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Pitout JDD, Church DL, Gregson DB, Chow BL, McCracken M, Mulvey M, Laupland KB (2007). Molecular epidemiology of CTXM-producing Escherichia coli in the Calgary Health Region: emergence of CTX-M-15-producing isolates. Antimicrob. Agents Chemother. 51: 1281-1286.

Pelczar JR, Harley JP, Klein DA (1993). Microbiology: Concepts and Applications. McGraw-Hill Inc., New York, pp. 591-603.

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ARTICLES

Full Length Research Paper

An inventory of plant species found in gravel borrow pit around Gaborone, Botswana

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This study sought to establish an inventory of plant species established at three gravel borrow pits around Gaborone, Botswana. At each, plant data were collected from randomly selected 10 x 10 m quadrats within and up to 30 m away from the borrow pits. Species of Acacia were the most numerous in the pits, while more non-woody than woody species were established within the pits. Most woody species within the pits were not found around the pits, and most of the non-woody species within the pits were found around them, with the exception of the Tlokweng pit.

Key words: Re-vegetation, reclamation, pioneer species, seed bank, borrow pit, *Acacia.*

INTRODUCTION

Quarrying for gravel has a number of negative impact that affect the integrity of the environment including degradation of ecosystems. The removal of vegetation reduces the ecology of a site and exposes it to other environmental factors such as soil erosion that may exacerbate the negative impacts already caused. However, efforts have been made worldwide to reduce these negative impacts through reclamation by re-contouring and re-vegetation (Cripps et al., 2004). In both cases, natural succession will occur, re-establishing native vegetation on the sites. This happens through species colonization, spreading, displacement and replacement over time until climax species are established (Davis et al., 1985). These processes happen as the quarry soils change overtime due to weathering and other physical, chemical and biological processes fed by pioneer species, (Legwaila, 2012). Under natural succession, establishment of vegetation on disturbed land is dependent on the availability of a seed bank from

vegetation adjacent to a disturbed site. Landform and soil characteristics may also have an impact on establishment of vegetation (Davy, 2008). Landform in disturbed land may experience accelerated erosion and runoff, inhibited infiltration and unfavourable micro climatic conditions, all of which have a negative effect on the natural recovery processes of disturbed land (Whisenant, 2008). Where topsoil has been replaced after decommissioning of a borrow pit, the soil is expected to carry numerous seeds of plant species from the local environment. However, it generally takes longer for environmental impacts to decrease and for desired outcomes to be achieved under natural succession than under technical reclamation and there will always be left over impacts regardless of the type of reclamation interventions (Figure 1). When technical re-vegetation is undertaken, the process may occur more rapidly resulting in more rapid re-vegetation.

Technical re-vegetation however, requires amelioration

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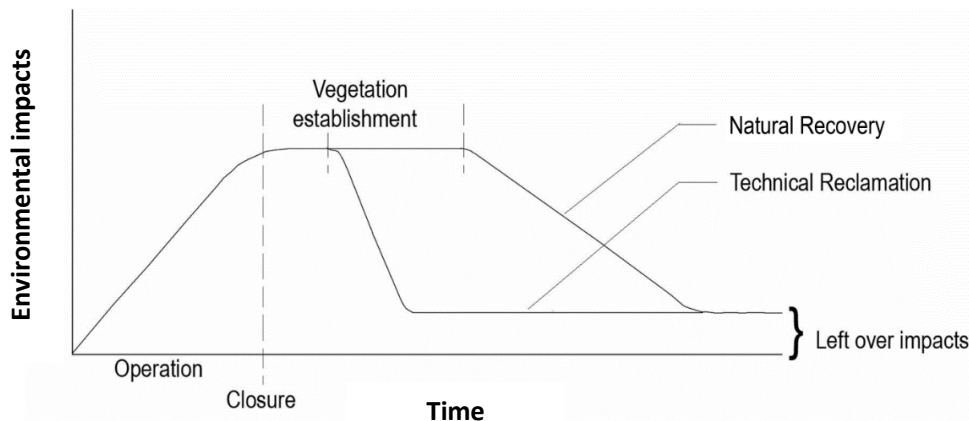
Figure 1. An illustration of the extent of environmental impacts over time after different reclamation interventions (Legwaila, 2012).

Table 1. Geographic coordinates of the sites.

Corners	Place		
	Bokaa	**Tlokweng**	**Mmokolodi**
A	S 24° 26` 02  E 26° 02`49.5	S24° 40' 20.52E 26° 02'14.8648	S24° 28' 09.0 E 26° 58'14.0
B	S 24° 26`03  E 26° 02` 58.8	S24° 40' 19.90E26° 02' 25.7320	S24° 28, 07.0 E 26° 58'23.0
C	S 24° 25`52  E 26° 02`57.7	S 24° 40'29.39 E26° 02' 24.4906	S 24° 28'17.0 E 26° 58'36.0
D	S 24° 25`53    E 26° 02`15.7	S 24° 40' 29.13E 26° 02' 13.3490	S 24° 28' 25.3 E 26° 58'28.0

of the quarry soils to support plant life as well as proper choice of plants which can survive the local conditions and provide the functions that are intended for the quarry after reclamation. This requires knowledge and selection of native species that are common to establish in disturbed land and be productive under less than normal conditions of quarry sites to ensure sustainability of the vegetation. It has been found in other studies that at times exotic species establish in decommissioned quarry sites, and has been concluded that they may have been introduced by humans (Davis et al., 2000). It has also been concluded that use of non-native species is "the second most important threat to biodiversity after habitat loss", (Vermeulen and Whitten, 1999).

This study sought to identify and develop an inventory of plant species that established in borrow pits that were quarried for gravel around the city of Gaborone, Botswana.

METHODOLOGY

Study sites

This study was conducted at three decommissioned borrow pits around Gaborone. The pits were located in the villages of Bokaa, Mmokolodi and Tlokweng. These borrow pits came about as a result of the high infrastructure construction developments that occurs in the city of Gaborone and the neighbouring areas. The land in these areas was previously used for communal grazing. The borrow pits were selected based on their close proximity to Gaborone. Their coordinates were taken at four corners of the sites (Table 1). The soils around these sites were slightly variable but generally supported a shrub savanna and savanna vegetation structure. The soils around Bokaa and Tlokweng pits were haplic lixisols which are common in the tropics with predominant dry seasons. They form subsequent to leaching of clay. They have very low levels of plant nutrients and are highly erodible. Mmokolodi on the other hand had eutric regosols which are weakly developed soils very common in unstable landforms. They also have low levels of nutrients and nutrient holding capacity.

Experimental design

Within each borrow pit site, four (4) quadrants of 10 m by 10 m were randomly selected. Around each borrow pit, eight quadrants of 10 m by 10 m from different sides of the pits were randomly selected to conduct an inventory of plant species around the pits. This procedure was performed to enable comparison of plant species within the borrow pits and those around them.

Collection and identification of plant species

All plants seen in the quadrats were recorded to species level. For those that could not be reliably identified in the field, specimens were collected for later identification in the herbarium at the Botswana College of Agriculture. The same procedure was

Table 2. Plant species found within the three borrow pits.

