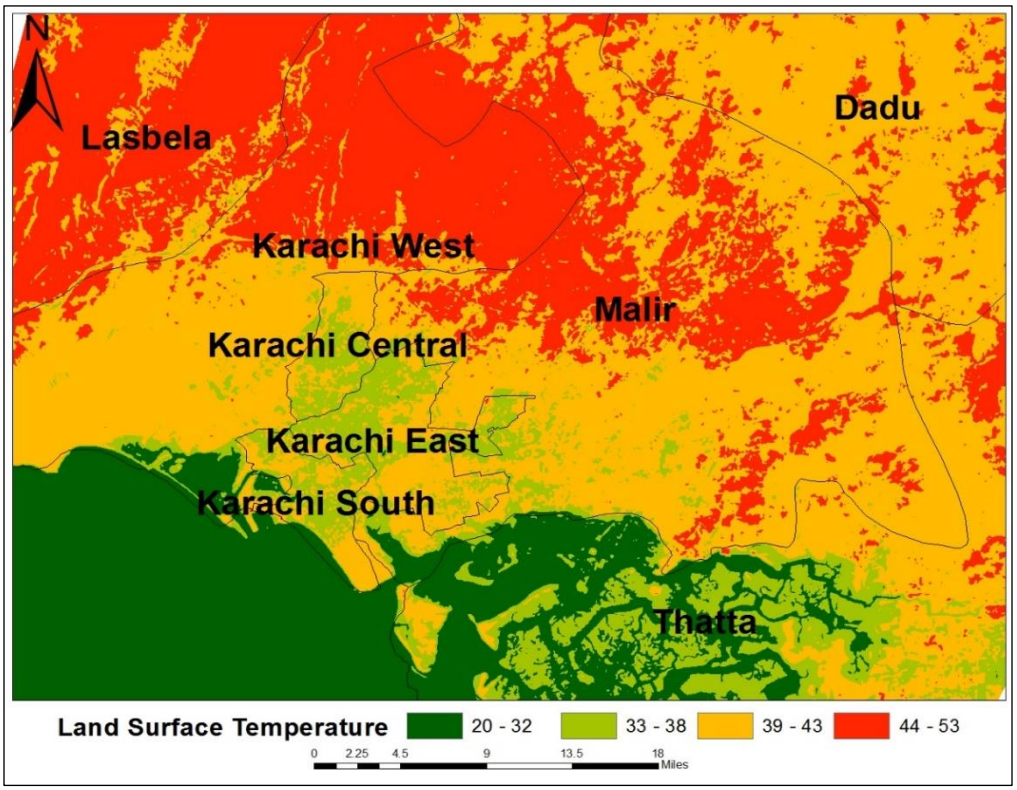


Figure 9: Land Surface Temperature of Karachi and Adjoining, June 2015 LANDSAT 8

The LST results show that the highest temperature range 44-53 ^{0}C observed over the Karachi west, north-west Malir and Lasbela. These areas are consist of barren land dominantly. The temperature range 33-43 ^{0}C observed in Karachi East, South and Central. Figure, 10 shows the comparison between LST, NDVI and LULC. The highest temperature observed up to 53 ^{0}C where the NDVI value is -0.03-0.08 and the area is totally barren land/ soil. Circle 1 over the Karachi west and Lasbela depicts the temperature 39-43 ^{0}C. The area is dominated by forest which means the least absorption of radiation. Circle 2 depicts the higher temperature up to 53 ^{0}C where the land features are mostly barren/ soil and least emissivity values found. The thermal contrast between the city and the surrounding shows the highest temperature observed over the barren land but the human losses or death toll reported was higher in the city. Reason for that was greater heat storage of urban surfaces during a sunny and very warm summer day because of specific thermal properties (i.e. heat capacity and conductivity) of man-made materials. Furthermore, heat accumulation in the city is also caused by the complex 3-

dimensional nature of the urban surface, especially within the continuous urban fabric. Moreover, emission of anthropogenic heat from industrial and communal processes may strengthen the effect.

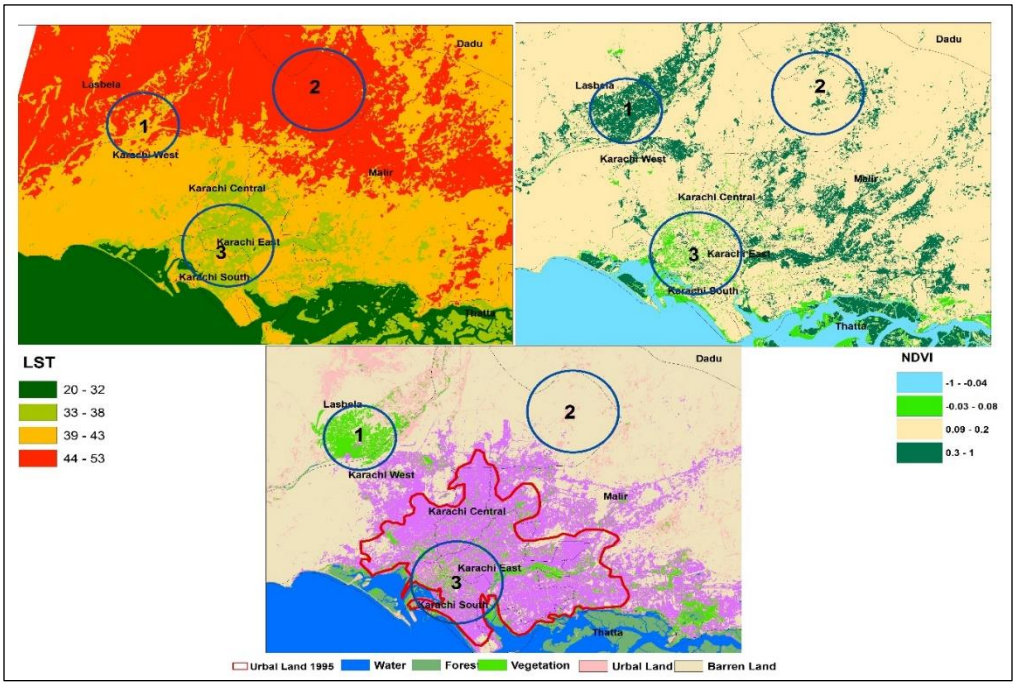


Figure 10, Comparison of June 2015 Land surface temperature, Normalized Difference Vegetation and Classified Image

Conclusion

The heat index has increased in recent past in the country and heat wave in Karachi is one the prominent example of such climate extreme events. The event was unprecedented and can be attributed to the prolonged presence of depression over the Arabian Sea which cut off the sea breeze. On the other hand a high pressure ridge prevailed over Baluchistan and adjoining parts of Sindh, including Karachi. The synoptic situation added up in the temperatures of the region and resulted into prolonged heat wave.

The LST retrieved from Landsat TIRS data and to analysis the relationship between LST, land cover and NDVI. Higher temperature on the surface was observed in the vicinity of the Karachi city. Vegetation in terms of forest is reduced from 1995 to 2015 but the vegetation along the roads and housing scheme has been observed to be slight greater in 2015 than that in 1995. While in terms of expansion, Karachi city has largely expanded since 1995. According to results vegetation cover along the roads and housing scheme is not playing effective role in cooling effect as compared to forests in the suburban areas. Karchi city have faced sever heat wave due to uncontrolled urbanization, industrial and commercial

areas. In addition, considerable reduction in the number of shady trees and vegetation, and rapid urbanization over the recent years had also contributed to the severity of the heat by generating Urban Heat Island Effect. Moreover, some adverse effects of water and power shortages during the heat wave of June 2015 cannot be totally ignored. There is a dearth of sufficient data and evidences to support the role of water and power shortages as a major contributing factor in rising death toll in Karachi.

Warmest years in the recorded history of climate have been observed in recent past and future climate scenarios indicate further rise in temperature. It becomes very crucial to understand future trends of heat waves and urban heat island effect in the environment of mega cities. Due importance may be given to the mentioned phenomena in the planning of big cities.

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CLIMATE CHANGE IMPACTS, MITIGATION AND ADAPTATION MEASURES

By: Muhammad Ramzan Javed[1]

This report presents what is climate change, its impacts and international efforts to combat the climate change. Impacts of climate change on various sectors in general and on water resources and agriculture sectors of Pakistan are specifically described in detail. The response of Pakistan to tackle these impacts and initiatives to formulate climate change policy and action plan to mitigate and adapt these impacts are described.

Climate change is an inconvenient truth, which is defined by IPCC as "change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer, whether due to natural variability or as a result of human activity" (IPCC Intergovernment Pannel on Climate Change, 2007). Observations show that earth's climate has been warming. Its average temperature has risen more than one degree Fahrenheit during the past hundred years or so (What is climate change, NASA, 2011). Due to climate change sea levels are raising, snow and ice cave are diminishing, rain pattern and growing seasons are changing. Climate change will boost the air pollution extent by thick smog and could increase health problems due to deadly heat waves changing weather patterns. Climate change is due to emissions of green house gasses into atmosphere, which has caused imbalance in the atmospheric gasses. "It is observed that percentage of carbon dioxide has increased 42% than pre industrial era. The world's leading scientists report that to prevent dangerous level of global warming all governments should take concrete action to limit global warming less than 2 ^{o}C by reducing greenhouse gas emissions" (Impacts of Climate Change).

Before describing efforts to combat climate impacts at local level here is a brief how world is reacting to mitigate and adapt for the change. Climate change is a complex issue, as it requires commitment from all the countries in the world to fight for the same objective. To address the issue the first world climate conference was held in 1979 and an Intergovernmental Panel on Climate Change (IPCC) was setup in 1988. In 1994 United Nations Framework Convention on Climate Change (UNFCC) entered into force with almost universal member countries that ratified it called parties of conference (COP). In 1997 Kyoto Protocol was formally adopted by member countries. After yearly negotiations COP21 met at Paris from 30 November to 12 December 2015 for getting commitment of member countries to fight for Climate Change and concluded as Paris Agreement to reduce global warming below 2 ^{o}C. UN Secretary General hails Paris Climate deal as "Health Insurance Policy for Planet" (Ban Ki-Moon Hails Paris Climate Deal, 2015). Each country has to act at national, regional and local level to reduce emissions of green house gases.

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Pakistan is my home country and is a large geographically diverse country with a number of significant ecological features, including extensive mountain, desert, rivers, wetland and coastal ecosystems, supporting distinct, diverse biological communities. It is the only country in the world where the altitude difference is greatest since Pakistan is home to several mountain peaks ranging over 8,000 meters and having its largest port city (Karachi) at almost sea level. It has a vast glacial area which covers about 15,000 square km comprising 5,000 glaciers which are in rapid retreat. The rate of this retreat has gone up by 23 percent in the previous decade (Geological Survey of Pakistan , 2014). Pakistan has very low forest cover only 4percent. More than half of the population depends on the use of natural resources for its livelihood. 15 million people have no access to electricity (Weiss & Mughal, 2012).

Pakistan is facing existence of major risks related to climate change including rise in sea level, glacial retreats, floods, higher average temperature and higher frequency of droughts. In addition, being a predominantly agricultural economy, climate change is estimated to decrease crop yields in Pakistan not only as a result of flooding, but also as a result of changing temperatures, which in turn will affect livelihoods and food production. As per USA Today news death toll was more than 1150 due to deadliest heat wave in Pakistan in June 2015 (Pakistan's deadliest heat wave on record, 2015). Deterioration of climate is irreversibly harming Pakistan; as the glacier melt in the Himalayas is projected to increases flooding along with severe rain events. As per BBC report during August 2015, 170 people died due to monsoon floods almost one million people affected due to floods, thousands of acre of agricultural land was destroyed (Pakistan Monsoon Floods, 2015). The northern part of Pakistan is facing flooding issues due to monsoon rains while southern part is experiencing drought situation. As per Express Tribune report 121 died including infants due to drought in Tharparkar, southern Pakistan (Drought in Tharparkar, 2014). Further this will affect water resources within the next two to three decades. This will be followed by decreased river flows over time as glaciers recede. The glacial melt will affect fresh water flows with dramatic adverse effects on biodiversity and livelihood with possible long-term implications on form and nonfarm sectors. (Alex, 2013). Report mentions that coastal areas of Pakistan including the Indus Delta are most vulnerable to climate change with rising sea surface temperature. The climate change effects, on one hand may reduce the flow of freshwater into the delta and on the other; it will accelerate the already occurring sea intrusion in the deltaic area.

Agriculture is the backbone of Pakistan economy as 55% livelihood of the total population is dependent on it. Textile sector is the second largest employer providing livelihood to 42 percent of work force but textile is also agriculture centric as it depends on the production of cotton crop in the country (Federal Bureau of Statistics, 2012). The concern becomes grave as almost 60-70 percent of the population of Pakistan depends on agriculture for their employment, income and food. (Agricultural Statistics of Pakistan. Ministry of Food, Agriculture and Livestock, 2010). Unfortunately, this sector is often affected by climate change and

poor people are most likely to lose their livelihood. The loss of livelihoods in these sectors put downward pressure on the other occupations and increase the competition and by creating the scarcity of jobs. There is a dire need to find ways for developing sustainable livelihood practices for vulnerable communities in Pakistan. (Mustafa, 2010).

The temperature increases in Pakistan are expected to be higher than the global average resulting in reduced national agricultural productivity. The yields of wheat, rice, other cereals and some important cash crops would decline in all the regions of the country except in the Northern Mountainous areas where wheat yield is likely to increase due to expected higher temperature during winter (UNDP, 2010). The studies have shown that the growing season length for major cereals will decline with increase in temperature in all agro-ecological zones of Pakistan resulting in 6-11 percent decline in yield of wheat and 15-18 percent reduction in yield of basmati rice by the year 2080. Livestock production could decline by 20-30 percent due to rising temperature creating crises in milk, meat and poultry supplies and pushing prices beyond reach of the common people. On average, the agriculture sector of Pakistan would lose up to 16 billion dollars per annum due to change in climate by the end of 21st century (Ministry of Environment Pakistan, 2011). Neglect or failure on the part of the society to develop and adopt technologies for climate change mitigation and adaptation of agriculture to sustainable resource use and environment-friendly improved practices may lead to enhanced poverty and severe food insecurity in the country. In Pakistan unskilled workers, women and children are already 'underpaid, overworked and exploited' and climate change will further leave them jobless and accentuate their vulnerability (UNDP, 2010).

Pakistan has the least contribution to global warming and the contribution to total greenhouse gas emissions is as low as 0.43 percent which is 135th of the world average of carbon dioxide emissions (German Watch Climax Index, 2011). Yet, it is faced with severe climate changes and according to German watch, report 2011, Pakistan has been ranked "third most vulnerable country to climate change".

Government of Pakistan is making efforts to tackle climate change issues. In 2008 Planning commission had set up a Climate Change Task Force (CCTF), to provide appropriate guidelines for ensuring security of vital resources of the country such as agriculture, water and energy and contribute to the formulation of climate change policy. The TFCC issued their final report in February 2010. The report describes Pakistan's vulnerability due to climate change impacts on various socio-economic sectors. It recommends various mitigation and adaptation measures based on initial assessment and viewed country's ongoing and planned responses. Findings of this report will be used for formulation of Climate Change Policy and plan of action (Task Force on Climate Change, 2010).

In response to international commitments, Government of Pakistan set up Ministry of Climate Change in 2012 which developed National Climate Change Policy (NCCP) in 2012, under the guidelines of TFCC. The NCCP comprehensively addresses all possible challenges of Climate Change adaptation and mitigation in

foreseeable future; and sure to provide rock solid foundational framework for ensuring climate change action plans, programs and projects. NCCP describes mitigation and adaptation measures in the sectors of; water resources, agriculture and livestock, human health, forestry, biodiversity, other vulnerable ecosystems, disaster preparedness, socioeconomic measures, climate change mitigation in the sectors of energy, energy efficiency and conservation, transport, town planning, industries, agriculture and livestock, carbon sequestration and forestry. Measures are defined for capacity building and institutional strengthening, awareness raising, international and regional cooperation, finance, technology transfer and policy implementation mechanism.

As per NCCP, to address the impacts of climate change on water resources and to enhance water security government of Pakistan shall take following policy measures; i) Infrastructures for water storage shall be built for additional needs, for harnessing of hill torrents, by early rehabilitation of existing structures and to enhance the life of existing structures. ii) Water conservation strategies will be adopted by reducing irrigation system losses and by introducing local rainwater harvesting techniques. iii) Integrated water resources management by proper water allocation affected due to climate change, protection of ground water resources, recycling of wastewater, preserving water catchment areas, active participation of farmers in water management, sea water intrusion and water distribution among provinces. iv) Legislative framework to protect water resources from contamination, for efficient water resources management and for protecting the glaciers. v) Enhancing Capacity by developing efficient technologies, monitoring of irrigation water delivery, preparing inventory of all water resources, remote sensing and GIS techniques. and vi) awareness rising. In the field of agriculture following policy measures will be adopted; i) Research for assessment of climate change impacts on various agro-ecological zones, by developing new variety of crops, better breeds of livestock, quality database, sustainable land management, for enhancing capacity of farming community. ii) Technology, for improving crop productivity, energy efficient farm mechanization, modern techniques, financial incentives, improves irrigation practices. iii) General management by establishing climate change units. iv) Risk Management by insurance of crop, by enhancing media, agricultural drought farming (National Climate Change Policy, 2012).

To implement NCCP, a Framework for Implementation of National Climate Change Policy was developed in November, 2013. This framework was developed by keeping in view current and future anticipated threats due to climate change to various sectors of Pakistan. Furthermore, appropriate actions relating to disaster preparedness, capacity building, institutional strengthening, and awareness raising in relevant sectors has also been described (Framework for Implementation of NCCP, 2013).

The good thing is that Pakistan has its first climate change policy approved from the cabinet which shows its commitment for mitigation and adaptation of climate change impacts but still too much work left to achieve the goal. Still climate change

policies and action plans have to be developed and implemented by the provinces and local governments alongwith firm financial commitments.

Conclusion of the findings are that Pakistan being less polluter in terms of greenhouse gases is the most affected country due to climate change. For Pakistan Climate change is not a distant threat, we are already feeling and experiencing its impacts across the country. Water scarcity is increasing, land productivity is decreasing and climate change is worsening these threats. The risk of natural disasters, also exacerbated by climate change as well as economic shocks, add to existing vulnerabilities. It needs for adaptation of agriculture to sustainable resource use and environment-friendly improved practices, to develop the human and technical capacity of public institutions & local communities to understand and address flooding and droughts risks, need of creating disaster control mechanism and awareness creation work to save the lives and livelihoods of vulnerable communities, to promote renewable energy and energy efficiency as climate mitigation measures, to promote sustainable use of natural resources and from resource users to resource managers. At national level Pakistan has developed climate change policy but at provincial and local levels there is no significant development. To meet the international commitments and to face this inevitable truth of climate change Pakistan still has to do a lot, at all levels, at war footing basis.

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ENVIRONMENTAL RISKS RELATED TO SHALE GAS ADVANCEMENT AND THEIR MITIGATIONS

Bilal Naveed[1], Talha Ayub[1], Muhammad Wajahat[1], Muhammad Junaid[1], Faizan Ahmed[1]

Abstract:

As the world is running out of Conventional resources of Oil and Gas, the biggest Unconventional resource (Shale) play an imperative role to meet the country's demand of energy consumption. It has raised the estimate of reserves abruptly of the countries which was once considered as impractical. Today USA is by far the dominant producer of tight gas and oil with 13.5 Tcf gas production in 2015. USA has sparked the world towards the Shale gas production.

This paper will review the major environmental risks affiliate with the Shale gas development and the strategies relevant to the minimization of issues. Environmental risks that will analyze in this paper associated with the Shale gas Production are:

1. Water Availability
2. Flow back Management.
3. Ground water Contamination.
4. Air quality Contamination.
5. Noise Pollution.
6. Moderate Earthquakes.

Further this paper will present strategies and solutions to overcome the concerned risks associated with Shale gas development.

Introduction:

Some years ago, oil and gas exploration companies scrutinized the natural gas resources in low permeable, tight shale as inappropriate and uneconomical to produce. But during the past years Shale gas development and enhancement has increased the reserves of countries to a very high number. According to the USEIA, United State has highest proven reserves of Shale gas 175,601 Bcf (2015). As the conventional resources of Pakistan is at its depletion phase, there is need to exploit the unconventional resources such as shale gas and coal bed methane. Total reserves of gas that can be produced technically are 15Tcf (EIA). Reservoirs with a permeability less than 0.1md are considered Tight Reservoir, and to make these deposits producible a well-established technique of Hydraulic Fracturing is used.

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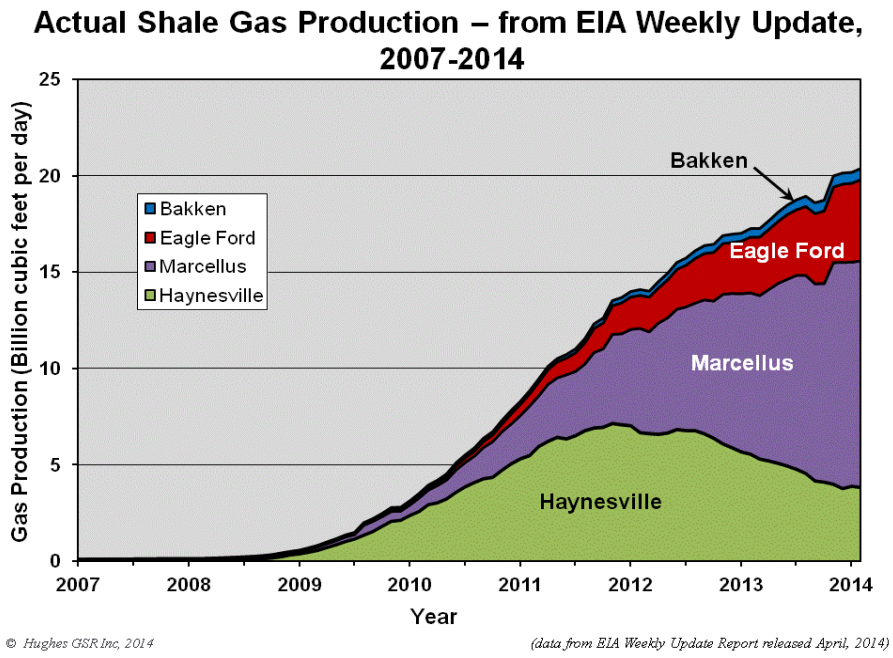


Figure 1: **Actual shale gas production from four**

Hydraulic Fracturing:

Hydraulic fracturing is a treatment of stimulation that is performed on less permeable reservoirs, whereby an appropriate engineered fluid is pumped into the well under high rate and pressure which causes to open the vertical fractures within the formation. Initially Hydrochloric acid is pumped into the well to wipe out the debris resulted from casing and cementing, then a pad approximately of 100,000gallons of slick water fills the wellbore and open the formation for the flow of proppants, then a mix slurry of fluid and solids are pumped into the formation to create fracture and intended to open it and, then finally an excess water is pumped into the wellbore to flush the proppant into the fractures that remained in the wellbore. Today over 1 million of reservoirs have fractured hydraulically [3]. Modern enhancements in hydraulic fracturing technique make it a very sophisticated engineering approach for the exploitation of tight resources.

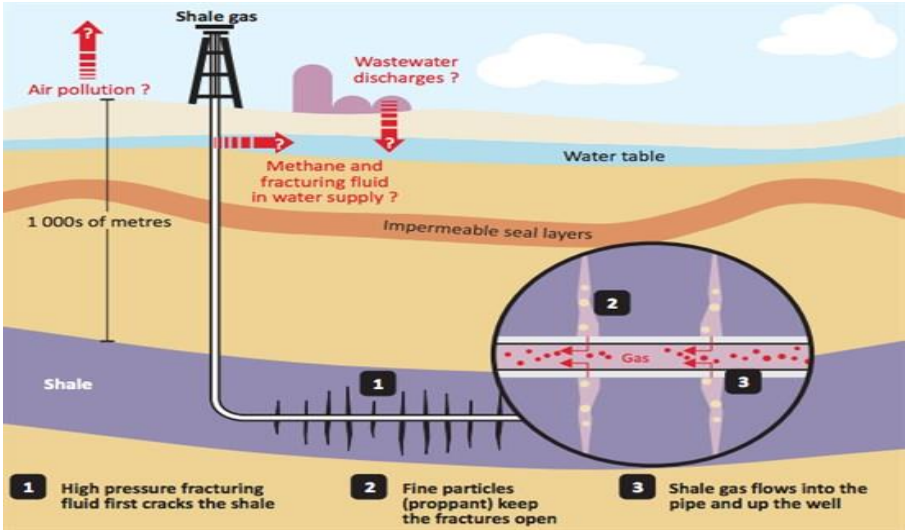


Figure 2: Overview of shale gas development (Carbon brief clear on climate)

The gap between the channels to open, the length of the fracture and extent of the pressure demand to achieve it are dictated by formation stress. The magnitude of the stress are calculated and tested by rock properties, tectonic system of that particular region, pore pressures and different tests and techniques. Fractures usually occur in a less stress region, overburden pressure of rock can also play role to make crack on rock. A fracture must have enough width & height so that fluid can transmit easily. The fracture gradient has a range from about 0.5 psi/ft. to over 1 psi/ft.

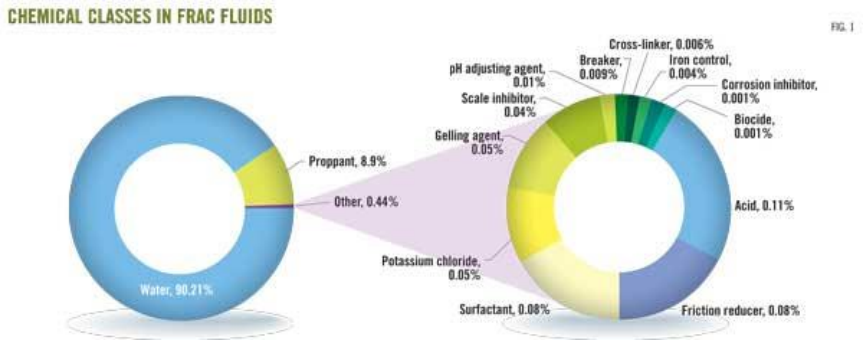


Figure 3: Composition of Hydraulic Fracturing Fluid (Adapted from OGJ Journal), Evaluating claims of groundwater contamination from hydraulic fracturing – tarek Saba (ogj)

USA Shale Play:

Advanced drilling and reservoir stimulation methods have dramatically increased gas production from unconventional shales. The U.S. increased its natural gas reserves by 6% from 1970 to 2006, producing approximately 725 Tcf of gas during

that period (BP, 2008; Navigant Consulting, 2008). The biggest shale plays of USA include Permian, Barnett, eagle ford and Marcellus shale that was once considered as uneconomical to produce. Marcellus Shale of the Appalachian Basin, located within parts of eight eastern U.S. states takes up a land area of about 54,000 square miles – an area larger than the state of Florida **[9]**.

Each basin is different from the other and has a unique set of exploration criteria and operational challenges. Environmental impacts are the major consideration for the producers. EPA (Environmental Protection Agency) released new source performance standards and national emissions standards for hazardous air pollutants in the oil and natural gas sector on April 17, 2012. The standards for hydraulically fractured gas wells require reduced emission (green) completions or flaring or released natural gas for wells developed prior to January 1, 2015 and green completions only on wells developed in 2015 and thereafter. This regulation is expected to reduce VOC emissions from shale gas wells by 95%. [10]

Hydraulic Fracturing process raises significant concerns about air and groundwater pollution, which has led to a polarizing, often heated public debate that continues to this day, and will likely continue for the future. Current US federal regulation of hydraulic fracturing, and oil and gas industry extraction operations, largely consists of a little oversight. The bulk of the regulatory responsibility is given to the several states, and these regulations vary widely in their complexity and level of protection of human health and the environment. New Jersey, for example, has banned hydraulic fracking [11].

Pakistan Shale Potential:

World is gearing its resources of hydrocarbons by exploiting the unconventional shale reservoirs. Pakistan is running out of its conventional reserves, according to Minister of Petroleum Shahid Khaqan Abbasi Pakistan is facing a huge gap between demand & supply of energy. The total production of gas is 4 Bcf/d against the consumption of 8 BCF/d. To improve the situation Mr. Abbasi said that OGDCL & PPL have given a task to drill pilot projects of shale gas and oil wells along with the help of international operators.

In the first assessment, USAID estimates showed that Pakistan had massive deposits of 10,159 trillion cubic feet of shale gas and 2.3 trillion barrels of shale oil. ARI estimates a total of 1,170 Tcf of risked shale gas in-place for India/Pakistan, 584 Tcf in India and 586 Tcf in Pakistan. The risked, technically recoverable shale gas resource is estimated at 201 Tcf, with 96 Tcf in India and 105 Tcf in Pakistan. In addition, we estimate risked shale oil in-place for India/Pakistan of 314 billion barrels, with 87 billion barrels in India and 227 billion barrels in Pakistan. The risked, technically recoverable shale oil resource is estimated at 12.9 billion barrels for the two countries, with 3.8 billion barrels for India and 9.1 billion barrels for Pakistan. The major deposits of shale gas are pressurized in Sembar, Kirthar, Ranikot, Chichali and Rakhshani formations [12].

Environmental Risks associated with Shale Gas Advancement:

Oil and Gas industry is bearing an exacting and tightening rules and regulations concerning the environmental issues. This trend is set and continuously growing with time. Advancement of Shale gas development yield the impacts on environment and it is crucial to discern the environmental considerations link with the drilling, completion and production of Shale gas. New challenges have been faced as the development of shale gas advances into high populated areas, new strategies and technologies are implementing and the expanding rules and strict regulations of environmental and governing agencies.

This paper will discuss the potential risks on environments that have been identified in Shale gas development. Following are the issues caused by Shale gas advancement:

1. Water Availability
2. Flow back Management.
3. Ground water Contamination.
4. Air quality Contamination.
5. Noise Pollution.
6. Moderate Earthquakes.

1. Water Availability:

Large quantities of water are required for drilling and completion of a well. Drilling of a vertical and horizontal well may require 400-4000 m^3 of water for many purposes. Then 7000-18000 m3 of water are needed for hydraulic fracturing of each well [1]. The common sources of water are groundwater, municipal supply, nearby surface water and produced water from wells for exploitation of shale gas. Municipal water supply will not be enough for the job because of shortage and limitations. Water from surface and ground may create a future problems for nearby population, over production of groundwater may alter the water tables.

2. Flow Back Management:

After the job of hydraulic fracturing , fracture pressure is released from the surface pumps that causes to a fluid to reverse back to the surface which is referred to as “flow back “.This fluid is a combined mixture of the pumped and the natural formation fluid which contains dissolved or undissolved minerals and organic constituents. The flow back can occur for days to weeks, the highest rate of fluid appears on the first day. The typical initial rate may be as high as 1000 m^3 (GWPC). The existence of radioactive element i.e. uranium, radium, radon and thorium is dependent on the geology of formation [4].

3. Ground Water Contamination:

Successful hydraulic fracturing requires mixture water, chemicals, proppants and thickening material pumped into a desired low permeable formation with a controlled and monitored manner above formation fracture pressure. Different type of acids, inhibitors and antibacterial compounds are also used in this operation to prevent formation damage, corrosion and blockage. These chemicals are the extreme threat for ground water contamination. Texas reported at most ~100 cases of confirmed contamination of groundwater from oilfield injection wells, saltwater pits and abandoned wells, even though at that time the state hosted more than 50,000 injection wells associated with oil and gas [5]. Methane migration has also a severe impact on ground water contamination.

4. Air Quality Contamination:

Volatile organic compounds have hazardous impact on air pollution when released during hydraulic fracturing operation. These compounds may be present in the flowback, produced hydrocarbons and as a recipe of an injected fluid. By products of combustion also discharge into environment which consist of diesel flaming emitted by the machinery use in tight gas drilling, completion and production. Other emission may result from produced natural gas flaming. These polluted gases causes a number of diseases to a nearby populated areas and create an impact on air quality.

5. Noise Pollution:

A bulk area is needed to prepare well site in which heavy machinery is run to drill the wells, a noise created from those machineries, heavy duty transportations, blasts from the failure of pumps or equipments can be very challenging for the Shale gas developers in areas nearby urban areas.

6. Moderate Earthquakes:

A number of moderate earthquakes under a magnitude of 3 have resulted to the injection of waste water by fracturing pressure [3]. These earthquakes are generated by the seismicity of disposal of millions of gallons of flow back, rather than hydraulic fracturing process. There is another possible cause of earthquake that's the injection of waste water and salt water into the sub surface cause the earthquake.

Practical Approach to Handle Environmental Impacts:

Production of oil and gas from unconventional reservoirs has become necessary due to the depletion of conventional reserves, but it should be balanced by minimizing the effects of environmental risks related to shale gas development. These risks can be mitigated by using proper rules and regulations, advance technologies and high performance planning & strategies.

Following are the practices that can help to mitigate the environmental impacts of hydraulic fracturing:

a) Private and government holding environmental agencies should focus and monitoring the exact composition of hydraulic fracturing fluid used in a particular well.
b) Use of fresh water should be limited by recycling and reuse of flowback , as the cost of disposing it can also be saved.
c) Flowback with high concentration of TDS can be treated and reused to the other simulation job.
d) Disposal wells should be drilled very far from fresh drinking water sources.
e) Companies should find alternative sources of fresh water such as high saline water, marginal ground water and impounded storm water that is unable to drink.
f) High performance technologies and strategies should be applied in drilling, completion & production of shale gas reservoirs.
g) 24 hours automated gas chromatograph should be installed near wellsite locations to investigate volatile organic compounds (VOC) emission.
h) Reduction of methane migration can be accessed by implementing Green completion.
i) Horizontal wells can be drilled and stimulated into the sections, instead of multiple vertical wells with multiple fracturing jobs. This can also help in reducing surface disturbances: few well pads, reduced traffic & fewer surface facilities.
j) Sound barriers can be used to reduce the impact of noise pollution.
k) Rapid fluid flow back after treatment and reduction of fluid volume can also minimize the cause of earthquake.
l) The advancement in technologies and increased experience will lead to a successful development of shale gas and reduce the environmental footprints.

Conclusion:

Compliance of environmental rules and regulations is must for all companies. Reinforcement and advancement of technology can play a vital role in shale gas development considering environmental risks. Shale gas development is new opportunity for Pakistan oil and gas sector, much can be gained from the considerations of environment and the strategies applied to mitigate them. Otherwise, it will be very difficult to explore unconventional resources in future.

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GREENING THE LANDSCAPE IN PAKISTAN

Abdul Aleem Chaudhry Ph.D.

Our cosmic oasis, cosmic blue pearl the most beautiful planet in the universe all the continents and the oceans of the world united we stand as flora and fauna united we stand as species of one earth black, brown, white, different colours. We are humans, the earth is our home.

Our cosmic oasis, cosmic blue pearl the most beautiful planet in the universe all the people and the nations of the world all for one and one for all united we unfurl the blue marble flag black, brown, white, different colours. We are humans, the earth is our home.

Earth Anthem penned by poet Abhay K is sung to celebrate World Environment Day

"Connecting People to Nature" theme for World Environment Day 2017 implores us to get outdoors and into nature to appreciate its beauty and its importance to protect the Earth that we share.