Bokaa		Tlokweng		Mmokolodi	
Plants within pit	Plant outside pit	Plants within pit	Plant outside pit	Plants within pit	Plant outside pit
Acacia erubescens*	*Acacia tortilis**	*Acacia erubescens**	*Acacia erubenscens**	*Acacia tortilis**	*Acacia tortilis**
Acacia gerrardii*	*Acacia mellifera**	*Acacia grrrardii**	*Acacia gerrardii**	*Acacia erubescens**	*Asparagus bechuanicus*
Acacia mellifera*	*Achyranthesaspera*	*Acacia mellifera**	*Acacia mellifera**	*Acacia gerrardii**	*Cambretum imbrebe**
Acacia nigrescens*	*Acrotome inflata*	*Acacia tortilis**	*Aristida congesta*	*Acacia mellifera**	*Carissa bispinosa**
Acacia tortilis*	*Aristida congesta subsp barbicollis*	*Achyranthesaspera*	*Aristida congesta subsp barbicollis*	*Acacia nigrescens**	*Combretum apiculatum**
Acrotome hispida	*Aristida conjesta*	*Aristida congesta subsp barbicollis*	*Asparagus bechuaniscus*	*Achyranthes aspera*	*Combretum hereroense**
Aristida congesta	*Asparagus bechuaniscus*	*Asparagus bechuaniscus*	*Combretum imberbe**	*Acrotome hispida*	*Dichrostachys cinerea*
Aristida congesta subsp. barbicollis	*Combretum imberbe**	*Ceratotheca triloba*	*Carissa bispinosa**	*Aristida congesta Subsp congesta*	*Euclea undulata**
Asparagus bechuanicus	*Carissa bispinosa**	*Corchorus olitorius*	*Ceratotheca triloba*	*Aristida congesta subsp barbicollis*	*Evolvulus alsinoides*
Ceratotheca triloba	*Chloris virgata*	*Dicerocaryum eriocarpum*	*Cucumis myriocarpus*	*Asparagus bechuanicus*	*Gomphocarpus fruticosus g*
Chloris virgata	*Combretum apiculatum**	*Dicoma tomentosa*	*Cyperus turrillii*	*Corchorus olitorius*	*Gomphrera celosioides*
Corchorus olitorius	*Combretum hereroense**	*Echinochloa holubii*	*Dichrostachys cinerea**	*Dicerocaryum eriocarpum*	*Grewia flava**
Cucumis myriocarpus	*Cucumis myriocarpus*	*Ehretia rigida**	*Gomphrera celosioiides*	*Dicoma tomentosa*	*Grewia flavescens**
Dicerocaryum eriocarpum	*Cyperus turrillii*	*Euclea undulate**	*Grewia flava**	*Echinochloa holubii*	*Kalanchoe lanceolata*
Dicoma tomentosa	*Ehretia rigida**	*Gomphrena celosioides*	*Grewia flavescens**	*Euclea undulata**	*Kyphocarpa angustifolia*
Dodonae aviscosa*	*Euclea undulate**	*Guillemineadensa*	*Kalanchoe lanceolata*	*Evolvulus alsinoides*	*Peltophorum africanum**
Ehretia rigida*	*Evolvulus alsinoides*	*Hermbstaedtiafleckii*	*Lantana rugosa*	*Fimbristylis hispidula*	*Perotis patens*
Euclea undulata*	*Gomphocarpus fruticosus*	*Kyphocarpa angustifolia*	*Ocimum canum*	*Gomphrena celosioides*	*Pogonarthria squarrosa*
Evolvulus alsinoides	*Gomphrera celosioides*	*Melinis repens*	*Pappea capensis*	*Gomphocarpus fruticosus*	-
Fimbristylis hispidula	*Grewia flava**	*Monsonia angustifolia*	*Peltophorum africanum**	*Grewia flava**	-
Gomphocarpus fruticosus	*Grewia flavescens**	*Sesbania bispinosa*	*Pogonarthria squarrosa*	*Guilleminea densa*	-

conducted outside the borrow pits from a distance of 30 m to the edge of the pits.

RESULTS AND DISCUSSION

Overall there were 44 species (11 woody and 33 non-woody) found at all borrow pits (Table 2). The woody species made a total of 25% of all the species found. The majority of the woody species were *Acacia* species making 46% (five different species). All of the other six species contributed 9% each. A total of 5 woody species, four *Acacia* species and *Euclea undulate* were present at each of the pits, (Table 3). The predominance of the *Acacia* species might be an indication of their greater tolerance to low levels of resources within the pits (Smith and Smith, 2014; Donfack et al., 1995). This enables them to efficiently exploit the little resources in the soil, better than other species. There was also an exotic species (*Dodonea viscosa*) at Bokaa pit commonly used as an ornamental plant in Botswana. Its existence in the pit could be attributed to the anthropogenic activities that took place at the pit during operation (Davis et al., 2000). Of the 33 non-woody species found at the different pits, 12 (36%) were common to all pits (Table 3).

There was a high number of non-woody plants that made the understory made up of grasses and small shrubs. The trees that existed with them might have created conducive micro-climatic and soil conditions, facilitating their growth and establishment (Smith and Smith, 2014; Whisenant, 2008).

It was expected that most plants that established within the borrow pits would either have been from the soil seed bank in the surrounding land or as a result of seed dispersion

Table 2. Contd.

Gomphrena celosioides	Kalanchoe lanceolata	Streptopetalum serattum	Streptopetalum serattum	Hermbstaedtiafleckii	-
Grewia flava*	Kyphocarpa augustifolia	Tricholaena monachne	Tricholaena monachne	Hypertelis bowkeriana	-
Guilleminea densa	Lantana rugosa	Urochloa mosambicensis	Urochloa mosambicensis	Kohautia subverticilla	-
Hermbstaedtiafleckii	Ocimum canum	Ziziphus mucronata*	Zyzypus mucronata*	Kyphocarpa angustifolia	-
Hypertelis bowkeriana	Pappea capensis	-	-	Melinis repens	-
Kohautia subverticillata	Peltophorum africanum*	-	-	Monsonia angustifolia	-
Kyphocarpa angustifolia	Perotis patens	-	-	Pogonarthria squarrosa	-
Melinis repens	Pogonarthria squarrosa	-	-	Sesbania bispinosa	-
Monsonia angustifolia	Solanum sp	-	-	Sida cordifolia	-
Ocimum canum	Streptopetalum serattum	-	-	Tricholaena monachne	-
Rhigozum brevispinosum*	Tarchonanthus camphoratus*	-	-	Urochloa mosambicensis	-
Schmidtia pappophoroides	Tricholaena monachne	-	-	-	-
Sesbania bispinosa	Urochloa mosambicensis	-	-	-	-
Sida cordifolia	-	-	-	-	-
Solanum sp.	-	-	-	-	-
Streptopetalum serratum	-	-	-	-	-
Urochloa mosambicensis	-	-	-	-	-

*Woody species found within the pits.

Table 3. Plant species common at all three borrow pits.