There's nothing quite like being in the wild, high on a mountain, deep in a forest or out on the vast ocean. Experiencing and touching nature is what makes it real for people, adults and children alike. We have seen it with pollution where—having witnessed the impact on their health—people are prepared to fight to make changes and pressurize businesses and governments to support them.

When we step into nature, we are reminded that all living organisms are connected. But too many of us rarely get to experience this. More and more people live in cities, miles away from nature. How can one expect them to protect something they don't see, understand or love? Theme for World Environment Day 2017 is the call of the DAY.

The question however remains: Where to go?

Going out in the wild and to places of interest is nothing new. Top tourist attractions in the all countries of the world are shown in the figure. Four main types of attractions include: Historic, Natural, Religious and Touristic. Tourists visit to satisfy their varied interests like going to cities that have archaeological and historical buildings and places of cultural interest, and offer modern facilities for tourists. Lahore, Peshawar, Quetta, Karachi are the main attractions. Taxilla, Harappa and Moenjodaro, Takhtbhai, Mehr Garh and Hunza are the most visited archaeological sites. K-2, Nanga Parbat, Trich Mir and other mountain tops around 8000m high are the destination of Climbers who come to Northern mountainous areas of Pakistan to test their skills during summer season. Nature lovers especially from foreign countries visit these areas that harbor some beautiful lakes like Karambar, Saifulmuluk, Lulusar, Banjusa, great glaciers such as Bilafond (in Siachin), Baltoro, Batura, Biafo, Biarchedi, Godwin-Austen and Gondogoro; and beautiful valleys-Swat, Kaghan, Neelum, Jhelum, Dir, Chitral and many sub valleys

in northern mountains. Wildlife viewing and hutting is another main touristic attraction.

Local tourists however prefer to visit lower foothills of Himalayas in preference to higher elevation mountainous areas including Murree, Gallies, Swat/Mingora, lower Kaghan, Chikar, Rawalakot mainly because of easy accessibility and lack / shortage of time at their disposal.

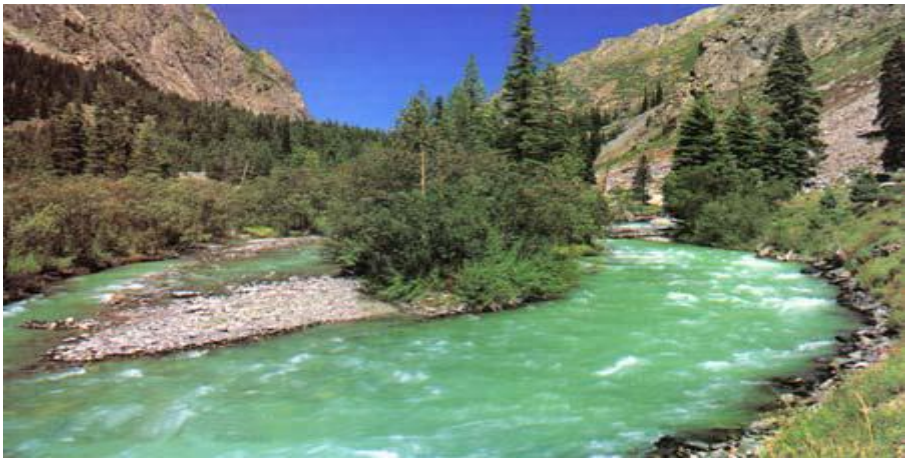
The Top destinations that people like to visit in Pakistan are: Neelum valley(AJ&K), Hunza valley (GB), Swat valley (KP), Kaghan valley (KP), Kalash valley (Chitral-KP), Murree Hills (Punjab), Shandur pass (GB/KP), Rawalakot (AJ&K), Ziarat Residency (Balochistan), Jhelum valley (AJ&K), Karachi Coastal areas (Sindh), Lahore, Islamabad and Karachi.



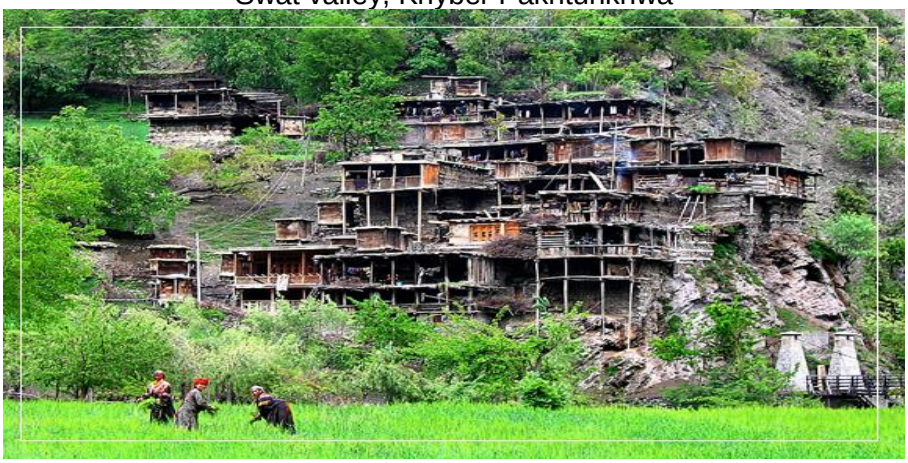
Neelum valley, Azad Jammu & Kashmir



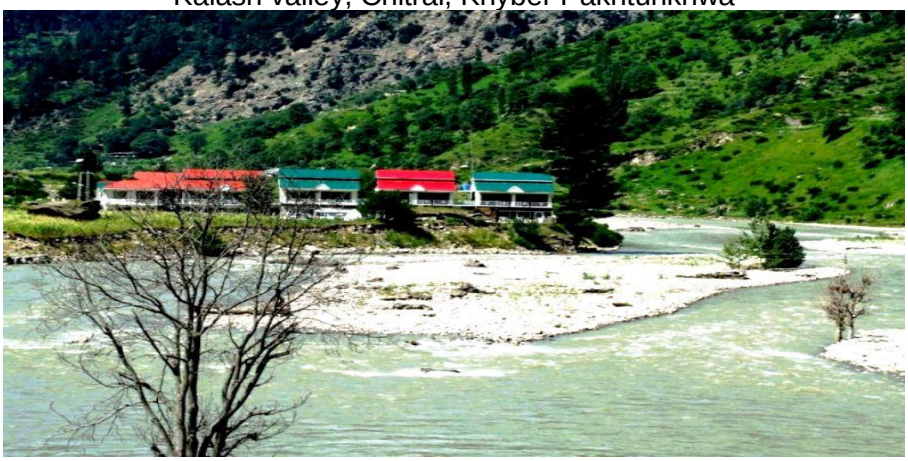
Hunza valley, Gilgit-Baltistan



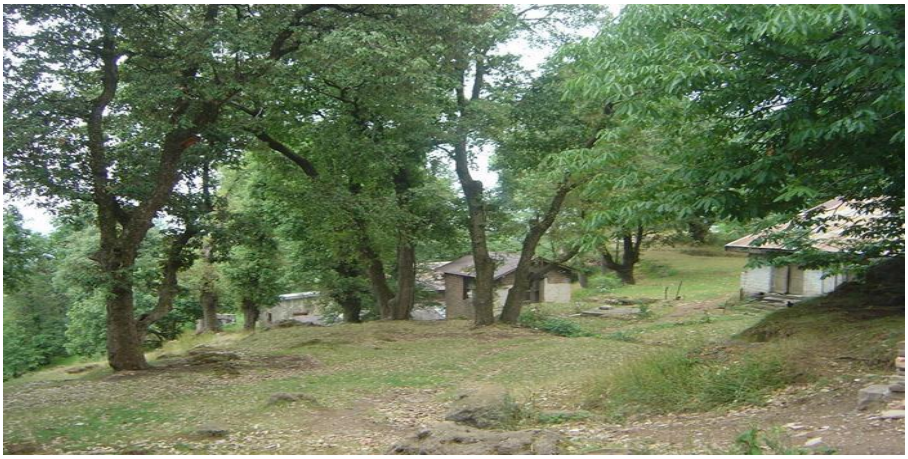
Swat valley, Khyber Pakhtunkhwa



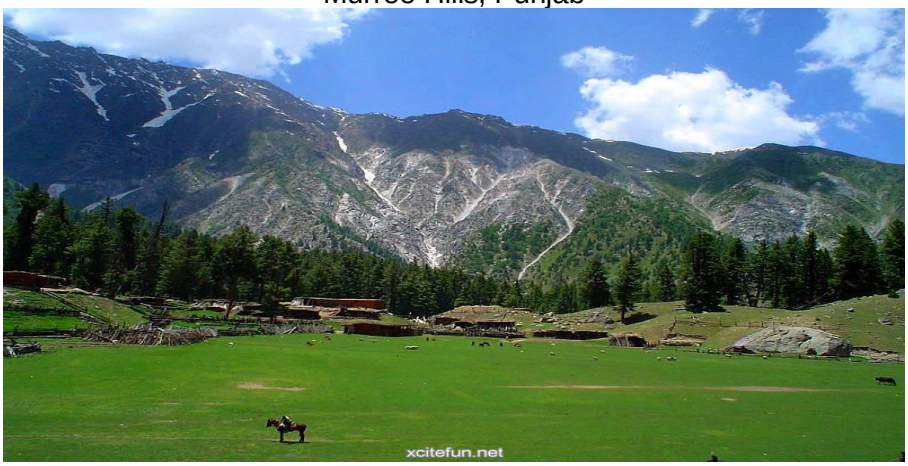
Kalash valley, Chitral, Khyber Pakhtunkhwa



Kaghan valley, Khyber Pakhtunkhwa



Murree Hills, Punjab



Shandur Pass, Gilgit-Baltistan / Khyber Pakhtunkhwa



Rawalakot, Azad Jammu & Kashmir

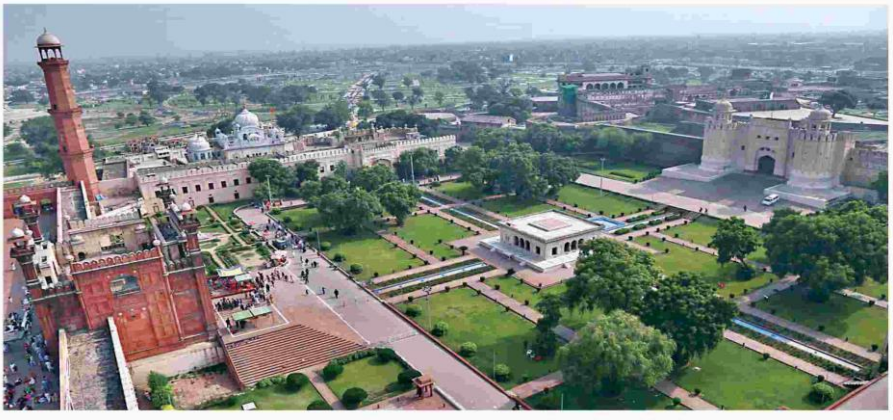


Karachi coast, Sindh



A VIEW of Model Town's Linear Park on an extremely hot day. Temperature soared to 45 degrees Celsius in the city. — White Star / Murtaza Ali

Linear Park, Lahore



AN aerial view of the historic Lahore Fort, Hazuri Bagh and Badshahi Masjid. — Online

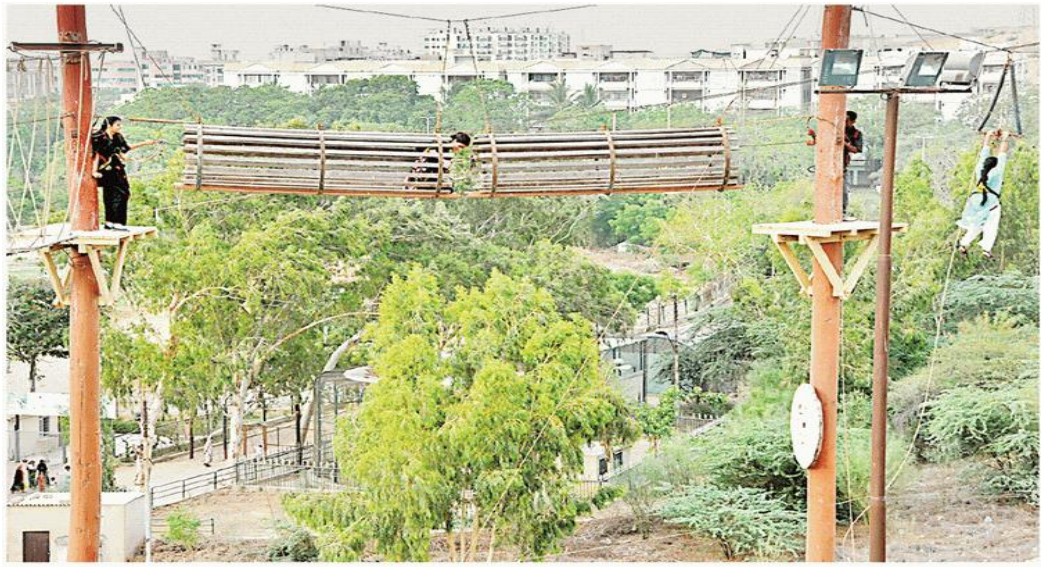
Lahore Fort,Badshahi Masjid, Allama Iqbal's Masauleum, Hazuri Bagh, Lahore



Changa Manga Forest Park, Kasur, Lahore, Punjab



Wildlife Breeding Centre Piranwala Khanewal
Peranwala Wildlife Recreational Complex Khanewal (proposed), Punjab

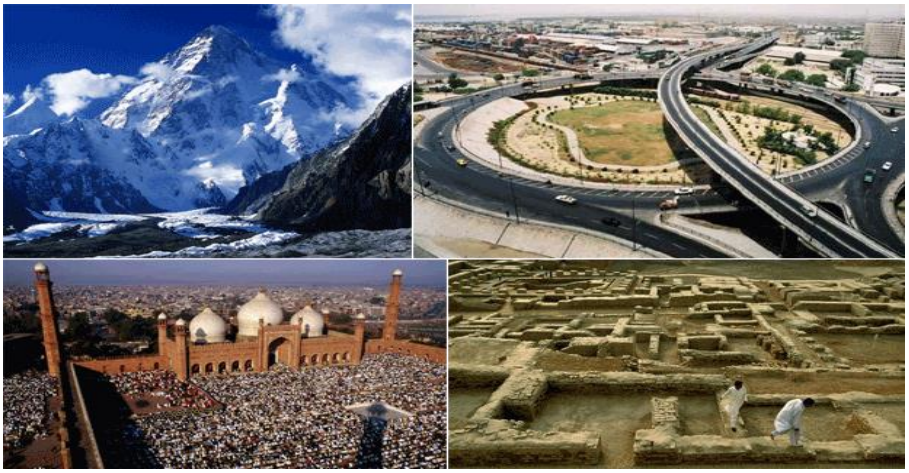


Some adventurous young women pulling off dangerous stunts at Safari Park *—The News photo by Naqeeb-ur-Rehman*

Safari Park, Karachi, Sindh



Kaghan valley: Lalazar grasslands, Kunhar river, Lulusar lake



Landscape in mid elevation Himalayas, Islamabad Highway Labyrinth, Badshahi mosque, Lahore and archaeological remains at Taxilla



Domesticated Yak in Khunjerab National Park, along China Border, Gilgit Baltistan



Marco Polo sheep (Critically endangered) in Khunjerab National Park, along China Border, Gilgit Baltistan



Himalayan Ibex in Khunjerab National Park, along China Border, Gilgit Baltistan



Kashmir Markhor (Endangered) Zoo Exhibit



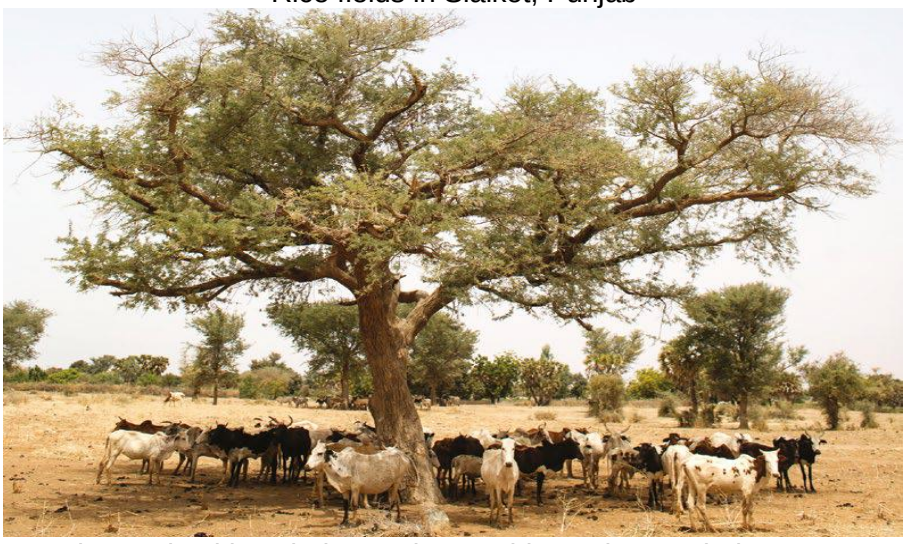
Snow leopard (Critically endangered) on a massif



Blackbuck (endangered), Nilgai and Chinkara gazelle in enclosure,
Lal Suhanra National Park, Bahawalpur



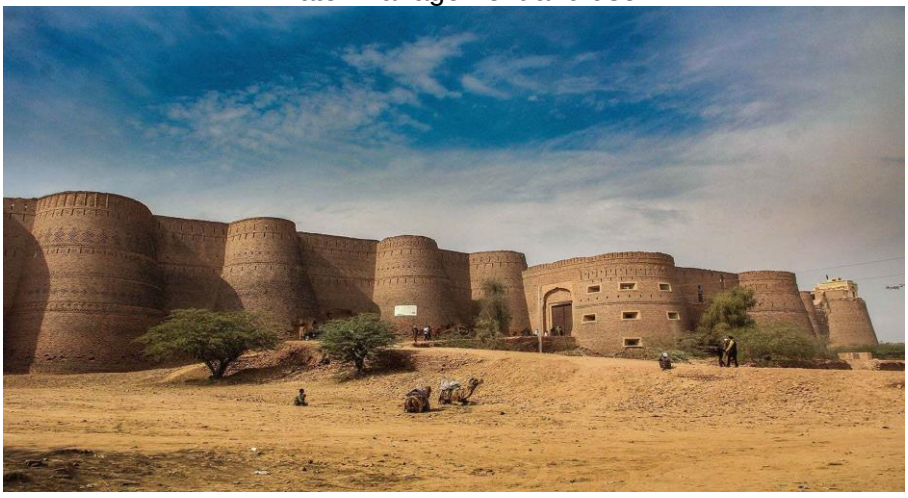
Rice fields in Sialkot, Punjab



Livestock taking shelter under an old Acacia tree during noon



Water management and use



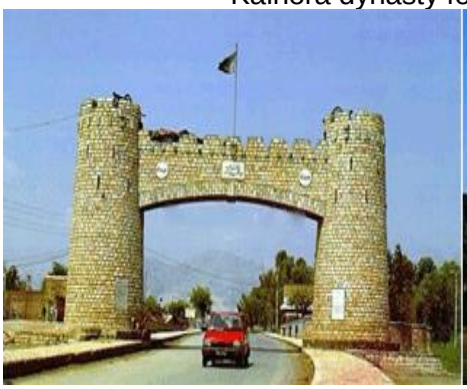
Darawar fort. Choloistan desert, Bahawalpur, Punjab



Rannikot fort, Khirthat National Park, district Dadu, Sindh



Kalhora dynasty fort, Khairpur Mirs





Gateway to Khyber Pass, Jamrud, Peshawar: Islamia College, Peshawar, Khyber Pakhtunkhwa



Green vegetation on top floor of a sky rise building, Urban landscape

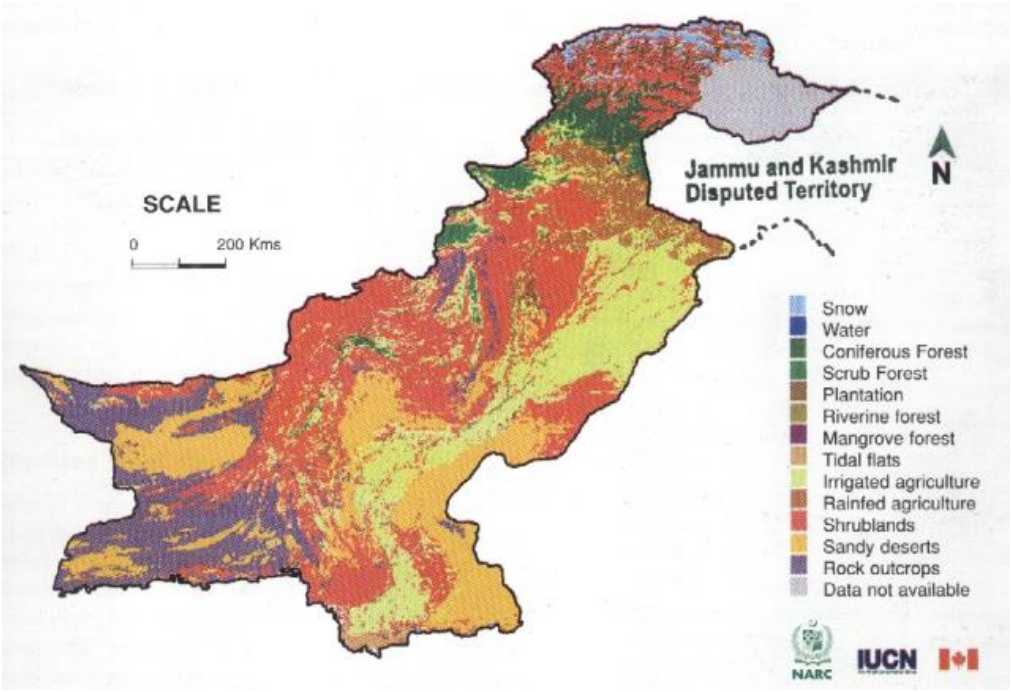


Babusar Pass connecting Gilgit Baltistan with Khyber Pakhtunkhwa, tourists on the move

One factor common to all these sites is the presence of green vegetation with emerging trees. The woodlots, forests are not a collection of trees only but are also support complete ecosystems that include dominants, co-dominants, understory, ground flora and all this is the habitat of wildlife and supports Biodiversity. Pakistan supports a diverse flora and fauna in a wide range of habitats from sea level to high elevation areas in the mountains, including 177 mammal and 660 bird species. This diverse composition of the country's fauna is associated with its location in the transitional zone between two major zoogeographical regions, the Palearctic, and the Oriental and the incursion of third region-Ethiopian in the south west of the country. The vegetation types occurring in Pakistan is shown in figure (Roberts 1997). Vegetation types / Ecosystems have been classified in to eight major vegetation types, further classified into 18 more or less distinct habitat types where vegetation also supports a diverse fauna. Major vegetation types include: Permanent snow and cold deserts, Alpine zone, Montane temperate forest, Tropical deciduous forest, Alpine dry steppe, Arid sub-tropical habitat, Tropical thorn forest, Riveriain plain or Indus basin.

Large parts of Pakistan have been so heavily influenced by man as to constitute degraded vegetation zones which cannot usually be related to any distinct ecological climax. To rehabilitate and improve the ecological complexes, vegetation protection by adopting various means and planting programs. Such programs are regularly constituted and followed. Forests are managed through management plans that are framed for a period of 5 to 20 years. Regeneration and afforestation program. s prescribed are followed to the best of capabilities keeping in view the resource position and local situations. To lure public into planting more trees two planting weeks are celebrated annually, one in spring and the second in monsoon seasons. Awareness campaigns are run and plants/tree saplings are provided on subsidized rates. Such campaigns have paid dividends. Farmlands in Punjab, for instance, farmlands that contained three (3) trees per acre had contained 17 trees per acre in 2002 when Punjab Economic Research Institute

conducted a survey Campaigns and planting programs are regularly being run, blanks in forests are being afforested however no survey has been conducted to assess the current status of trees on farmlands. Similar campaigns are run in provinces and federating units.



Vegetation types of Pakistan (Roberts, 1997)

World Environment Day 2017 Emblem

Annual afforestation and regeneration activities and celebrating planting weeks twice a year have become a norm in all the provinces. These activities are undertaken to meet the wood demand for its use as timber, firewood and several other uses as with the exponential increase in population wood demand has also increased tremendously. Once wood is harvested from a forest, it has to be replanted. Unlike agricultural crops forests have long life spans i.e. the trees take a long time to grow to an exploitable size e.g. a poplar tree may be cut after five (5) years, a eucalyptus after 10 years, *semal* after 15-20 years, a *shisham* tree after 20 -22 years (for low quality timber/ firewood)-after 60 years for timber, *kikar/babul* after 10-20 years, a chir pine after 100 years, *kail* after 150 years and *deodar*, fir/spruce after 200^{+} years. Hence it is imperative that long term planning may be resorted to. That is why all Government forests, community forests managed by the Government and private forests are managed through the implementation of Working Plans that are formulated on a long term basis.

Forests have other functions too. Forests are also the custodians of WATER. Water received in the form of precipitation and snow in high hill areas that serve as catchments/watersheds is stored in the forest floor and slowly released over the year. This effectively reduces the devastating floods and keeps the rivers flowing all the year round. This water ultimately proves to be the lifeline of Pakistan by providing irrigation water through a vast irrigation system in the Indus basin.

Forests also provide fodder for the livestock besides providing shade especially in dry arid lands like Cholistan, Thal, Thar and arid Balochistan. Almost one third of livestock in Pakistan is supported by the forest areas.

Forests also provide the habitat for wild animals that become the destination of wildlife lovers who want to shoot them both with camera and the gun.

Khyber Pakhtunkhwa Government have taken initiative and announced the planting of a Billion trees within a span of three (3) years.

The project is being implemented in the entire province through its three forest regions i.e. Southern and Central region, Malakand region and Hazara region. Hazara region also includes the Watershed Management Circle. Phase 1 of the Project has been implemented during 2014-15, while Phase 2 is being implemented starting from 2015-2016 and to be completed by June 2017.

- 60% of the BTTAP is through community protected natural regeneration - so it includes the regeneration of 40 different indigenous varieties. No saplings planted here.



Billion trees Tsunami

- For the remaining 40% the focus is on new afforestation through managed plantations (various public-private models used depending on land ownership).
- Again 21 different varieties planted and eucalyptus happens to be one of them - mostly planted in water logged/saline areas in south KP

Overall Eucalyptus is not more than 10-12% of the total target of Billion trees

To ensure transparency, quality, and effective and judicious utilization of development funds, WWF-Pakistan was assigned to carry out independent monitoring of the BTTAP project interventions. WWF monitored the interventions carried out in 28 territorial and watershed divisions of the KP Forest Department covering 50% of the implemented activities except farm forestry, which is 10% (*Third party monitoring of Billion trees Tsunami afforestation project in Khyber Pakhtunkhwa WWF-Pakistan, January 2016*).

By August 2015, 238.71 hectare of central model nurseries had been established including bare rooted and potted nurseries. Survival rate varied from 72 t0 83% in monitored nurseries. 26 million seedlings in tubes, 1.854 million bare rooted plants were ready for planting in monitored nurseries (132 out of 238).

A total of 2756 units of private nurseries had been established, raised both by men (87%) and women (13%). 18.15 million seedlings survived (73%) in private out of which 10.41 million (57%) potted plants and 5.47 million bare rooted plants were ready for planting.

6758 ha of block plantations and 494 ha of roadsides and canal-side plantations had been carried out till August 2015 out of which 3774 ha of block plantations and 257 ha of linear plantations were monitored. The average survival rate was 86% in block plantations and 79% in roads and canal side plantations.

On an average 2316 seedlings were available per hectare of enclosures (in 210 out of 411 monitored). Over 13 different indigenous species had been regenerated, which also included some endangered species such as *Taxus walichiana* (Yew/*Burmi*).

Forest and watershed divisions distributed 6.98 million seedlings to farmers (49% achievement), with a survival rate of 65% (out of 0.804 million seedlings monitored and verified).

135 ha of saline and waterlogged areas were treated against the target of 150 ha. Suitable species had been planted with an overall survival rate of 72% (81 ha area monitored).

To rehabilitate landslides and control gully erosion 178 ha was treated with engineering and bio-engineering measures mostly in Upper Dir, Swat, Kohat, Gallies, Kaghan and Siran Forest and Kunhar Watershed Divisions. The overall survival rate of brushwood and seedlings was 74% (75.90% monitored). Eleven types of engineering, bio-engineering and biological measures had been applied for badlands treatment. About 57% of the measures were suitable and relevant according to the selected sites while 86% of the measures had good layout and designs. In general the bioengineering works had been carried out during off season resulting in failure of plants material in these structures. Lack of knowledge and capacity regarding soil bio-engineering works were also noticed mainly in Malakand and Southern Regions.

Some selected activities mostly engineering and bioengineering structures had been carried out in Manur valley in Kaghan and Balakot village in Kalam forest division watersheds. Suitable engineering and bioengineering techniques had been applied and the success rate of vegetation ranged from was 81% in Manur valley and 50% at Balakot village in Kalam forest division. The low success rate was mainly due to establishing these structures during off season.

A total of 411 enclosures had been established out of which 210 enclosures were monitored. Average number of seedlings per hectare of enclosures was found as 2316. Over 13 different indigenous species had been regenerated, which also included some endangered species such as *Taxus wallichiana* (Burmi).

Under the farm forestry 6.98 million seedlings had been distributed by the respective forest and watershed divisions with an over achievement of target by

49%. Out of this a total 0.804 million seedlings were monitored and verified. The overall survival rate was 65% which is quite acceptable keeping in view different priorities and practices of the farmers.

Under the rehabilitation of saline and waterlogged areas a total of 135 ha had been treated against the target of 150 ha out of which 81 ha area was monitored. Suitable species had been planted with an overall survival rate of 72%. Average spacing of plants and pits size were well within the recommended limit. There were no management plans available to deal with such sites. Planting of suitable species in trenches and on mounds had been carried out.

Three sites were planned under watershed management during Phase-1. Some selected activities mostly engineering and bioengineering structures had been carried out in Manur valley in Kaghan and Balakot village in Kalam forest division. Suitable engineering and bioengineering techniques had been applied and the success rate of vegetation ranged from was 81% in Manur valley and 50% at Balakot village in Kalam forest division. The low success rate was mainly due to establishing these structures during off season.

Green Pakistan Program

Green Pakistan Program was launched by the Prime Minister of Pakistan in March 2016 whereby over 100 million trees will be planted in the country. The idea is based on the 'Great Green Wall Program' of China. The Ministry of Climate Change is implementing the Program.

The program targets to add 100 million plants over the next five years all over the country. This includes one thousand avenue miles of Canal Side and Roadside Plantations in Punjab, KP and Sindh, plantations in Changa Manga (Kasur), Daphar (Gujrat), Bahawalpur and Chichawatni (Shiwal). Mangroves forests in Karachi and Badin along with hill forests of Khirthar Range in Sindh, Juniper forests of Ziarat and Chilghoza forests in Suleiman Ranges of Balochistan and areas in GB, AJ&K, Muree, Hazara, Kotli Sattian, Malakand, Fata (Orakzai, North Waziristan, etc.) are some of the locations for plantations.

Reclaiming and developing forest areas and protection and management of wildlife are the main aspects of the program.

All relevant federal and provincial ministries and agencies are being facilitated to fulfil the task so that the desired objectives of forests preservation and wildlife protection is achieved. Assessment of forest resource depletion, use of modern technology, and development of immediate and long-term forest resource expansion plans are some of the salient features of the program.

Zoological Survey of Pakistan is undertaking the inventory of endangered wildlife species and habitats across Pakistan. Internationally recognized wildlife habitats, including Khunjrab National Park (GB), Khirthar National Park (Sindh), Hingol National Park (Balochistan), Chitral Gol National Park (KP), Lal Suhanra National

Park and Salt Range area (Punjab), Machiara National Park (AJ&K) and Margalla Hills National Park (Islamabad) are being inventoried and rehabilitated.

Rs. 553 million was physically disbursed to all provinces/GB/AJ&K/FATA to be spent until June 2017. The ministries of climate change and science & technology will lead the regular stock-taking of deforestation and forest degradation on periodic basis for producing "Report on State of Forestry in Pakistan". The GIS laboratory in Punjab and the Forest Inventory in KP Environment will help in maintaining the report while Suparco (Pakistan Space and Upper Atmosphere Research Commission) will extend technical support in the form of provision of images.

Landscape Restoration

Forest restoration has the potential to bring millions of hectares of land back to life. Landscape and/or coastal and island seascape of high and/or distinct scenic quality and with significant associated habitats, flora and fauna and associated cultural features is the result of a balanced interaction between people and nature.

Forest landscape restoration leads to a wide variety of benefits, including improved water quality, soil retention, increased wood supplies, and job creation. More recently, the focus has expanded to recreation, wildlife and biodiversity conservation, and climate change mitigation benefits. In the past, forests have too often been sacrificed in the name of economic development. In the future, it is now envisioned forest landscape restoration as an integral part of economic development, providing jobs for rural communities and generating a multitude of renewable goods and services.

Lessons learnt from Forest landscape Restoration are:

Forest livelihoods and landscapes are undervalued in decision making, and economic analyses need to account for both the local-level and ecosystem benefits as well as the commercial revenues;

- Markets and prices don't reflect the true value of sustainable forest management;
- Economic policies and instruments tend to favor environmentally destructive activities within landscapes. It has been suggested to remove subsidies, unfair taxes, and perverse incentives to encourage local market participation;
- In addition to market solutions, rights, responsibilities, and information are needed for producers, consumers, and investors to fully participate and benefit from market incentives.

Establishment of Protected Areas to Conserve the Wild habitats and Wildlife

IUCN defines protected areas as "a specifically delineated area designated and managed to achieve the conservation of nature and the maintenance of associated ecosystem services and cultural values through legal or other effective means" (Dudley 2008).

Following six categories of Protected Areas have been recognized by International Union for the Conservation of Nature (IUCN):

I. Strict Nature Reserve / Wilderness area

Ia. Strict Nature Reserve (managed mainly for science or wilderness protection)

Ib. Wilderness Area (managed mainly for wilderness protection)

II. National Park (managed mainly for ecosystem protection and tourism)

III. Natural Monument (managed mainly for conservation of specific natural features)

IV. Habitat / Species Management Area (conservation through management intervention)

V. Protected Landscape / Seascape (landscape/seascape conservation and recreation)

VI. Managed Resource Protected Area (sustainable use of natural ecosystems).

Pakistan has designated 26 national parks, 96 wildlife sanctuaries and 93 game reserves covering **14,613,130** hectares of land area as given in the following Table:

Protected Areas of Pakistan as of June 2017 (Area in acres)

Protected Area	AJ&k	Balochistan	Federal	GB	KP	Punjab	Sindh	Total
Wildlife Sanctuary	-	13	1	6	3	40	33	**96**
National Park	7	2	1	5	6	4	1	**26**
Game Reserve	7	6	1	9	36	21	13	**93**
	6,518,700	**1,506,843**	**94,186**	**2,182,830**	**817,706**	**1,737,265**	**1,755,600**	**14,613,130**

Specific objectives for three kinds of Protected Areas (PAs) viz., National Parks, Wildlife Sanctuaries and Game Reserves, were developed

National Park: Category **II** protected areas are large natural or near natural areas set aside to protect large-scale ecological processes, along with the complement of species and ecosystems characteristic of the area, which also provide a foundation for environmentally and culturally compatible, spiritual, scientific, educational, recreational, and visitor opportunities.