Botanical Name	Common Name
Acacia tortilis*	Mosu (Hairy umbrella thorn)
Acacia gerrardii*	Moga, Moki (Red thorn; Grey haired acacia)
Acacia mellifera*	Mongana (Black thorn; Hook thorn)
Acacia nigrescens*	Mokoba (Knob thorn)
Aristida congesta subsp. barbicollis	Seloka; Bojang-ja-motlhaba-jo-bonnye; (Buffalo grass)
Asparagus bechuanicus	Lesitwa, (Wild asparagus)
Dicerocaryum eriocarpum	Tshetlho; Legatapitse (Devil's thorn; boot protector plant)
Dicoma tomentosa	Ombahu
Enchinochloa holubii	(Limpopo grass; Antelope grass; Kalahari water grass)
Euclea undulate*	Motlhakola (Thicket euclea)
Gomphrena celosioides	Mositanoka (Prostate globe amaranthas; bachelor's button)
Guilleminea densa	Mohulapitse (Small mat weed)
Hypertelis bowkeriana	Motlhabana; Munyu-wa-pasi
Kyphocarpa angustifolia	Mosono-wa-mmutla; Silky burweed; Hare's tail bush

Table 3. Contd.

Melinis repens	*Lenapa; Senyane (Fairy grass)*
Monsonia angustifolia	*Phusana; Tsatsalopane (Crane bill)*
Sesbania bispinosa	*Mositanokana; Selaole (Spiny sesbina)*

*Woody species found within the pits.
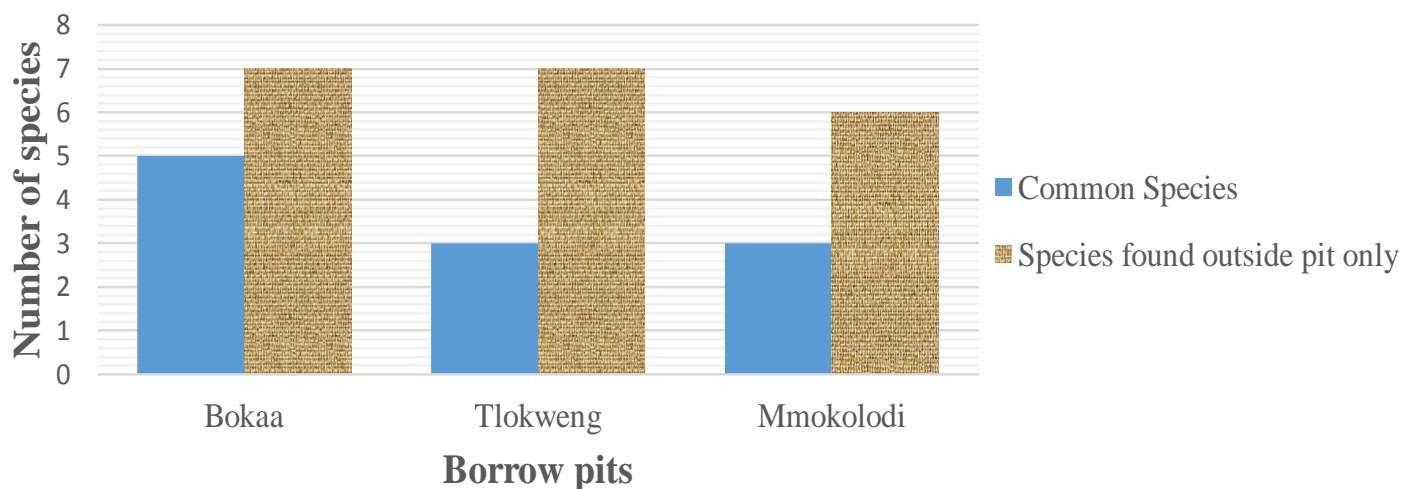
Figure 2. A comparison of woody species within the pits and adjacent to the pits.

from the vegetation stand surrounding the pits. The distance of the different species from the pits and their dispersal characteristics could also have affected what got established in the pits (Makhabu and Marotsi, 2012). It should be noted that vegetation surrounding the pits was only sampled to a distance of 30 m. It was found that the majority of woody species that grew around the pits were not found growing within the pits (Figure 2). With the exception of the Tlokweng pit, majority of non-woody plants that were found around the pits were also found growing inside the pits (Figure 3).

Conclusion

It can be concluded that *Acacia* species have a great tolerance for poor underdeveloped soils found in decommissioned borrow pits. This can make them suitable candidates for pioneer species in technical reclamation, especially when there is a limitation of topsoil available for re-vegetation. They can be used to provide conducive environmental conditions for other plant species.

It can also be concluded that most non-woody species are easy to establish in disturbed lands. They are useful in the control of negative impacts such as soil erosion as well as improving the capability for water infiltration. This contributes to the success of other processes such as decomposition which can accelerate development
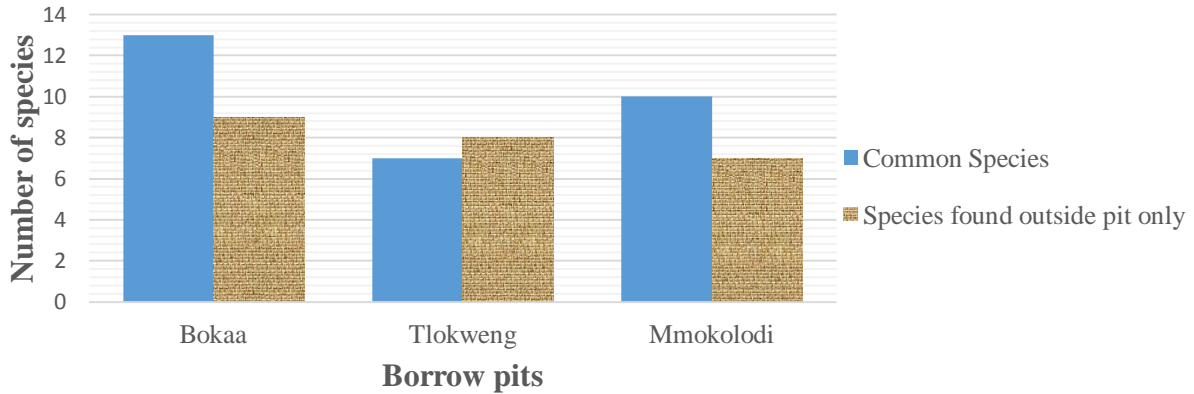
Figure 3. A comparison of non-woody species within the pits and those adjacent to the pits.

of better soil that can support re-vegetation.

Conflict of interests

The author(s) did not declare any conflict of interest.

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Full Length Research Paper

Soil organic carbon stock estimation in range lands of Kumrat Dir Kohistan KPK Pakistan

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The present study was carried out in two grass land of Kumrat Dir Kohistan, North Hindukush regions of KPK Pakistan. Locally these two grass land are known as Roshi Dab and Bothore Dab. The area of these two Dabs is about 400 hectare. The elevation of these two Dabs ranges from 7665 feet to 7954 feet while the geographic location of the study site was N 35° 33.249' and E 72° 12.258'. Stratified random sampling method was used for data collection. 18 soil samples were taken with the depth of 0-15 cm and 16-30 cm. The average soil pH was 5.3. The mean soil bulk density was 1.107 -g/cm^3. In present study it was found that the undisturbed range land stored maximum amount of soil carbon (32.69 tons hac^{-1}) as compare to range land near to the agriculture land (29.77 tons hac^{-}1) Similarly the rangeland near to forest land stored 35.62 t ha^{-1} carbon, also stored more carbon as compare to range land near to agriculture land 29.77 t ha^{-1}. The results of the present study confirmed that conversion of range land into agriculture land reduced the soil carbon in the study area.