Wildlife Sanctuary: Habitat/Species Management Area: Category **IV** protected areas aim to protect particular species or habitats and management reflects this priority. Many Category IV protected areas will need regular, active interventions to address the requirements of particular species or to maintain habitats, but this is not a requirement of the category.

Game Reserve: Managed Resource Protected Area (sustainable use of natural ecosystems). These areas do not conform to IUCN Protected Area categories as these are specifically established to manage sustainable hunting.

Protected Areas are also a Favorite Tourist Destination.

Sustainable TOURISM and ECOTOURISM

Due to its diverse culture, people and landscape, **Tourism** is a growing industry in Pakistan. According to British Magazine "The Economist". Pakistan has very diverse and rich culture to offer tourists together with lots of opportunity for adventure tourism as the four provinces and three territories of Pakistan are very diverse and so different that foreign tourists could not have imagined that they were in the same country with such diverse culture, attractions and different seasons. In Pakistan there are number of varieties of attractions that range from the ruins of ancient civilization such as Mohenjo-Daro, Harappa and Taxila, to the Himalayan hill-stations that attract those interested in field and winter sports. Moreover, Pakistan has several mountain peaks of height over 8,000 meters (26,250 feet), that attract adventurers and mountaineers from around the world, especially to K2 and Nanga Parbat. Many domestic and International tourists visit these areas most often in the months starting from April to September. Tourism has become the source of income for local people.

In 2009, Pakistan was ranked 113 out of 130 countries to visit, According to the World Economic Forum's Travel and Tourism Competitiveness Report (TTCR). Due to Political instability, suicide attacks, religious conflict, kidnapping of foreigner and uncertainty in the country has however, badly affected Tourism throughout the country, especially Khyber Pakhtunkhwa.

For decades, **Ecotourism** has been the significant part of tourism business in Pakistan, as it has offered much tremendous experience along with the stunning mountains of KP, GB and AJ&K attracting hundreds of thousands tourists all over the world for hiking, skating, forest camping, climbing, and exploring the region's natural parks and forests. Pakistan ecotourism destination is unforgettable for those who have ever visited it (http://whc.unesco.org/en/statesparties/pk).

The natural beauty of this mountainous scenery has attracted tourists generating vital jobs for local people in the hospitality-related businesses. Moreover the Swat valley alone - known as the "Switzerland of the East" - has become the centre for 800 hotels. Over 40,000 local people Pakistan employed directly in hospitality (http://whc.unesco.org/en/statesparties/pk).

Besides Security Tourism activities in Pakistan are currently far from sustainable, as in many other mountain regions worldwide mainly due to deforestation, uncontrolled land utilization, unplanned growth of tourism, mushrooming growth of accommodations, and, above all, outmigration of young, energetic people as a result of limited job opportunities and lack of local ownership and participation in tourism ventures. Some other factors adding to woes of this multibillion dollar trade the world over include: lack of infrastructure, facilities to the tourists, transport, discouraging response from officials circles etc. The areas need to be improved.

Pakistan should improve the image of country by first improving security situation in order to convince foreign tourist that they are safe in the country. Together with these measures Pakistan needs to improve its image by promoting itself on various platforms around the world and together promoting hospitality industry through giving them incentives, Pakistan can catch significant number of tourists looking for adventurism or natural beauty to visit Pakistan and contribute significant revenue for the government of the country while providing employment to a large number of its population.

Tourism could be helpful in

- Providing durable productive base that allows local inhabitants and service providers to enjoy rising standards of living;
- Ensuring ecological, economical, and cultural friendly tourism;
- Controlling activities by the local community in which tourism activities are being generated; and

Managing tourism / ecotourism sustainability, and providing sound environmental management.

ENVIRONMENTAL CONCERNS FOR SUSTAINABLE USE OF GROUNDWATER FOR FOOD SECURITY IN PUNJAB

By

Ghulam Zakir Hassan[1] and Faiz Raza Hassan[2]

Abstract:

Pakistan is the 8th largest food producing country where irrigated agriculture contributes more than 90% of Pakistan's food production. Agriculture is the largest single sector which contributes 22% of GDP, employs about 45% of the overall labor force and generates over 60% of foreign exchange. Groundwater consists of 96% of planet's unfrozen freshwater and globally 60% of it is used for agriculture, 20% for domestic and 20% for industry. Pakistan is 4th largest user of groundwater after India, USA and China where more than 90% drinking, almost 100% industrial and more than 40% irrigation water requirements are met from groundwater. Global warming, temporal/areal variations in rainfall patterns, uncertainty in river flows, glacier melting are the major challenges to water resources of Pakistan. Pakistan has also suffered from the climatic changes like other parts of the world. Extreme events like floods and droughts have disturbed the hydrologic-cycle posing severe impacts on water resources.

Groundwater resources are being rapidly expiated at an alarming and unsustainable rate in many areas of the world. A recent NASA study concluded that 21 of the largest 37 aquifers in the world have exceeded sustainability tipping points and are being over depleted.

In Punjab province about 1.2 million farmer tube wells are pumping groundwater to meet 40 to 50 % of crop water requirements at farm-gate which has put the aquifer under stress especially in sweet groundwater zones consequently putting this natural gift beyond the limits of human utilization. To meet the ever increasing demand of food and fiber, cropping intensity has increased from 67% to 150% or even more in some areas which is a major driver for dependence on groundwater.

About 3000 piezometers have been installed in the province to monitor the groundwater levels twice in a year and groundwater quality is being monitored from farmer tube wells. Research studies have indicated that activities like increasing cropping intensities, unplanned over pumpage, lack of awareness, use of chemicals in agriculture/food production, industrialization, urbanization, acidic rains due to air pollution, domestic waste, solid waste landfills, etc. are the major threats to sustainable use of groundwater which are deteriorating its quality and

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quantity at very alarming rates. Abnormal lowering of water table in sweet groundwater areas, inter-mixing of saline and fresh groundwater, increase in cost of groundwater pumping due to increase in depth to water level, threats to agriculture due to secondary salinization etc. are the major consequences of ill-planning and over exploitation of groundwater reservoir. In this paper findings of various studies have been outlined to identify the critical areas and to suggest some management options for the replenishment of this fast depleting natural resource in Punjab. In urban areas, like Lahore City, threat is very severe where annual average depletion rate of water level is 2.5 ft. At the same time it has been found that during flood 2014, average groundwater table rose up to 2.5 ft. Potential sites for artificial recharge of aquifer have been identified and possibility of aquifer recharging through flood water has been explored. Impacts of theses global climatic changes on groundwater have been evaluated and some options for sustainable use of groundwater have been suggested.

1. Background

As the world's largest distributed store of fresh water, ground water plays a central part in sustaining ecosystems and enabling human adaptation to climate variability and change. The strategic importance of ground water for global water and food security will probably intensify under climate change as more frequent and intense climate extremes (droughts and floods) increase variability in precipitation, soil moisture and surface water. Here we critically review recent research assessing the impacts of climate on ground water through natural and human-induced processes as well as through groundwater-driven feedbacks on the climate system. Furthermore, we examine the possible opportunities and challenges of using and sustaining groundwater resources in climate adaptation strategies, and highlight the lack of groundwater observations, which, at present, limits our understanding of the dynamic relationship between ground water and climate.

An assured supply of water has, therefore, been the prime concern of all societies. In our own time the increasing stress on capacities of water systems has led to a growing realization that it is only through a scientific approach to their management that we can hope to sustain the quality and regular availability of this basic human requirement. The need for appropriate integrated studies in developing countries is the most important in view of an increasing population, widespread aridity and scarcity of fiscal resources and vagaries of hydro-meteorological conditions.

Groundwater, surface water and land comprise a complex interlocked system and they must be considered and managed in their totality towards making the most optimal use of this precious resource. Groundwater resources are now being increasingly tapped to meet societal needs on account of their possible availability in the vicinity of the consumer. However, it is important to recognize that although groundwater has ubiquitous occurrence and vast magnitude, its potential as a perennial source is subject to wide spatio-temporal variations. With the advent of remote sensing and sophisticated data processing techniques, the speed and scale of investigations of visible resources such as land and surface water have

greatly improved. Since last many years, rapid increase in population and urban sprawling has resulted in over extraction of groundwater especially in the urban areas to meet with human demands due to which underground water table is depleting at alarming rates. Urban sprawl is to be the fastest growing threat to local environment and quality of life. As urban areas expand, environmental problems like losing green space, groundwater recharge area, and degradation of natural ecosystem and deterioration of water resources are increased. The un-planned pumpage of groundwater is also causing salt-water intrusion into fresh groundwater due to which sweet groundwater resource is becoming scare. This needs formulation of long term policy framework and comprehensive planning to guard against fast depleting ground water resources. According to the 1981 census, Lahore has population of 2.7 million which increased to 6.4 million in1998 **(Faiza & Tabsum 2009).** Now the estimated population of Lahore is more than 10 million and it is ranked in the most populated urban areas in the World **(Wikipedia).** It has been reported that more than 480 WASA tube wells are extracting about 478.67 Million gallon of groundwater per day and is supplied through 7700 km pipelines distributed in the city **(Hussain and Sultan 2013).** This situation has resulted in tremendous depletion of groundwater levels. The only source to recharge Lahore aquifer is Ravi River, the smallest eastern river of the Indus River System (IRS) which remains nearly dry except during monsoon season. However, Ravi River along Lahore is used for the discharge of untreated domestic and industrial waste water and effluent. There are over dozen disposal stations and surface water drains that discharge untreated waste water into the River. It was observed that untreated waste water is being discharged into the Ravi River **(EPD 2008, Ejaz & et al 2011)** and it is causing deterioration of groundwater quality along the river which may impact the overall quality of aquifer due to salt intrusion. According to survey it was estimated that levels of impurities in the water in drains enter into Ravi River are in excess of National Environmental Quality Standards set by the Pakistan Environment Protection Council and enforced by the Environment Protection Agency, Punjab **(EPD 2008).** As indicated in vision 2025 that in near future serious water scarcity situation may occur in Lahore city and it may suffer badly if necessary measures are not taken from today for the management of water resources and improvement of groundwater quality along Ravi River. A proper detailed investigation/research using groundwater flow and solute transport modeling approach in this regard is required to recommend the ways and means to replenish the groundwater reservoir to cater for the ever increasing stress on groundwater reservoir.

Over exploitation of groundwater possess serious consequences on our infrastructural network in addition to other socio environmental concerns. Land subsidence is the lowering of the land-surface elevation from changes that take place underground. Common causes of land subsidence from human activity are pumping water, oil, and gas from underground reservoirs; dissolution of limestone aquifers (sinkholes); collapse of underground mines; drainage of organic soils; and initial wetting of dry soils (hydro compaction). In areas where climate change results in less precipitation and reduced surface-water supplies, communities will

pump more ground water. Also, increased demands on ground-water supplies cause more land subsidence in areas already subsiding and new subsidence in areas where subsidence has not yet occurred.

In Punjab province about 40 to 50 % of crop water requirements at farm-gate and about more than 90% of drinking water demands are being met from groundwater by means of tubwells. Groundwater levels are depleting in certain locations (about 1.2 million tubewells) putting this natural gift beyond the limits of human utilization. In urban areas, this threat is very severe for example in Lahore City, the annual average rate of fall is 2.5 ft. Its quality is also deteriorating at many places due to one or the other reasons. Human activities like increasing urbanization, use of chemicals in agriculture/food production, industrialization, acidic rains due to air pollution, domestic waste, solid waste landfills, increasing cropping intensities, unplanned over pumpage etc are the major threats to groundwater which are deteriorating its quality and quantity at very alarming rates. Growth of farmers Tubewells as shown in figure 1.

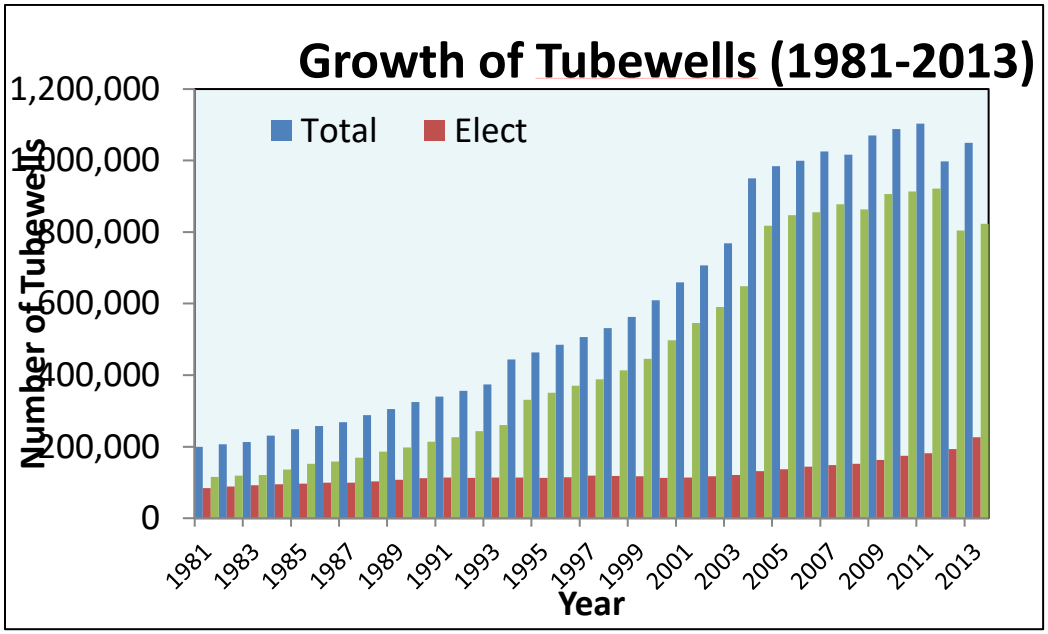


Figure 1: Growth of farmers Tubewells

2. Climate Changes in Pakistan

Pakistan is highly vulnerable to climate change as its economy is heavily reliant on climate-sensitive sectors like agriculture and forestry, and its low- lying densely populated deltas are threatened by a potential risk of flooding. Climate change leads to changes in precipitation and evapotranspiration rates, which show a direct effect on the quantity and quality of both surface and subsurface water. Increase in temperature increases the capacity of the atmosphere to hold water and thus precipitation rate may increase. However, its effect on climate is spatio-temporal,

being controlled by local or regional factors such as topography, vegetation, wind velocity etc.

Studies based on the ensemble outputs of several Global Circulation Models (GCMs) projected that the average temperature over Pakistan will increase in the range from 1.3-1.5 °C by 2020s, 2.5-2.8 °C by 2050s (**Planning Commission Govt. of Pakistan, 2010**). The summer of 2010 caused a temperature of above 50 °C in twelve cities of Pakistan.

Similarly, distribution of rainfall in Pakistan varies widely, mostly depending upon the monsoon winds and the western disturbances, but the rainfall does not occur throughout the year. Punjab and Sindh provinces receive 50- 75% of rainfall during monsoon season **(Salma, S et al., 2012)**.

Gasoline, fertilizer, paint thinner, antibiotics – if it's used or abused by humans and dissolves in water or soaks through soil, it may show up in Wisconsin's groundwater. New concerns are coming to the attention of local citizens and state government. These emerging issues include the potential for pharmaceuticals, pathogens and viruses to contaminate public or private wells.

2.1. Impact of Climate Changes on Groundwater

The impact of climate change on groundwater includes, long term decline in groundwater storage, increased frequency and severity of groundwater droughts, saline water intrusion into fresh water aquifers, secondary salinity, land subsidence etc.

The direct impact of climate change on groundwater resources depends upon the change in the volume and distribution of groundwater recharge. If drier, warmer summers lead to the seasonal deficits in the moisture content of soils extending into the autumn, the winter groundwater recharge season may be shortened. This could be compensated, at least to some extent, by an increase in winter rainfall. However, aquifers are recharged more effectively by prolonged steady rain which continues into the spring rather than short periods of intense rainfall. The impacts of climate change could increase the cost of providing water supplies already rising as a result of deteriorating groundwater quality. Groundwater, of course, cannot be considered in isolation - impacts of climate change not necessarily related to groundwater, such as changing land use and population density, will have a knock-on effect on groundwater, for example through changes in water demand. In Punjab province about 40-50% crop water requirements are being met from groundwater through about 1.2 million tubewells installed by the farmers. Groundwater quality in the Punjab province is deteriorating with the passage of time and sweet water is becoming rare and out of reach of the common farmers who are dependent on groundwater for their livelihood (Hassan et al, 2014). In Punjab province, about 1.2 million tubewells are extracting groundwater without any scientific planning. Consequently groundwater management is confronted with multitude of tiny users in Pakistan. Electricity and diesel are the major sources of energy for groundwater pumpage to boost up the food production. About 47%

farmers are running their tubewells with tractors or diesel engines. The Indus Basin Irrigation System (IBIS) is the largest integrated irrigation system in the World. Historically IBIS has been fed through run of river supplies derived from River Indus and its five major tributaries. For supplying water to Pakistan's irrigation network, the Indus Basin Project (IBP) was designed and constructed to replace the waters of Eastern Rivers. Any reduction in these waters will put Pakistan's agriculture, food security and economy at great risk. Tremendous increase in population demands for more food and fibre for which we need the extra water, similarly climatic changes have made the availability and reliability of surface water a question mark. Resultantly pressure on groundwater is increasing and water levels are dropping abruptly taking this resource beyond the bound of rural poor farmers. Energy costs of pumping deeper groundwater are increasing manifolds. In many areas the unplanned and over pumping has caused intrusion of saline water into fresh groundwater. This has led to a very complex situation and the problem needs to be tackled in food security-groundwater-energy-climate change nexus.

Hassan et al, (2013) during a study found that pollution in surface water bodies is affecting the groundwater quality in the underlying aquifer in Lahore city. They recommended to allow/arrange minimum flow in the River at least to meet the requirements of dilution of pollutants and to treat the wastewater before throwing it into the river. Domestic and industrial effluents contain organic and inorganic pollutants, which deeply percolate to groundwater. Flow in Ravi River especially during the winter is remarkably insufficient to dilute and wash off wastewater pollution **(Hassan et al, 2016).**

2.2. Groundwater Resources and Climate Change

According to USGS, 96.5 % of Earth's water is oceans and 2.5% freshwater and other 0.9 % saline. Only a little more than 1.2% of all freshwater is surface water which serves most of life's needs. About 70% of fresh water is locked up in ice and another 20.9% is found in lakes. Rivers make up 0.49% of surface freshwater. Although rivers account for only a small amount of freshwater, this is where humans get a large portion of their water from. About 60% of groundwater withdrawn worldwide is used for agriculture; the rest is almost equally divided between the domestic and industrial. In many nations, more than half of the groundwater withdrawn is for domestic water supplies and globally it provides 25% to 40% of the World's drinking water **(Vrba, J., and J. van der Gun. 2004)**.

Developing countries – despite their larger populations have much less contribution in anthropogenic emissions. Developing countries, especially Least Developed Countries (LDCs) and Small Island Developing States (SIDS), who are already facing difficulties in alleviating poverty as a result of their economic situation, are particularly vulnerable to the adverse effects of climate change. These countries have insufficient social, technological and financial resources to adapt the situation **(UNFCCC, 2007)**. The effects of global warming and climatic change require multi-disciplinary research, especially when considering hydrology

and global water resources.The Intergovernmental Panel on Climate Change (IPCC) estimated that temperature of the Earth is continuously rising and it has increased 0.6 ± 0.2 2^{o}C since 1861 and predicted an increase of 2 to 4^{o}C over the next 100 years. Global sea levels have risen between 10 and 25 cm since the late 19th century **(IPCC 2007).** Pakistan, as a part of South Asia has also observed warming in spite of less discharge of greenhouse gasses as compared to industrialized developed countries **(Pant and Kummar, 1997**).

Climate change has local, regional and globally impacts, some examples of major projected impacts are increased water related stresses such as droughts, sea level rise, decreased freshwater availability, increased floods, decreased agricultural productivity, food production and security etc **(IPCC 2007)**. Climate change actually accounts for about 20% of the global increase in water scarcity. Climate variability and change can affect the quantity and quality of various components in the global hydrologic cycle. It includes atmospheric water vapour content, precipitation and evapotranspiration patterns, snow cover and melting of ice and glaciers, soil temperature and moisture, and surface runoff and stream flow with increasing temperatures **(Bates et al, 2008**). However, the extra precipitation will be unequally distributed around the globe. Some parts of the World may see significant reductions in precipitation or major alterations in the timing of wet and dry seasons. Information on the local or regional impacts of climate change on hydrological processes and water resources is becoming more important.

Water resources, both in terms of quantity and quality, are critically influenced by human activity, including intensive agriculture and use of agro-chemicals, land-use pattern, construction and management of reservoirs, industrial development, pollutant emissions, water and wastewater treatment. Water use is linked between changes in population and food consumption**.**

Global water use is probably increasing due to population and economic development but also changing societal views on the value of water. Predictions include higher incidences of severe weather events, a higher likelihood of flooding, and more droughts. The impact would be particularly severe in the tropical areas, which mainly consist of developing countries, including Pakistan.

Pakistan is the 4th country out of 15 nations with the largest estimated annual groundwater extractions **(J. van der Gun. 2013)**. According to United Nations World Water Development Report, 2.5 billion people worldwide depend solely on aquifers, which include 273 transboundary aquifer systems, as their primary water resource to meet their daily needs. Groundwater contributes flow to rivers, lakes and wetlands. Water reserves of the 21 out of 37 largest aquifer of the world have been declined.

The most noticeable impacts of climate change could be fluctuations in surface water levels and quality. The greatest concern for water managers and Government is the potential decrease in level and quality of groundwater supplies. The rise in groundwater use associated with predicted population growth would pose a higher threat to the aquifer than climate change **(Loaiciga 2003**). The

unscientific abstraction of groundwater resources has extent of the interface and seawater intrusion into the aquifer **(Sherif and Singh, 1999; Ghosh Bobba, 2002**). Irrigation generates about 40% of total agricultural output **(Fischer et al., 2006**). Groundwater levels have been measured using water level indicator from the piezometers biannually (pre-monsoon and post-monsoon). The observed data have been analyzed to visualize the aquifer behavior in the Punjab province. **(IRI, 2009) and (IRI, 2013)** conducted a field survey and investigation study by installation of sixty exploratory boreholes at various critical sites in Punjab to explorer the groundwater quality and soil stratification to observe the impact of surface drains and other potential threats for groundwater. Wherein it was observed that surface water bodies especially drains are playing a vital role in contamination of groundwater. A study was conducted for groundwater investigation in Faisalabad area using Groundwater Model (MODFLOW) where tile drainage and surface drainage networks are functional and groundwater is brackish for which one of the causes is heavy industrial pollution in the area **(IRI, 2012).** Total recharge of aquifer during flood season 2014 in Chaj Doab has been estimated as 1.20 MAF (million acre-feet). Recharge potential in Chaj doab during October 2010 and June 2012 were found out as 4.32 and 4.675 MAF respectively **(IRI, 2016).**

3. Water and Food Security

3.1. Groundwater Scenario in Pakistan

Pakistan is the 4th largest user of groundwater after India, USA and China wher groundwater is also used for domestic and industrial purposes. Irrigation System in Indus Basin (IBIS) was designed during the 19th century to meet the designed cropping intensity of 60- 70%. Presently, the cropping intensity in the IBIS is around 160% to meet the food requirement of increased population. Due to insufficient supply of surface water, groundwater has been used more than 40% for agriculture in Pakistan. There were about 0.55 Million tubewells in the country in 2000 which have reached about 1 million tubewells in Punjab. High extraction of the groundwater by tubewells has resulted negative effects including a decrease of groundwater levels which is positive in areas where fields are waterlogged or salinized due to capillary rise from shallow groundwater **(IWASRI 1991).**

Climate changes show both negative and positive impact on the use of groundwater for agriculture and domestic purposes. In the areas, where low rainfall and drought periods exist, the intensity of groundwater extraction has enhanced resulting declining of water levels. In the areas where high rainfall exists and flooding occur, less extraction of groundwater and more recharge of aquifer takes place. Low Land and Water Productivity as shown in figure 2.

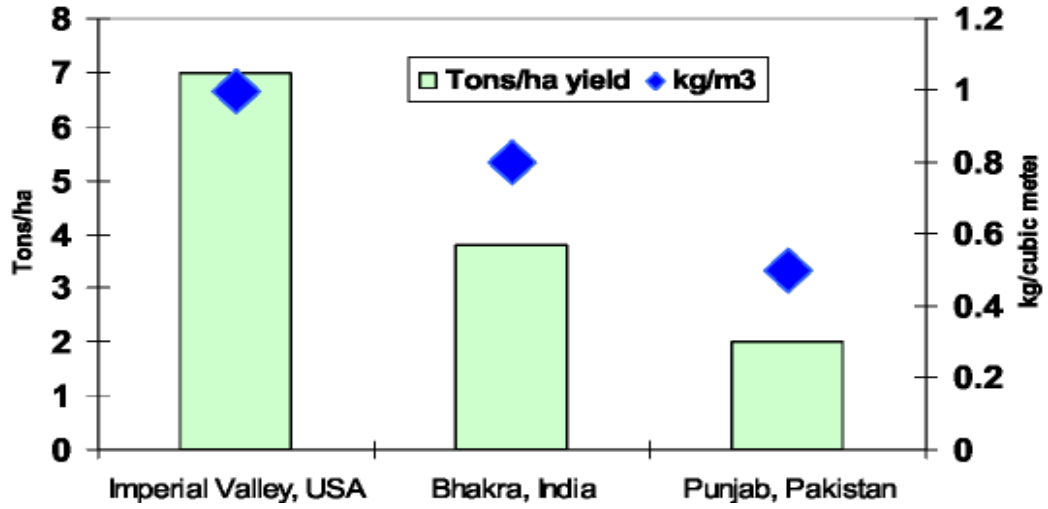


Figure 2: Low Land and Water Productivity

Excessive use of groundwater is critical for food production and environmental sustainability. Research study carried out in Lower Bari Doab Canal (LBDC) has indicated that by increase of depth to water table from 40 ft to 70ft the cost of pumping per acre-feet has increased 125%. Our food basket, the Punjab province is under severe threat due to excessive energy requirements for pumping the groundwater from deeper and deeper aquifers. Due to lowering of water table deeper and deeper, pumping cost has also increased in the critical areas of Punjab as shown in Figure 3.

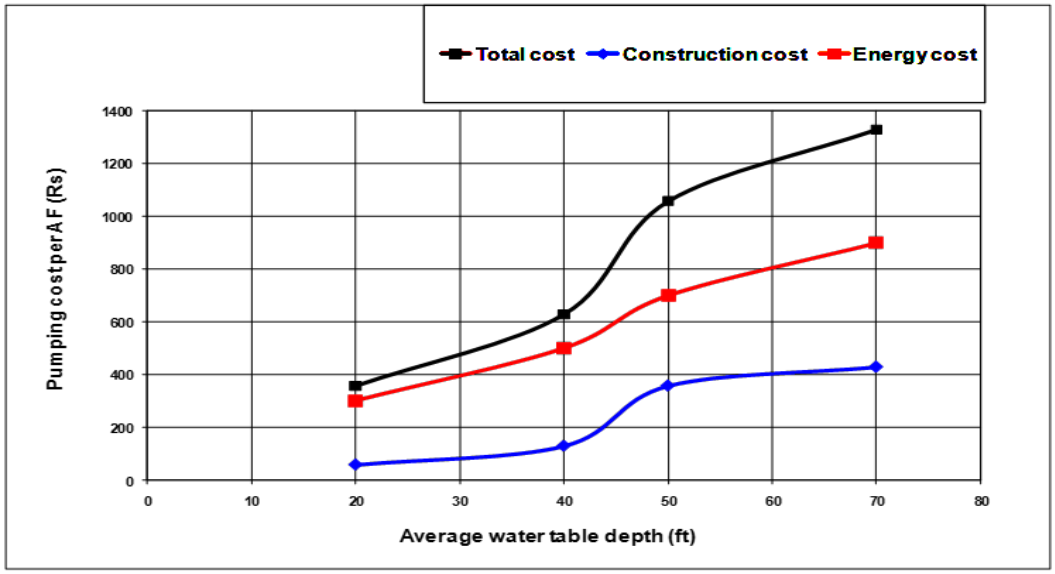


Figure 3: Increase in Cost of Ground Water Pumping with Decline in Water Table

About 40 to 50 % agriculture water requirement is met from groundwater and almost 100% of the water supply in urban areas is dependent on groundwater. Due to unplanned discharge of groundwater; the levels are continuously falling down. For example in Lahore city (provincial capital) the groundwater levels are falling at an alarming rate of 2.5 ft/year (2009-13).

Groundwater levels in the rural irrigated areas districts like Vehari, Multan, Khanewal, Chiniot etc. are declining continuously due to high pumpage by farmers and public tubewells. It has been predicted that an average drop in groundwater level by 1 m would increase carbon emissions by over 1%, because for the withdrawal of the same amount of water by diesel operating tubewells, there will be increased fuel consumption **(IRI, 2015)**. Continuous depletion of groundwater has been shown in Figurers 8 and 9 for an area in Southern Punjab. Average rise in water-table in Rechna doab during flood 2014 has been observed is 2.57 ft/season. Total recharge of aquifer during flood season 2014 in Rechna Doab is 1.90 MAF **(IRI, 2015).**

GW contribution NOW can be more than 50% in irrigation sector. The groundwater annual abstraction increased from about 4 MAF in 1959 to about 50 MAF in 2000. Growing Role of Groundwater in Irrigation Sector in Pakistan as shown in figure 4.

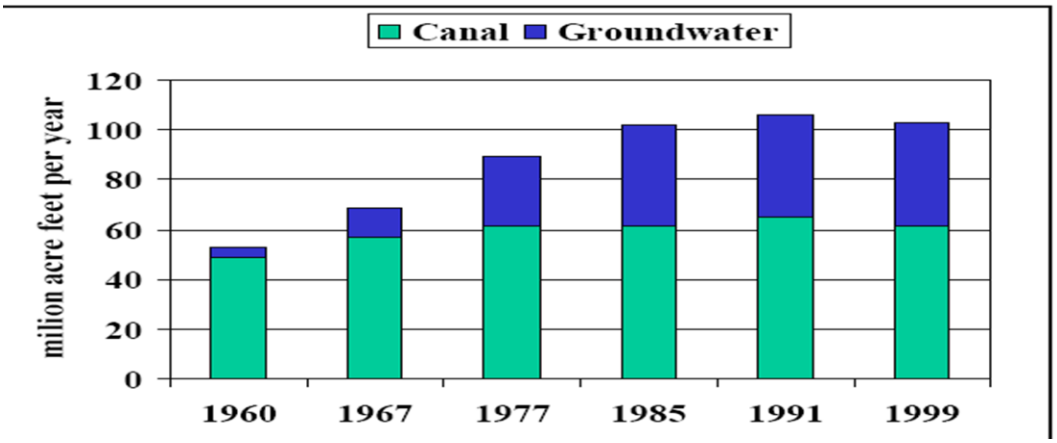


Figure 4: Growing Role of Groundwater in Irrigation Sector in Pakistan

3.2. Air pollution is water pollution

Particles clouding the air from car exhaust, smokestacks and dust from city streets or farm fields can contribute to groundwater contamination. These particles of hydrocarbons, pesticides and heavy metals settle on the ground, are washed into the soil by rain, and eventually trickle into aquifers. Although a rain shower may disperse the particles from the air, the rains can carry the pollutants down into the ground as the water hits land.

3.3. Fertilizer and manure storage and application

Protecting water quality and farm profits is a balancing act that the University of Wisconsin (UW)-Extension's Nutrient and Pest Management Program is trying to

perfect. To produce good yields, farmers need to apply nitrogen, phosphorus and other **nutrients** to their crops. If farmers don't account for the nutrients contained in the manure they spread on their fields, crops may be over-fertilized. Excess nitrate plants can't use will leach into the groundwater and excess phosphorus will runoff into lakes, streams and wetlands. Proper measuring of nitrogen and phosphorus in manure saves farmers the cost of purchasing extra commercial fertilizer – and also protects groundwater. Farmers also must be careful about where and when they spread manure. Spring snowmelt or excessive rainfall can lead to fish kills and contamination of drinking water wells due to bacteria in manure that has run off from farm fields. As subdivisions replace farm fields in rural areas, lawn replace crops. Over-use of commercial lawn fertilizer is an additional source of nitrate to groundwater. Fertilizer consumption in Punjab as shown in figure 5.

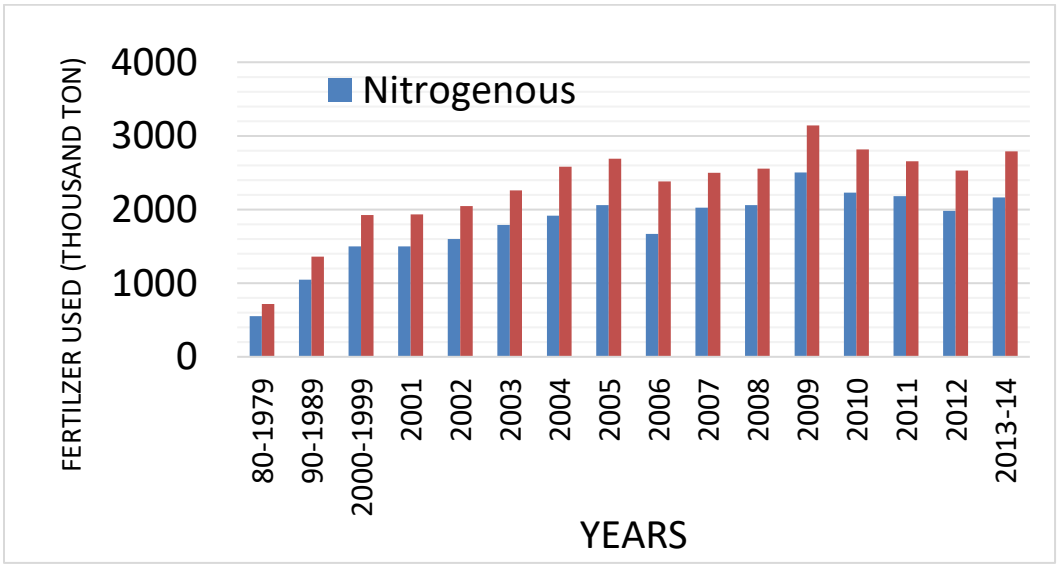


Figure 5: Fertilizer consumption in Punjab

3.4. Use and misuse of pesticides

All types of pesticides, (insecticides, herbicides and fungicides) have been used in Wisconsin agriculture for a long time. These pesticides can reach groundwater when spilled at storage, mixing and loading sites, or when over-applied to fields. "Empty" pesticide containers not properly disposed of are another source of trouble. Just a little spill of most pesticides can have a big impact on groundwater quality. For example, three parts per billion of atrazine (an herbicide used widely for riding corn crops of weeds) in groundwater is enough to increase the risk of cancer for those who drink the water. Area Treated with Pesticides as shown in figure 6.