Key words: Carbon stocks, climate change, soil bulk density, range lands, forestry.

INTRODUCTION

The matter of great concern among scientific communities around the globe is the increase level of CO_2 and other green house gases. This increase level of green house gases leads to global warming and climate change. The most contributing agent in global climate change is Carbon Dioxide (IPCC, 2007). The atmospheric concentrations of CO_2, N_2O, CH_4 and other greenhouse gases prolong rise, affects the global climate. The Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) and succeeding agreements have set accurate targets in terms of levels and dates for sinking overall greenhouse gas emissions to the atmosphere (Watson et al., 2000).

The current concentration of CO_2 in the atmosphere is 402 ppm in 2014 (www.CO$_2$now.com). The carbon dioxide comes from different sources like fossils fuel burning, cement industries and other anthropogenic activities. Cement industries and fossil fuel burning contributes 91% that equals to 33.4 billion metric tons and the remaining 9% or 3.3 billion metric tons comes from land use changes particularly from the conversion of forest land to other land uses. This humanity's carbon dioxide 50% or 18.4 billion metric tons goes to atmosphere, 26% or 9.5 billion metric tons goes to land and the remaining 24% or 8.8 billion metric tons goes to oceans (www.CO$_2$ now.com). Rangelands signify 24% of

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the world's land area (FAO, 2007). Grassland Soil Organic Matter can be strongly influenced by supervision and management (Conant et al., 2001). SOC losses due to exchange of 'native' or freely grazed grassland (FGG) to cropland and poor grazing land management activities (Davidson and Ackerman, 1993; Guo and Gifford, 2002).

Range lands has so many importance like it support our wild life and livestock, it reduces soil erosion, and ensure clean water by reducing siltation (Milchunas, 2004). Apart from the above, range land acts as a sink of carbon and plays a noticeable role in the global climate change mitigation by catching and storing the atmospheric carbon dioxide (IPCC, 2006). Temperate grasslands contain soil organic matter (SOM) that averages 331 Mg ha^{-1}, and grasslands contain 12% of the earth's SOM (Schlesinger, 1997). Therefore, enhancing carbon sequestration in terrestrial ecosystems is an important approach for controlling the increase in atmospheric CO_2 concentration. Grazing decreased soil carbon absorption, especially when initial soil carbon concentration was higher than 2%. Compared with no or light grazing, typical soil carbon concentration decreased in reaction to heavy grazing by 30.0% and moderate grazing by 17.0%. It decreased on average by 16.2% in response to heavy grazing and by 8.2% in response to fair grazing (Shiping et al., 2011).

Land use change can go ahead to change in a range of soil properties, including soil carbon (C), nitrogen (N) content, soil bulk density and pH (Callesen et al., 2003). There is significant alarm that land use change can lead to variation of the soil carbon (C) (Houghton et al., 1999; Schlesinger, 1990) though, Lal (2004) reported that more conventional soil properties such as total C is susceptible to land use change as complicated physical fractionation schemes. Soil is the largest organic C reservoir in the terrestrial biosphere; about two times superior than that of vegetation or the atmosphere (Schlesinger, 1997). Even an insignificant change in SOC storage could result in a major variation in atmospheric CO_2 concentration (Callesen et al., 2003; Wynn et al., 2006). Rangelands stored about 30% of the world's soil carbon (White et al., 2000; Grace, 2004; Milne et al., 2007).

In Pakistan about 60% of the total area of the country comprises rangelands. The area fairly supports 93.5 million head of livestock. Even so, there remains an insufficiency of basic ecological information that is needed to get better understanding of why, when and where rangeland ecosystems function as C sinks or sources. Pakistan is signatory to the Kyoto protocol. The protocol stress on the member countries to quantify the carbon, stored in different sinks. In Pakistan study on range land regarding forage production, carrying capacity and biomass estimation has been carried out. Study regarding carbon stocks of range land particularly on soil carbon is scarce. The present study was carried out in Kumrat valley. The study aimed to find out the total carbon stored in the soil of rangelands in Kumrat Dir Kohistan.

METHODOLOGY

Research design

Stratified random sampling design was used. The range land of the area were divided into three strata that were undisturbed range land, range lands near to forest and range lands near to agriculture land. In all these three strata the soil sample was taken. 18 soil samples were randomly taken in each site at the depth of 0-15 cm and from 15-30 cm.

Soil samples collection

The elevation and coordinates of each unit are from where soil samples were collected and were measured by GPS. Collection of soil samples was done in two depths; 0-15 and 15-30 cm and the weight of each sample was measured in the field and was put in labeled bags and brought to the laboratory for further analysis.

Calculation of soil bulk density

The soil samples which were collected in rangelands were brought to the laboratory and were kept in the oven for 48 h on 72°C to dry. The soil samples were put in the known volume of a cylinder (H= 5.12 cm and Cross sectional Area= 20.32 cm^2). After this the samples were weighted (through digital balance) and their volumes were calculated. The volume of soil core was calculated and was 104 cm^3. Soil bulk density gcm^{-3} was calculated by using following formula:

$$B.D = Mass/volume$$

Soil pH estimation

For the determination of soil pH, 50 g of air- dried soil was taken into a 500 ml glass beaker, and 50 ml of distilled water were added. After titration, the contents were mixed and allowed to stand for an hour. After this, the soil pH was calculated by using soil pH meter (Mc Lean, 1982).

Soil carbon estimation in Tons ha^{-1}

Soil carbon in tons ha^{-1} was calculated from the relation of soil organic carbon (SOC %), Soil bulk density (g/cm^3) and thickness of horizon (cm). The following formula (Persion et al., 2008; Adnan et al., 2014) was used to find out soil carbon in tones ha^{-1}:

SOC (tones ha^{-1}) = SOC content %* SBD (g/cm^3)* TH (cm)*100

Where, SOC = soil organic carbon; SBD = soil bulk density and TH = thickness of horizon.

Soil Organic Carbon (tons hac^{-1}) = Soil Organic Content % × Soil Bulk Density (g/cm^3) × Thickness of Horizon (cm) × 100.

Statistical analysis

For the statistical analysis different software like MS Excel, Sigma plot software, program and PAST was used. Mean Standard deviation, and CV% Standard error were calculated. Regression

Table 1. Details of soil pH, SBD gm/cm^3, SOM%, SOC%, and SOC tons hac^{-1} in all sample plots.

Plot number	Elevation ft	Latitude	Longitude	Avg pH	Avg BD (g/cm^3)	Total SOM%	SOC %	SOC tons hac^{-1}(30) cm
1	7665	N 35° 33'.249"	E 72° 12'.258"	5.21	1.03	1.81	1.04	28.59
2	7689	N 35° 33'.262"	E 72° 12'.135"	4.95	1.01	1.62	0.93	32.90
3	7695	N 35° 33'.244"	E 72° 12'.268"	5.34	0.96	1.71	0.99	32.55
4	7697	N 35° 33'.262"	E 72° 12'.292"	4.91	1.14	1.71	0.99	30.92
5	7711	N 35° 34'.768"	E 72° 10'.956"	5.95	1.13	1.71	0.99	33.31
6	7732	N 35° 34'.765"	E 72° 10'.971"	5.19	1.19	1.83	1.06	37.96
7	7761	N 35° 33'.25"	E 72° 12'.093"	5.85	1.24	1.81	1.04	39.06
8	7781	N 35° 34'.79"	E 72° 10'.997"	4.85	1.07	1.61	0.93	39.34
9	7845	N 35° 34'.673"	E 72° 10'.626"	5.29	0.97	1.82	1.05	28.61
10	7852	N 35° 34'.417"	E 72° 10'.762"	4.86	0.99	1.71	0.99	36.76
11	7853	N 35° 34'.438"	E 72° 10'.774"	5.85	1.13	1.71	0.99	33.76
12	7879	N 35° 34'.654"	E 72° 10'.683"	5.37	1.08	1.77	1.02	34.19
13	7879	N 35° 34'.578"	E 72° 10'.729"	5.42	1.10	1.71	0.99	33.90
14	7884	N 35° 34'.639"	E 72° 10'.712"	5.93	1.07	1.65	0.95	29.61
15	7916	N 35° 34'.556"	E 72° 10'.718"	4.94	1.07	1.4	0.81	26.11
16	7921	N 35° 34'.539"	E 72° 10'.721"	5.01	1.08	1.6	0.92	30.11
17	7934	N 35° 34'.785"	E 72° 10'.449"	5.97	1.23	1.71	0.99	29.99
18	7954	N 35° 34'.776"	E 72° 10'.457"	5.95	1.37	1.65	0.95	30.90
Min	7665	-	-	4.85	0.96	1.4	0.81	26.11
Max	7954	-	-	5.97	1.37	1.83	1.06	39.34
Mean	7813.78	-	-	5.38	1.10	1.69	0.98	32.70
SD	97.02	-	-	0.42	0.10	0.10	0.05	3.76
Std. error	22.86	-	-	0.10	0.02	0.02	0.01	0.88
CV %	1.24	-	-	7.96	9.39	6.07	6.07	11.51

models were developed in order to study the relationship between soil organic matter and elevation and soil organic carbon and elevation.

RESULTS AND DISCUSSION

Soil pH of each sample plot

Results of soil pH are given in Table 1. Soil pH ranged from 4.5 to 5.9. The average soil pH was 5.3 which showed the acidity in nature. In order to find out the relationship between soil pH and elevation, regression model was developed (Figure 4). The relation of soil pH and elevation is polynomial cubic. The value of R2 was 0.13 and that showed that there was week relation between elevation and soil pH.

Soil pH of Range land near to agriculture land

These range lands were the disturbed range land.

Majority of these range lands were converted to agriculture lands. Soil samples were collected in these range land from those area which are not still converted to agriculture fields. These unconverted areas are mostly located at relatively high altitude and sloppy area. Soil samples were taken from those areas and there pH was calculated. The results of soil samples are given in Table 2. The average soil pH in this site was calculated as 5.91. These soils are less acidic in nature then those of undisturbed range land and

Table 2. Details of soil pH, SBD gm/cm³, SOM%, SOC%, and SOC tons hac⁻¹ in range land near to agriculture land.

Plot number	Elevation (ft)	Avg pH	Avg BD (g/cm³)	Total SOM%	SOC %	SOC (ton hac⁻¹ 30 cm)
1	7711	5.95	1.01	1.62	0.93	28.59
2	7761	5.85	1.14	1.71	0.99	34.19
3	7853	5.85	1.07	1.61	0.93	29.99
4	7884	5.93	0.99	1.71	0.99	29.61
5	7934	5.97	1.07	1.40	0.81	26.11
6	7954	5.95	1.08	1.60	0.92	30.11
Min	7711	5.85	0.99	1.40	0.81	26.11
Max	7954	5.97	1.14	1.71	0.99	34.19
Mean	7849.5	5.91	1.06	1.60	0.93	29.77
SD	96.20	0.05	0.05	0.11	0.06	2.62
Std. error	39.27	0.02	0.02	0.04	0.02	1.07
CV %	1.22	0.89	5.12	7.04	7.04	8.81

Table 3. Details of soil pH, SBD gm/cm³, SOM%, SOC%, and SOC tons hac⁻¹ in undisturbed rangeland.

Plot number	Elevation ft	Avg pH	Avg BD g/cm³	Total SOM%	SOC %	SOC ton hac⁻¹ 30 cm
1	7665	5.21	1.03	1.81	1.04	32.55
2	7695	5.34	0.96	1.71	0.99	28.61
3	7732	5.19	1.19	1.83	1.06	37.96
4	7845	5.29	0.97	1.82	1.05	30.90
5	7879	5.37	1.08	1.77	1.02	33.31
6	7879	5.42	1.10	1.71	0.99	32.90
Min	7665	5.19	0.96	1.71	0.99	28.61
Max	7879	5.42	1.19	1.83	1.06	37.96
Mean	7782.50	5.30	1.05	1.77	1.02	32.71
SD	96.48	0.08	0.08	0.05	0.03	3.10
Std. error	39.38	0.03	0.03	0.02	0.01	1.26
CV %	1.23	1.69	8.18	3.05	3.05	9.48

range lands near to forest lands.

Soil pH in undisturbed range land

The result of soil pH in undisturbed range lands is presented in Table 3. In the present study, it was found that soil pH in undisturbed range land ranges from 5.19 to 5.42 while the mean soil pH was 5.30.

Soil pH of range land near to forest land

The results of soils pH of range land near to the forest land is given in Table 4. The minimum soil pH of range land near the forest land was 4.85 while the maximum soil pH was 5.01. The Mean soil pH was 4.92.

Soil bulk density (g/cm³)

In the present study the soil particles were examined and soil bulk density was find in each study site. Soil bulk density ranged from 0.96 to 1.37 g/cm³. The mean soil bulk density was 1.107 g/cm³. Details of soil is given in Table 3 and Figure 7. In order to find out relationship between soil bulk density and elevation, regression model was developed. The relationship between soil bulk density and elevation is polynomial cubic. The value of R2 was 0.61. This value of R2 indicated that there is a positive relation between soil bulk density and elevation. The relation of soil bulk density and elevation is best represented in Figure 5.

Soil bulk density (g/cm³) in undisturbed range land

Soil SBD (g/cm³) in UDRL ranged from is 0.96 to 1.19

Table 4. Details of soil pH, SBD gm/cm^3, SOM%, SOC%, and SOC tons hac^{-1} in rangeland near to forest.