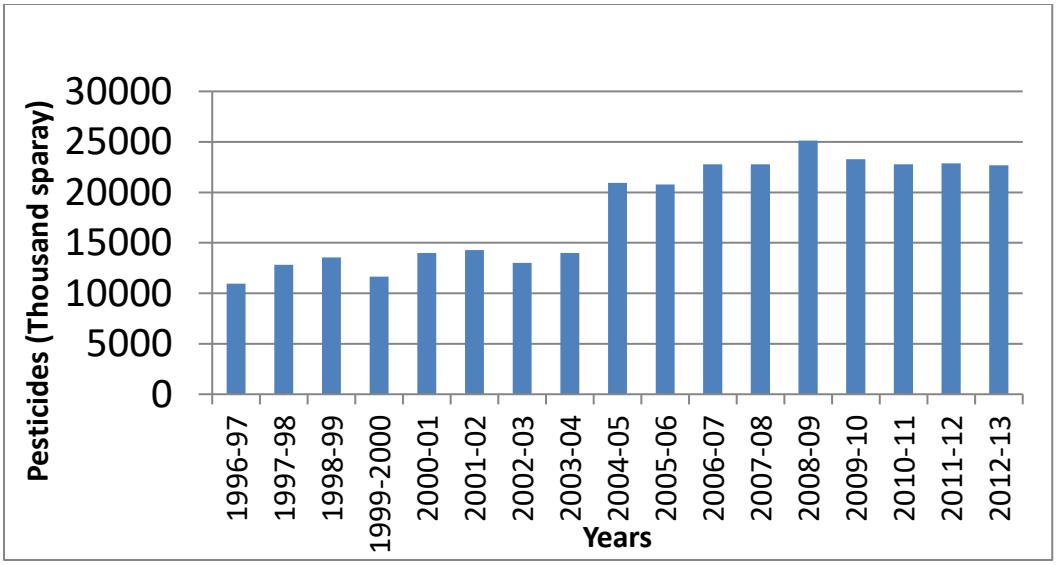


Figure 6: Area Treated with Pesticides

Protecting groundwater from pesticide contamination while maintaining farm profitability isn't easy – too much pesticide and the environment suffers; too little and crop yield goes down. Integrated pest management (IPM), is a pest control strategy that uses all appropriate control methods (chemical and nonchemical) to keep pest populations below economically damaging levels while minimizing harm to the environment. Here's how it works: farmers "scout" their fields for weeds and pests. After identifying what is present, the farmer purchases and applies the minimum amount of herbicides and insecticides only in the areas where weeds and bugs are a problem. Farmers using IPM find they spend less on pesticides. It's a bargain for the environment, too.

3.5. Wastewater

Wastewater, generated by municipalities, industries and farms may be treated or stored in ponds or lagoons. Many small communities operate lagoon systems for treating sanitary sewage through bacterial degradation of organic material in the wastewater. A manure lagoon on a dairy farm can hold waste until conditions are right for field application.

Lagoons are sealed with compacted clay or plastic liners. Nevertheless, burrowing animals or soil movement can cause leaks. Routine inspections and maintenance are necessary to keep lagoons operating properly and to prevent contamination of groundwater. Some industries dispose of their wastewater by applying it to farm fields or to land specifically operated as a disposal system. Most municipalities and some industries also apply **sludge** produced in their treatment systems to cropland as a nutrient and soil conditioner. The waste is applied according to how much water, solids and nutrients soil and crops can absorb. If the system isn't managed properly, and too much waste and water are applied to the land, or if the operator fails to adjust the amount applied to account for rainfall, groundwater and wells can

be contaminated or the material may run off to surface waters. In the Rechna Doab, analysis of 2500 shallow water samples (6 to 18 cm below ground surface) shows that about 50% of the total samples contain salinity of 750 ppm, about 40% up to 1500 ppm and the rest goes up to 3000 ppm. In general, a vertical gradient exists within the GW aquifer that must be taken into account in GW studies, the water depth occurred at a depth of more than 10 meters, and in the center of the Doab at more than 30 meters **(Qureshi, et al. 2002).**

The effective conjunctive water use may help the farmers to increase the cultivated area under crops in the Rechna Doab. It is recommended that the technical conjunctive water use strategies must be identified and implemented on the farmers' fields in order to help them in increasing their income whilst promoting sustainable conjunctive use and management of surface and groundwater. Careful monitoring of institutional reforms is required to assess the adequacy of reform, the impacts of new arrangements on water resource infrastructure, productivity and the environment **(Jehangir et al. 2002).**

3.6. Storm water

When development occurs, recharge to groundwater can be short-circuited. Rainfall, instead of infiltrating, runs off pavement and collects in lakes rivers and streams. Stream levels become more variable or "flashy," floods and channel erosion are more common, and groundwater recharge decreases. Because storm water from roofs, driveways, parking lots and streets contains contaminants such as gasoline, metals, and bacteria it must be cleaned up or pretreated before it is put back in the ground using engineered storm water infiltration devices.

3.7. Sources of natural contamination

Minerals found naturally in soils and rocks dissolve in groundwater, giving it a particular taste, odor or color. Some elements, such as calcium and magnesium, are beneficial to health. Radium, radon gas, uranium, arsenic, barium, fluoride, lead, zinc, iron, manganese and sulfur are undesirable ingredients found in Wisconsin groundwater. The levels of the contaminants depend on their concentrations in the aquifer and the amount of time the water has been in contact with them. Radioactive contaminants expose those drinking the water to risk of cancer. Public water systems are required to test groundwater for radioactivity. Most natural contaminants aren't harmful, the problem is aesthetic rather than safety. Iron and manganese are found throughout the state. They stain plumbing and laundry, and can give drinking water an unpleasant taste and odor.

3.8. Future effects

Some of the long-term effects of global climate change in the United States are as follows, according to the Third National Climate Assessment Report:



Due to climate changes, Punjab Province has experienced flood events during the past several decades. Flood 2014 resulted in significant infrastructural damages, population displacement and loss of lives in the province of Punjab. However, floods and local rainfall have significant positive impacts on shallow groundwater. Depth to ground water table during flood 2014 has reduced. Groundwater levels at selected points have been observed pre and post flood 2014, to see the impact of flood water on groundwater level fluctuations. Flood water contributes significantly towards recharging the aquifer average. Average rise in water-table in Rechna doab during flood 2014 has been observed is 2.57 ft/season. Total recharge of aquifer during flood season 2014 in Rechna Doab is 1.90 MAF (**IRI, 2015).** Average water level raised in Rechna Doab in some areas is shown in Figure 7.

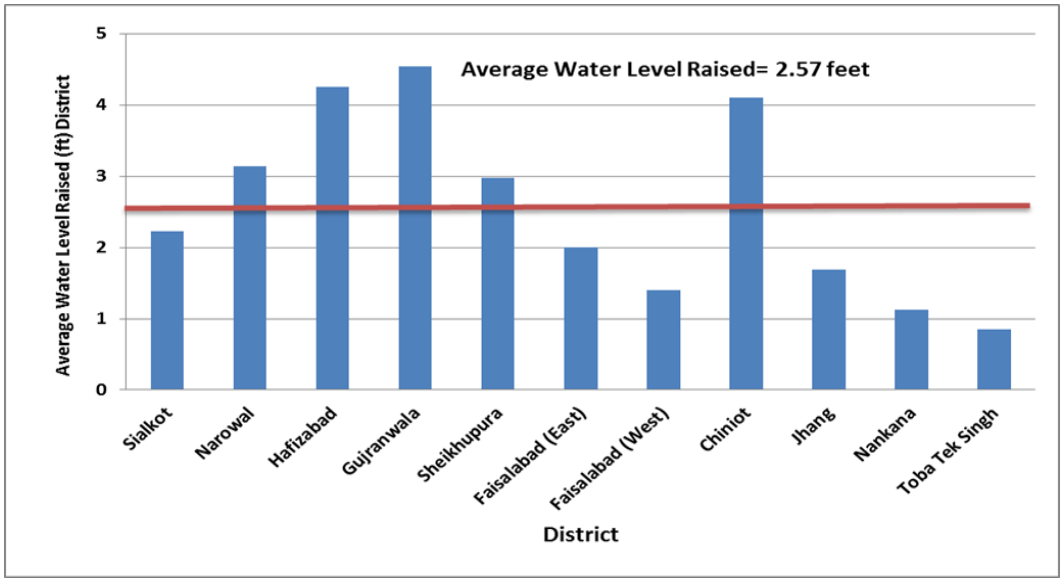


Figure 7: Average water level raise in various areas in Rechna doab during flood 2014

3.9. Droughts and Heat Waves

Droughts in the Southwest and heat waves (periods of abnormally hot weather lasting days to weeks) everywhere are projected to become more intense, and cold waves less intense everywhere.

Summer temperatures are projected to continue rising, and a reduction of soil moisture, which exacerbates heat waves, is projected for much of the western and central U.S. in summer. By the end of this century, what have been once-in-20-year extreme heat days (one-day events) are projected to occur every two or three years over most of the nation.



About 40 to 50 % agriculture water requirement is met from groundwater and almost 100% of the water supply in urban areas is dependent on groundwater.

Due to unplanned discharge of groundwater; the levels are continuously falling down. For example in Lahore city (provincial capital) the groundwater levels are falling at an alarming rate of 2.5 ft/year as depicted in Figure 8 (2009-13).

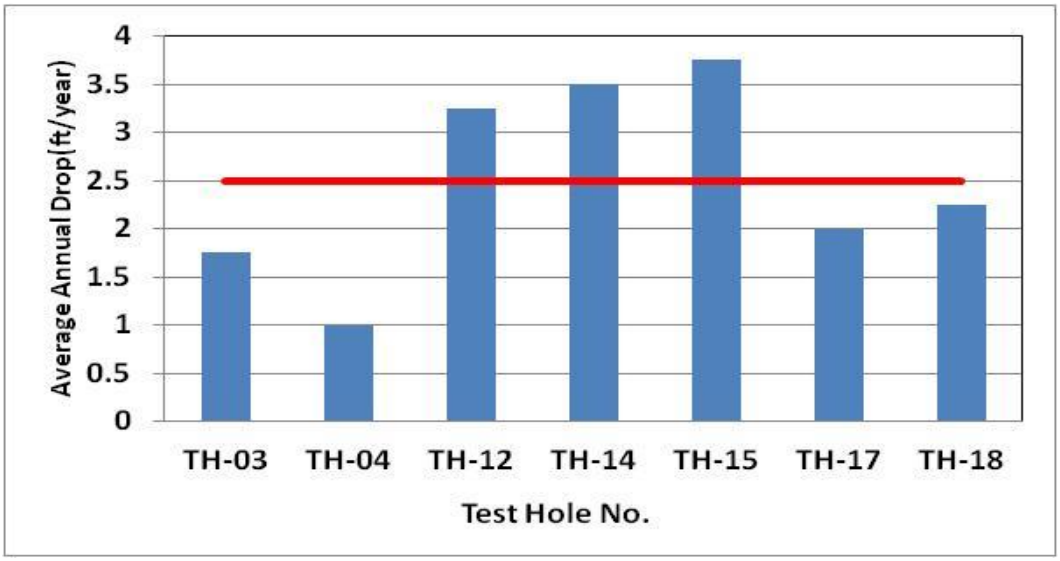


Figure 8: Groundwater depletion in Urban Areas (Lahore city)

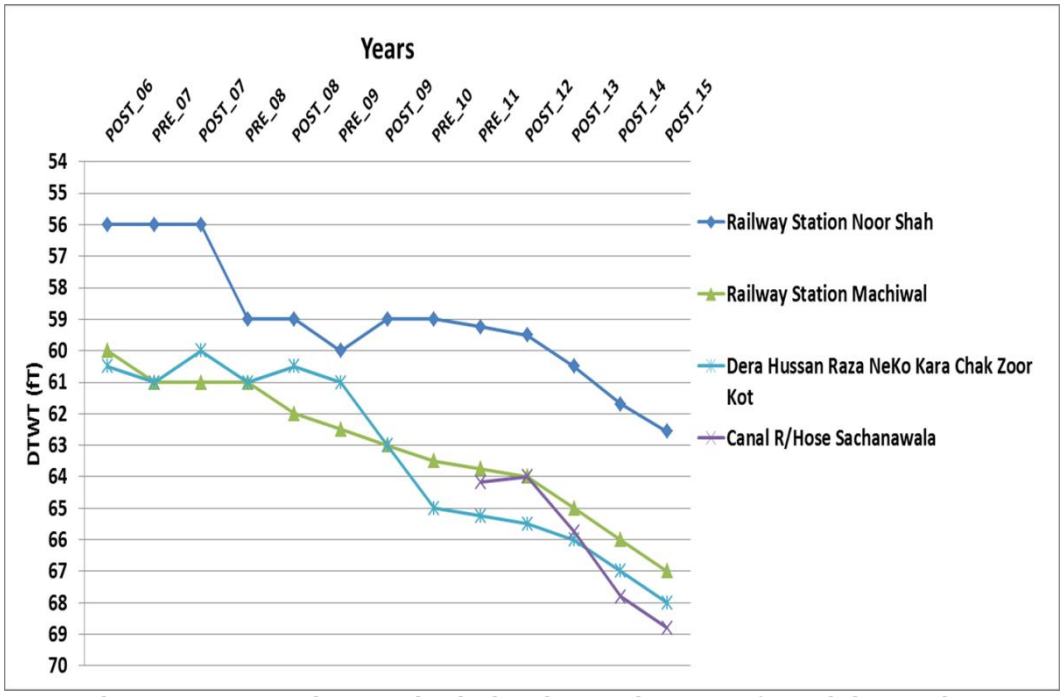


Figure 9: Groundwater depletion in rural areas of Punjab provice

Groundwater levels in the rural irrigated areas districts like Vehari, Multan, Khanewal, Chiniot etc. are declining continuously due to high pumpage by farmers

and public tubewells. It has been predicted that an average drop in groundwater level by 1 m would increase carbon emissions by over 1%, because for the withdrawal of the same amount of water by diesel operating tubewells, there will be increased fuel consumption (IRI, 2015). Continuous depletion of groundwater has been shown in Figurers 8 and 9 for an area in Southern Punjab.

4. Conclusions

From the analysis of data collected it has been observed that unplanned excessive pumpage, lack of awareness and capacity of stakeholders, lack of regulatory framework and spatial/temporal uncertainty in surface water due to climatic changes (droughts and floods) are the major challenges for groundwater management in Punjab. In Chaj Doab the watertable are showing rising trends with an average rate of 0.9 ft/year and quality is deteriorating with the passage of time. In the Rechna Doab area it is been observed the average depleting rate is 1-2ft/year and over exploitation in certain areas is causing intermixing of fresh and saline water leading to overall groundwater quality. Groundwater in Bari doab is under the worst conditions where water table has gone below 50-60 ft in certain areas and cost of pumpage has increased more than 100 times. In urban areas due to increase in population and reduction in recharge to infrastructural development groundwater in under tremendous pressure. For example in Lahore city (provincial capital) groundwater has fallen even more than 100 ft below the natural surface and average annual rate of groundwater depletion is 2.54 ft. Direct energy intensity has risen 80% (from 1 to 1.8 MJ per kg of crop produced) in Punjab between 1995-2010. Use of groundwater in irrigated agriculture consumes 30 times more energy as compared to surface water. It has been observed that flood water plays a significant role in recharging the aquifer. For example during flood 2014, 2.57 ft rise in water table has been observed in Rechna doab.

- Groundwater-Energy and Food Security are linked together and impose serious impacts on each other
- Sharp increases in the energy price lead to sharp declines in food production, or rapid increases in world food prices.
- The sharp increase in energy price are unlikely to help stop or reverse the ongoing degradation of groundwater ecosystems
- Threat of salinity and waterlogging owing to miss-management of groundwater will lead to reduction in food production and will consume more energy for reclamation.
- Demand for water, food and energy is expected to rise by 30-50% in the next two decades
- About 47% farmers are running their tubewells with tractors or diesel engines

- Use of groundwater in irrigated agriculture consumes 30 times more energy as compared to surface water
- Energy costs increase as the GW levels fall down

5. Recommendations

- Treatment of industrial and municipal effluents before throwing into the River-
- Before drainage we should think about groundwater
- Production of all pollutants should be reduced or minimized at source through scientific research and tools.
- To maintain minimum flow in Ravi River for dilution of pollutants
- Drainage effluents should be minimized at source
- Solid waste management use of geo-synthetic materials
- Farmers must be educated to use less toxic and in limited/required quantity fertilizers, pesticides, weedicides etc.
- Formulation of long term policy framework/ legal framework and comprehensive master planning
- Rainfall should be kept separate from Industrial and domestic effluents and be harvested to recharge the aquifer
- Training, capacity building and awareness raising among the stakeholders

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CHALLENGES FOR ENVIRONMENTAL SUSTAINABILITY AND FOOD SECURITY IN PAKISTAN

By

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ABSTRACT

Pakistan is one of the top ten countries most vulnerable to climate change and has large agriculture based economy that is climate sensitive. Soil sustainability is a great importance to feed a growing world population, particularly in developing countries including Pakistan. However, the productive land is shrinking due to rapid industrial development and urbanization. Any deterioration in environmental quality and services leads to soil degradation, which may be triggered by climate change and other environmental factors. Soil is very important for sustainable development and to ensure food security to provide sufficient food and fiber in the long term. Pakistan is predominantly an arid to semi-arid country where annual precipitation is less than 300 mm, resulting in soil degradation. More than 90% of Pakistan's soils are low in organic carbon (<1%) and harsh climatic conditions in Pakistan also prevent the production and maintenance of high levels of organic matter in the soil. Similarly, water scarcity is a major problem, threatening agricultural yields in Pakistan. In addition, rapid population growth and increased industrial pollution are causing serious environmental concerns and deterioration in soil quality and crop productivity. Ecological and biological services provided by soils are an integral part of carbon and water cycles. Therefore, effective and careful soil management is necessary to maintain long-term sustainability, especially in the context of climate change, which ultimately will ensure food security. In this talk, various factors affecting environmental sustainability in context with the climate change will be discussed critically and remedial measures will be suggested for sustainable soil management to ensure food security in Pakistan.