Plot no	Elevation ft	Avg pH	Avg BD g/cm^3	Total SOM%	SOC %	SOC ton hac^{-1} 30 cm
1	7689	4.95	1.13	1.71	0.99	33.90
2	7697	4.91	1.24	1.81	1.04	39.06
3	7781	4.85	1.13	1.71	0.99	33.76
4	7852	4.86	1.07	1.65	0.95	30.92
5	7916	4.94	1.23	1.71	0.99	36.76
6	7921	5.01	1.38	1.65	0.95	39.34
Min	7689	4.85	1.07	1.65	0.95	30.92
Max	7921	5.01	1.37	1.81	1.04	39.34
Mean	7809.33	4.92	1.19	1.70	0.98	35.62
SD	103.50	0.06	0.10	0.05	0.03	3.33
Std. error	42.25	0.02	0.04	0.02	0.01	1.36

g/cm^3. Mean soil bulk density was 1.058 g/cm^3. Details are given in Table 3.

Soil bulk density (g/cm^3) of range land near to forest land

Table 4 showed that among all three study site Soil bulk density (g/cm^3) of RLNFL was maximum and was 1.199 g/cm^3. The minimum and maximum Soil bulk density in this site was 1.07 and 1.37 g/cm^3 respectively. Mean soil bulk density was 1.199 g/cm^3.

Soil bulk density (g/cm^3) of each sample plot of range land near to agriculture land

The soil bulk density near to agriculture land is expressed in Table 2. In this study site BD ranges from 0.99 to 1.14 g/cm^3. Mean soil bulk density was 1.06 g/cm^3.

Soil organic matter (%)

The results showed that the sample plots which were taken in undisturbed range land has maximum amount of soil organic matter than the sample plots taken in the range land near to forest land and agriculture land Table 1. The soil organic matter was calculated by Walkley and Black method in the laboratory. Minimum soil organic matter was recorded in Range land near to agriculture land and maximum soil organic carbon of 1.83% was found in undisturbed range land. Mean soil organic matter was 1.69%. In order to study the relation of soil organic matter and elevation, regression model was developed. The relation between soil organic matter and elevation was negative the value of R2 was 0.19 (Figure 6).

The results of the present study shows great variation in soil organic matter in each study site. Undisturbed range lands has more SOM%, range lands near to forest has moderate SOM% while the range lands near to agriculture lands has in SOM%. The results show that the sample plots which were taken in undisturbed range land has maximum amount of SOM% than the sample plots taken in the range land near to forest land and agriculture land. SOM% of all these sample units ranged from 1.4 to 1.83%. Mean SOM% was 1.69%. In undisturbed range lands SOM% ranged from 1.71 to 1.83% while the mean soil organic matter was 1.775%. Range lands near to forest land SOM ranged from 1.65 to 1.81% while the mean SOM% was 1.70%. SOM% in range lands near to agriculture land ranged from 1.4 to 1.71% while the mean SOM% was 1.60%. These statistics shows that SOM% is more in undisturbed range land while less in range land near to forest land and lesser in range land near to agriculture lands.

Soil organic matter% of sample plots taken in undisturbed range land

Table 3 shows the soil organic matter (SOM %) in undisturbed range lands. Minimum SOM% was 1.71% and maximum was 1.83% while the mean SOM% was 1.775%.

Soil organic matter% of sample plots taken in range land near to forest

Details of soil organic matter in this site are presented in Table 4. Soil organic matter% in this site ranged from 1.65 to 1.81% while the mean soil organic matter % was 1.70%.

Soil organic matter% of sample plots taken in range land near to agriculture land

Table 2 showed that minimum of SOM% was 1.4% and maximum was 1.71% while the mean SOM% was 1.60%.

Soil organic carbon SOC%

The SOC% was calculated from the SOM% by using the following formulae:

SOC% = SOM% / 1.724 (Walkeley and Black, Ahmad et al., 2014).

Where, SOC = soil organic carbon; SOM = soil organic matter; 1.72= constant.

Soil organic carbon concentration (SOC%) of each plot taken in undisturbed range land

Table 3 shows the total soil organic carbon concentration of SOC%% in undisturbed range lands. Minimum of SOC% was 0.99% and maximum was 1.05%. Mean SOC% in these range lands were 1.02%.

Soil organic carbon concentration (SOC%) of each plot taken in range land near to forest land

Table 4 shows the SOC% in each sample unit taken in range land near to forest land. Minimum of SOC% was 0.95% and maximum was 1.04%. Mean SOC% was 0.989%.

Soil organic carbon concentration (SOC%) of each plot taken in range land near to agriculture land

Table 2 shows the SOC% in those range lands which are near to agriculture lands. Minimum SOC% was 0.92% and maximum was 0.99% the mean SOC% was 0.93%.

Soil organic carbon concentration in tons hac^{-1} of each sample plot

Table 1 shows that in each study site the soil organic carbon in t ha^{-1} was calculated. For the calculation of soil organic carbon, the following formula was used (Walkley and Black, 1934):

SOC (tons hac^{-1}) = SOC% × SOM × TH × 100. Where, SOC = soil organic carbon; SOM = soil organic matter; TH = thickness of the horizon of the soil.

In the present study, soil organic carbon ranged from 26.11 to 39.34 t ha^{-1}. The average soil organic carbon was 32.70 t ha^{-1}. The results of the present study reveals

that the soil of undisturbed range land stored maximum soil carbon while the soil of the range land near to the agriculture land hold minimum soil carbon. In the present study, relation of soil organic carbon and elevation was determined through regression model (Figure 8). The relation is poly nominal cubic. The value of R2 was 0.63.

In Undisturbed range land, SOC (tons hac^{-1}) ranged from 28.61 tons to 37.96 tons hac^{-1}. The Mean SOC was 32.69 tons hac^{-1}. Range lands near to forests stored an average soil carbon of 35.62 t ha^{-1}. Range lands near to agriculture lands stored an average soil carbon of 29.77 tons hac^{-1}. These results showthat the undisturbed range lands soils stored maximum amount of SOC while soils of range lands near to forest lands stored less soil carbon t ha^{-1}.

Soil organic carbon t hac^{-1} in undisturbed range lands

Table 3 shows the total SOC in tons hac^{-1} stored by the undisturbed range lands. Minimum amount of SOC stored by these soils was 28.61 tons hac^{-1} and maximum amount of SOC stored by these soils was 37.96 tons hac^{-1}. Mean SOC which was stored by these soils was 32.69 tons hac^{-1}.

Soil organic carbon in tons hac^{-1} in range land near to forest land

Table 4 shows the total SOC tons hac^{-1} stored by range land near the forest lands. Minimum SOC was 30.92 tons hac^{-1} and maximum SOC was 39.34 tons hac^{-1} while mean SOC was 35.62 tons hac^{-1}.

Soil organic carbon in t ha^{-1} in range land near to agriculture land

Table 2 shows the soil organic carbon in t ha^{-1} in range land near the agriculture land. Minimum SOC was26.11 t ha^{-1} and maximum SOC was 34.19 t ha^{-1} while mean SOC was 29.77 t ha^{-1}. The results of the present study confirms that in undisturbed range land the soil organic carbon was more as compared to range land near the agriculture land. Soil disturbance occulted due to various agriculture practices that lead to soil erosion and loss of soil organic carbon.

CONCLUSION

The study was conducted in Kumrat valley Dir Kohistan. Elevation of the study site ranged from 7665 to 7954 ft, while the geographic location is N 35° 33'.25 to 34'.785' and E 72° 12'.135' to 12'.997'(Figure 1 and 2). GIS image showed location and description of Kumrat Dir Kohistan (Figure 3). The minimum average soil weight was 103.5 g

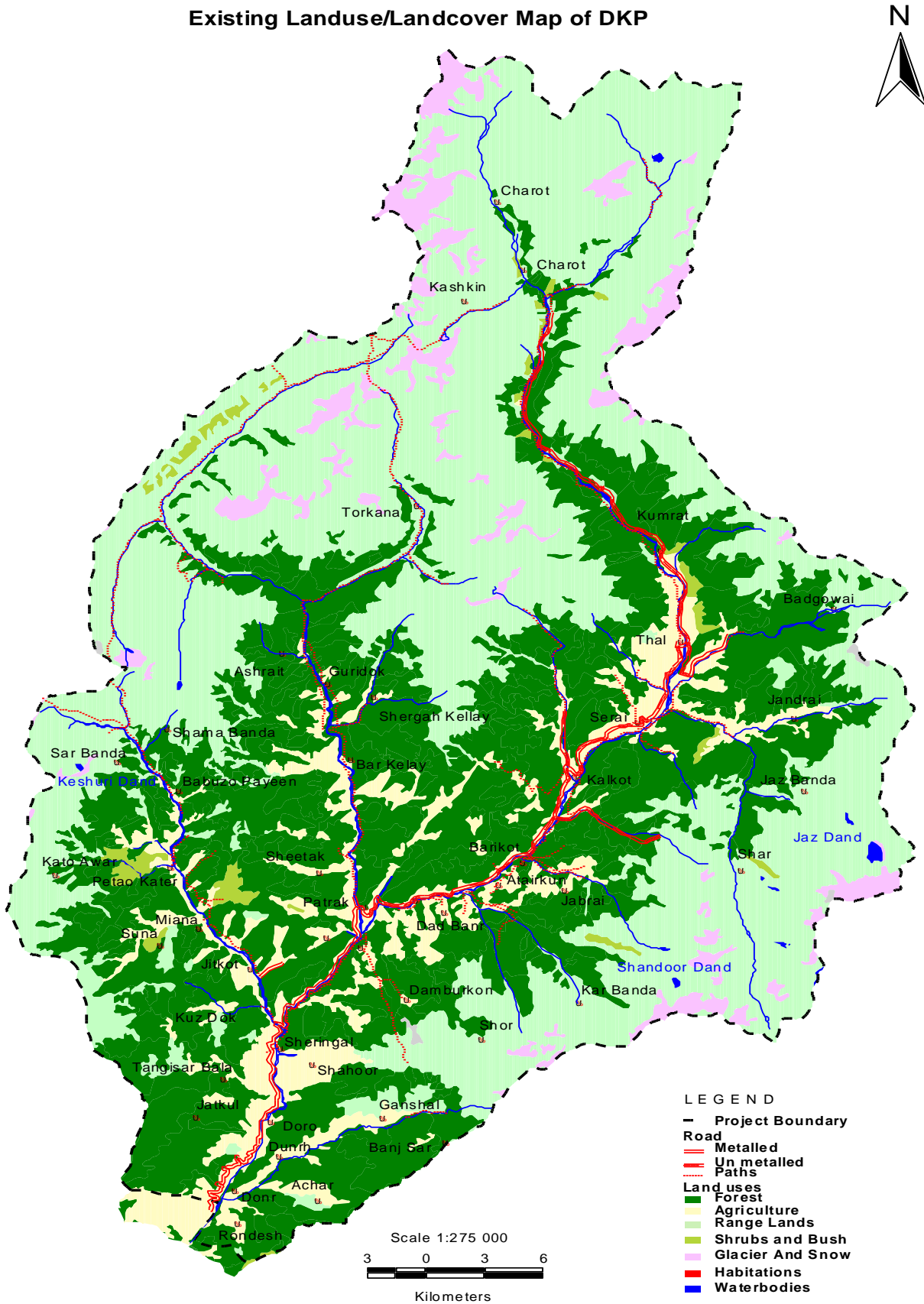**Figure 1.** Image of Roshi Dab.

Figure 2. Image of Bothore Dab.

Existing Landuse/Landcover Map of DKP

N

L E G E N D

- — Project Boundary

Road
- — Metalled
- — Un metalled
- ···· Paths

Land uses
- Forest
- Agriculture
- Range Lands
- Shrubs and Bush
- Glacier And Snow
- Habitations
- Waterbodies

Scale 1:275 000

3   0   3   6

Kilometers

Figure 3. GIS image of Dir Kohistan.

$$R2=0.13$$
$$f=-892.24+34.31*x+-0.0044*x^2+1.87E-007*x^3$$
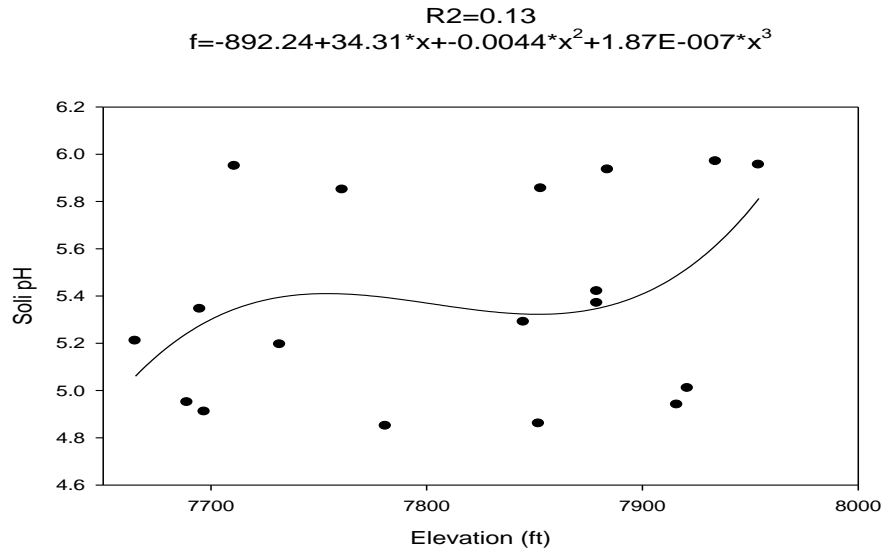
Figure 4. Relation between soil pH and Elevation (ft).