Key words: Environmental degradation, food security, climate change, sustainable production

INTRODUCTION

Food security is an issue of concern, both in national and international context. Major concerns of food insecurity came into limelight in 2007–2008 when stockpiles of cereals observed at their lowest level in 30 years and prices of rice and wheat along with other staple cereals rose dramatically and unrest in more than 20 countries. After a decrease in prices of staples; by January 2011, the prices rose again and they were higher than in 2007–2008 (FAO, 2011). The objectives of food security could be achieved when the whole nation has an easy access to

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safe and nutritious food that fulfills their nutritional needs for vigorous and fit life (The World Food Summit, 1996). Food security has different extents including production, distribution and accessibility of food. On considering various dimensions of food production, temperature and rainfall have considerable impacts on food production (Mahmood et al., 2012; Janjua et al., 2010).

Climate change is deliberated as the most influencing key factor of food security. Climate change is expected to have serious impacts on food production, food transportation, food safety and food prices (UN, 2011). Climate change induces new configurations of crops cultivation, human and animal diseases, and causes new risks for food security, safety and human health. Consequences of climate change may be positive or negative, resulting from the complex interactions of temperature and precipitation (Beddow et al., 2012). Direct influence of climate change on agricultural production and the food system as a whole is in turn expected to transform into relative increase in occurrence of starvation. Thus, climate change has a secondary influence on nutrition uncertainty and a more direct impact on food availability and access (Crahay, 2010).

Food security has stayed the primary objective of the Government of Pakistan. Therefore, the policy makers dedicate more time to scheme sound food policy that ensures food security. Food security is impacted by various factors such as agronomic, institutional and political factors, along with climatic factors. Pakistan has an agro-based economy. At present, agriculture of Pakistan is confronting very grave difficulties like scarcity of water for irrigation and less rainfall due to climate change (Provincial Health Service Authority, 2010). Major crops in Pakistan such as rice, vegetables, spices, cereals and other grains are climatic sensitive. Changing patterns of rainfall and temperature cause problems like water shortage, it leads towards the signs of food security due to low productivity especially in cropped food sector. Social and economic development is greatly hindered by food insecurity and it is the need of time to take this issue seriously in the context of climate change. The negative impacts on agricultural productivity can be reduced by adapting to climate change (Di Falco & Chavas, 2009).

Economic Context

Economic accessibility is the chief restrictive feature of food security. In Pakistan, 74% population is living under $2 a day with nearly one-quarter of the total population is categorized as poor. Human Development Index of Pakistan is 0.539 and GDP (per capita) of $982, which is 125th in world (World Resource Institute 2007). World's 17 countries are facing shortage of water and 36 countries have serious threat of food crises and unfortunately Pakistan is one of these countries (WHO, 2009).

The situation of Pakistan regarding to food security should be understood in its odd situations. The whole world is facing the three "F" (food, fiscal, fuel) crisis, while Pakistan is facing (and still continue to face) the six "F" crises—food, fuel, fiscal, functional democracy, frontier (meaning the war on terrorism, which spills across the frontier dividing Pakistan and Afghanistan and in the Khyber

Pakhtunkhwa and Balochistan), and delicacy of climate. There is a multiplier effect exists between these six "Fs" and a solution to any single crisis seems difficult to find without addressing the other crises. The livelihoods and food security of the society's poor sector is seriously threatened by the growing effects of the six "F". Here it is relevant to mention here that the livelihoods are still majorly dependent on the agriculture and absorbs 44.7 percent of the country's total labor force (FAO, 2009).

Agriculture

About 21.8% of the country's GDP is comprised of agriculture and is the mainstay of the rural livelihood. Against all odds, Pakistan's agricultural norms were revived in 2008-09. An increasing agricultural growth rate (4.7%) was recorded against expected growth rate (3.5%) and it was exceptionally good against the growth rate recorded in 2007-09 (1.1%). Growth in 2008-09 mainly stemmed from the subsector of major crops. Major crops exhibit a crucial role by having 7.7 percent growth rate against negative 6.4 percent during 2007-08 (SPDI, 2009). Livestock is the major contributor to agriculture value added with almost 48% and with 33.4% major crops have the second largest contribution to value addition. However, agricultural growth did not ensure the socio-economic food accessibility and prices of essential food commodities (which are mainly consumed by poor households) such as wheat flour, rice and edible oils increasing continuously. Although the key rate establishment system and trade strategies in the region implies important policy concerns as crop production is greatly influenced by climate change. (Iqbal et al., 2005).

Social Context

Some social factors like population, migration and urbanization may have effects on food security. More than half about 60% of the country's total population is facing this serious issue of food insecurity. The main reason behind this serious issue is limited economic access to sufficient and diverse diet by the common people. An average Pakistani spends half of its monthly income about 50.8 percent on food and shocks, such as high food prices, flooding, and significant population displacement. According to recent national nutrition survey, Pakistan has the second highest rate with 15 percent of children under the age of 5 suffer from acute malnutrition. About 44 percent children under the age of 5 are suffering from stunted growth, 32 percent are underweight and many children even not fulfill their necessary requirement like vitamins and minerals. Due to different cultural and social issues, women and girls have limited access to humanitarian assistance and services (WFP, 2012).

Climate Change Trends

By assessing the results of indices used to measure the vulnerability to climate change, it is observed that Pakistan is amongst the most vulnerable countries to climate change. According to Maplecroft's (2011) index of vulnerability to climate change Pakistan has been given 16th rank in 170 countries of the world.

Global Climate Risk Index (GCRI) Germanwatch 2012 Global Climate Risk Index (GCRI) ranked Pakistan 8th among 180 counties of the world. However, Pakistan has ranked 135th amongst countries contributing to the global greenhouse gas (GHG) emission as Pakistan contributes very less to it. It has observed 0.64 to 1.0°C rise in temperature (since early 1900s) while faced decrease in precipitation by 10 to 15% since last 40 years (IPCC, 2007). It is expected that in coming 50 years Western Himalayan glaciers retreat and a decrease of flows by up to 30 to 40% will be observed (GCISC, 2009a).

Monsoon patterns will also be influences by Climate Change. Himalayan-Karakoram Glaciers will be retreated more rapidly and it will result in serious threat for the Indus River System flows. There is more probability of glaciers melting by 2030 and capability of natural reservoirs is reducing as snowline rises. As a result of reduction in agricultural production, food insecurity is a major threat in arid and semi-arid regions along with water shortage in these areas. (GCISC, 2009b).

Climate Change Impacts in Relation to Agriculture and Food Security

Although Pakistan's Gross Domestic Product (GDP) is facing a decline from last few years, the income of 45% of the total population of country depends on agriculture (FAO, 2012). In particular, wheat production of 24 million tons in 2010 plays a role of backbone in country's food security. Pakistan is facing a severe decrease in food security from last few years other than the production of primary crops of the country. The food insecure population rose from 38 percent of the total population to 50 percent (83 million people) between 2003 and 2009; it has estimated that this will further reach to 90 million people after the flood disaster in 2010 (WFP, 2012). The financial condition of the country is also greatly affected by militant activities as it contributes to increasing unemployment and a rapid increase in inflation level of the country (16% by 2010) (WFP, 2012).

Different programs that work for the food security of Pakistan primarily emphasize on the wheat production as wheat is the principal food crop of the country. For sustainable food security per capita accessibility of this principal food crop in Pakistan is an important objective (FAO, 2012, GOP, 2011). There is a decrease in number of days in growing season length as a result of temperature rise as shown in Tab-1 (GCISC, 2009c).

Table-1: Impact of rise in temperature on wheat growing season length in Northern and Southern Pakistan

Temperature (C increase over baseline)	Growing Season Length (Days)			
	Northern Pakistan		Southern Pakistan	
	Mountainous Region (Humid)	Sub-mountainous Region (Sub-humid)	Plains (Semi-arid)	Plains (Arid)
Baseline	248	161	148	137
1	232	155	140	132
2	221	149	135	127
3	211	144	130	123
4	202	138	125	118
5	194	133	121	113

According to Global Change Impact Studies Center (GCISC, 2009c), wheat production is going to decrease by 5.7% in scenario A2 and by 6.4% in scenario B2 by 2080. We may only experience increase in production of wheat in northern mountainous regions where the yield is predicted to increase from 2500 kg/ha to 3500 kg/ha with increase in temperature maximum by 3 C. Fig-1 shows the change in yield of wheat by 2080 in both A2 and B2 scenarios. Whereas, wheat production experiences economic losses due to climate change and other associated factors are given in Tab-2.

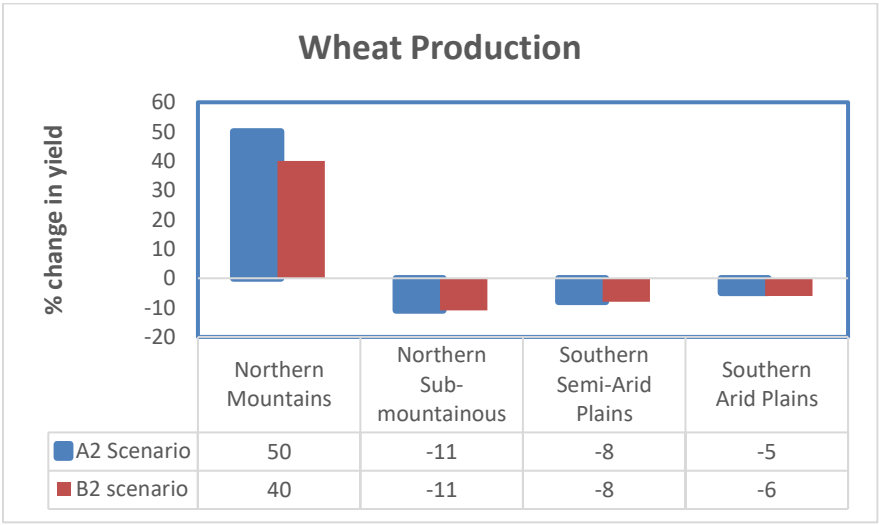


Fig-1: Impact of climate change on Wheat Production by 2080 under A2 and B2 scenarios

Table-2: Expected wheat production economic losses due to climate change and other associated factors by 2080

Regions	Production Distribution	% Share in National Production	Change in yield (%)	Quantity Loss (000 t)	Economic Loss (Rs. Mill.)
Northern Mountains	465.9	2	+4	186.4	4.43
Northern Sub-mountainous	2096.5	9	-11	-230.6	-5.48
Southern Semi-Arid Plains	9783.8	42	-8	-782.7	-18.59
Southern Arid Plains	10948.5	47	-6	-656.9	-15.60
Total	**23294.7**			**-1483.9**	**-36.24**

CONCLUSIONS

Temperature rise in Pakistan is estimated to be more as compared to the estimated rise in global average temperature. Projected temperature rise in northern areas of Pakistan is likely to be more than in the southern areas of Pakistan whereas, expected rise in temperature in winter season is higher than that observed in summer season. However, because of unpredictability of models, it is difficult to study different trends of precipitation in a proper way. In Pakistan, a decrease in wheat and rice production is observed other than the Northern mountainous regions. For ensuring food supply to a common man, certain development areas should be preferred like facing minimum salary by common workman, benefits for unemployed personnel of the community, “food-for-work” programs, health care facilities along with agricultural production should be ensured. In this situation of the country’s agriculture funds should be provided for sustainable agriculture and local farmers. To ensure the food security by combating the impacts of climate change drought resistant crops, alternative agricultural practice and less cultivation of water intensive crops should be encouraged.

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Listing of Papers Presented at Various World Environment Day(s), Commemorated by Pakistan Engineering Congress

Sr. No.	Title of Paper	Name of Author
	2007 – Climate Change:	
1.	Engineering options for Managing and Mitigating Climate Change	Safia Shafiq
2.	An overview of Glacier Depletion in Tibetan	Rehmatullah Jilani
3.	Plateau Climate Change and Sustainable Development	Dr. Qamar-uz-Zaman Chaudhry
4.	Glaciers- The Barometer of Climate Change	Rakhshan Roohi Arshad Ashraf Rozina Naz
5.	Climate Change and Tree-limit status: A case study based on comparison between an optimistic scenario for European mountains and a pessimistic on for Pakistan	Amin U Khan
6.	Adapting to Risks of Climate Change	Shafqat Masood
7.	Impact of Temperature Gradient With Time & Its Variation With reference To Change Of state	Engr. Shaukat Ali Awan
	2008 – Kick the Habit, Towards a Low Carbon Economy:	
8.	Clean Development Mechanism	Muhammad Ashraf
9.	Hydel Power Generation: A Low Carbon Prospect For Prosperous Pakistan	Dr. Allah Baksh Sufi, A. Dastgir and Zahid ul Haq
10.	Re-Utilization of Solid Waste Carbon Saves Economy	Muhammad Khalid Iqbal, Tahira Shafiq & Khursheed Ahmad
11.	Low Carbon Economy – A Pakistan Perspective	Muhammad Daniel Saeed Pirzada
12.	Isotipic and Chemical Characterization of Coal from Selective areas of Pakistan	A .Mashiatullah, T. Javed, R. M. Qureshi, Z. Shah, Z. Latif and Habib-ur-Rehman
13.	ENERCON and Low Carbon Economy	Asif Masood

2009 – Your Planet Needs You-Unite to Combat Climate Change:

14.	Social and Economic Benefits of Weather, Climate and Water Services	Dr. Qamar-uz-Zaman Chaudhry
15.	Influence of Climate Change on Upper Indus River Flows	Danial Hashmi and Dr. Muhammad Siddique
16.	Vehicular Emissions and their Impacts on Human Health in Karachi – A Case Study	Muhammad Ashiq, Ambreen Kanwal and Said Rehman
17.	Emission Inventory of Lahore – 2007	B.M. Ghauri and A.N. Khan
18.	Accountability of Chemical Industries Towards Sustainable Development	S.E Benjamin
19.	Environmental Issues Related to Water Resources Development and Integrated Water Resource Management in Pakistan	Dr. Muhammad Nawaz Bhutta
20.	E-Waste : An Impending Challenge	Muhammad Daniel Saeed Pirzada and Farkhanda Nahid Pirzada
21.	Unsafe Drinking Water and Health Hazards	Sabir Ali Bhatti and Zia Mustafa
22.	Environmental Management for Menace of Water Logging of Chashma Jhelum Link Canal in Thal Desert Area – A Case Study	Dr. Allah Bakhsh Sufi, Syed Javed Sultan and Atia Dastagir
23.	Impact of Western Economic Policies on the Planet [With Special Reference to Pakistan]	Dr. Zafar Altaf
24.	Drinking Water Quality Berween Source and Point – of – Use in Satellite Town Rawalpindi – A Case Study	Shaukat Farooq, Imran Hashmi and Sara Qaisar
25.	Drinking Water Quality in Rawalpindi / Islamabad and Adjoining Areas in 2008	Jamal a. Nasir, Birjees Mazhar Qazi, M. Salman and Alam Khatoon
26.	An Overview of Ploye thylene Terephthalate Recycling in Pakistan	Dr. Zahiruddin Khan

27.	Poverty alleviation – a Challenge for Pakistan	Shahida Saleem
	2010 – Bio-Diversity Connecting with Nature – Many Species, One Planet, One Future	
28.	Deforestation – A Trample on the Moonscapes	Engr. Usman-e-Ghani
29.	River Ravi Potential, Pollution and Solutions; An Overview	Abdullah Yasar Fawad Ali Fateha Arshad Amna Iqbal Zainab Razi
30.	Wetlands in Pakistan: What is happening to them?	Dr. Abdul Aleem Chaudhry
31.	Promoting Better Management Practices An Initiative of WWF – Pakistan to reduce the ecological footprint of thirsty crops	Hammad Naqi Khan Arif H. Makhdum Zernash jamil Asad Imran A.Rasheed Bhutto Lal Khan Babar
32.	Botanical Diversity in Pakistan; Past, Present and Future	Muhammad Ibrar Shinwari, Maryum Ibrar Shinwari
33.	Biodiversity – A stavle Ecosystem (A Review)	Dr. Zaheer-ud-Din Khan
34.	Biodiversity and Economic Growth	Shahida Saleem
35.	Climate Change Threats to Biodiversity in Pakistan	Dr. M. Mohsin Iqbal Arshad Ahmad Khan
36.	Future of your Fuel Tank!!!	Umarah Mubeen Zia-ul-Islam Dr. Mian Wajahat Hussain Dr. Kauser Abdullah Malik

37.	Effect on Carbon Nitrogen Ratio, Ammonia Nitrogen in food waste composting using different techniques	Muhammad Khalid Iqbal, Tahira Shafiq Sameer Ahmed Khurshied Ahmed
38.	State of Forests in Sindh as well as the Economic benefits flowing out of it	Muhammad Sadiq Mughal
	2011 – Forests-Nature at Your Services	
39.	Forest and Climate Change	Dr. Abdul Aleem Chaudhry
40.	"Moringa: A Miracle Plant of Agro-Forestry and Southern Punjab, Pakistan	Prof. Dr. M. Ashfaq, Shahzad M. Basra and Umair Ashfaq
41.	Medicinal Plant Resources for Economic Development of Rural Community in Mankial, District Swat	Iftikhar Ahmad, Prof. Dr. Nowshad Khan and Fouzia Anjum
42.	Growth and Metal Accumulation in Various Tree Species in Response to Urban Waste Water Irrigation	Muhammad Ayyoub Tanvir Dr. M. Tahir Siddiqui and Zafar Hussain
43.	Significance of Forests in Islam	Engr. Mumtaz Hussain
44.	Creating Forests Resources in Thal Desert for Combating Land Degradation	Raja Attaullah Khan
45.	An Overview of Forests in Pakistan	Engr. Saeed Iqbal Bhatti
	2012 – Green Economy-Does it Include You	
46.	Making Agricultural Economy Green: Reducing Carbon Emissions Through Improved Irrigation Management	Dr. Asad Sarwar Qureshi
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