$$R2=0.61$$
$$f=-60.47+23.31*x+b-0.003x^2+1.27E-007*x^3$$
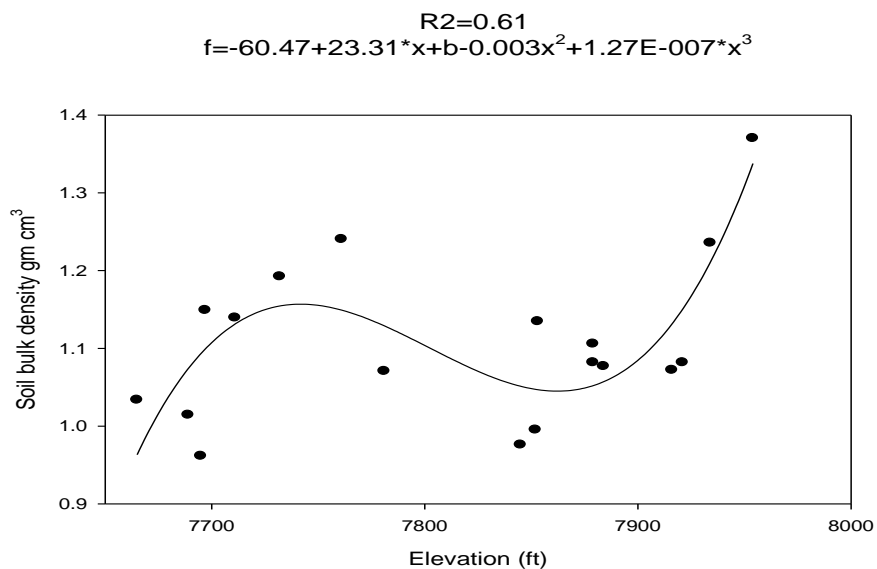
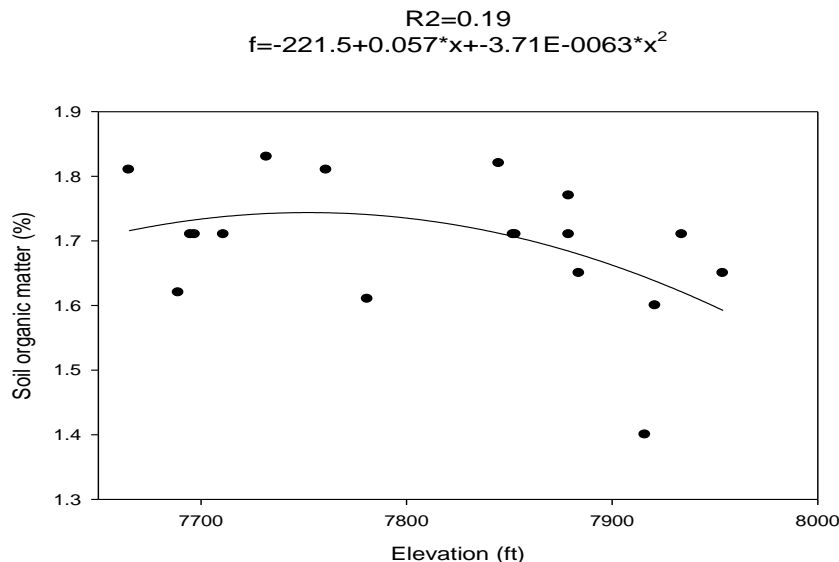**Figure 5.** Relationship between soil BD (gm cm^3) and Elevation (ft).

while the maximum soil sample weight was 142.5 g. The average soil sample weight was 116.77 g. Soil pH ranged from 4.5 to 5.9. The average soil pH was 5.3 which showed the acidity in nature. A regression model between soil pH and Elevation (ft) was developed (Figure 4).

Soil bulk density in all sample unit ranged from 0.96 to 1.37 g/cm^3. The mean soil bulk density was 1.107 g/cm^3. Soil SBD (g/cm$^{3)}$ in UDRL ranges from was 0.96 to 1.19 g/cm^3. Mean soil bulk density was 1.058 g/cm^3. RLNFL have the minimum and maximum SD in this site was 1.07 g/cm^3 and 1.37 g/cm^3 respectively. Mean soil bulk density

is 1.199 g/cm^3. The soil near to agriculture land BD ranges from 0.99 g/cm^3 to 1.14 g/cm^3. Mean soil bulk density was 1.06 g/cm^3. A regression model was developed between SBD and Elevation (Figure 5)

SOM% of all these sample units is ranges from 1.4% to 1.83%. Mean SOM% is 1.69%. Undisturbed range lands have SOM% ranges from 1.71% to maximum of 1.83% while the mean soil organic matter % is 1.775. Range lands near to forest land have SOM ranges from 1.65% to maximum of 1.81% while the mean SOM% is 1.70%. SOM% in range lands near to agriculture land is ranges from 1.4% to maximum of 1.71% while the mean SOM%

R2=0.19

$$f = -221.5 + 0.057 \cdot x + -3.71E\text{-}0063 \cdot x^2$$

Figure 6. Relationship between Soil organic matter % and elevation (ft).

R2=0.19

$$f = -128.4 + 0.033 \cdot x + -2.15E\text{-}006 \cdot x^2$$
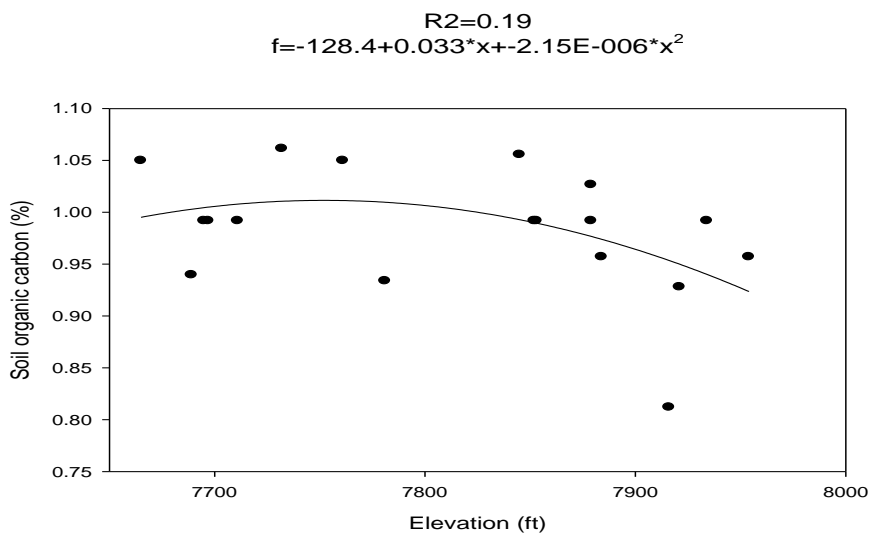
Figure 7. Relationship between soil organic carbon % and elevation in each study site.

is 1.60%. These statistics shows that SOM% is more in undisturbed range land while less in range land near to forest land and lesser in range land near to agriculture lands. It is due to the severe disturbance of land soil surface which leads to prevent the soil from carbon storage. A regression model was developed between SOM% and elevation (Figure 6).

SOC% ranged from 0.92 to 1.05%. Mean SOC% was 0.98%. SOC% in undisturbed range lands ranged from 0.99to of 1.05%. Mean SOC% 1.02%. SOC in range lands near to forest lands ranges from 0.95 to 1.04%. Mean SOC% was 0.989%. SOC in range lands near to

agriculture lands ranged from 0.92 0.99% while mean SOC% was 0.93%. A regression model was developed between SOC% and elevation (Figure 7). Land use change can go ahead to change in a range of soil properties, including soil carbon (C), nitrogen (N) content, soil bulk density and pH (Callesen et al., 2003). Though, Lal (2004) reported that more conventional soil properties such as total C, it is susceptible to land use change as complicated physical fractionation schemes. Soil is the largest organic C reservoir in the terrestrial biosphere, about two times superior than that of vegetation or the atmosphere (Schlesinger, 1997). These results showed

R2=0.63
$$f=-1540344.7+588.8*x+-0.07*x^2+3.18E\text{-}006*x^3$$
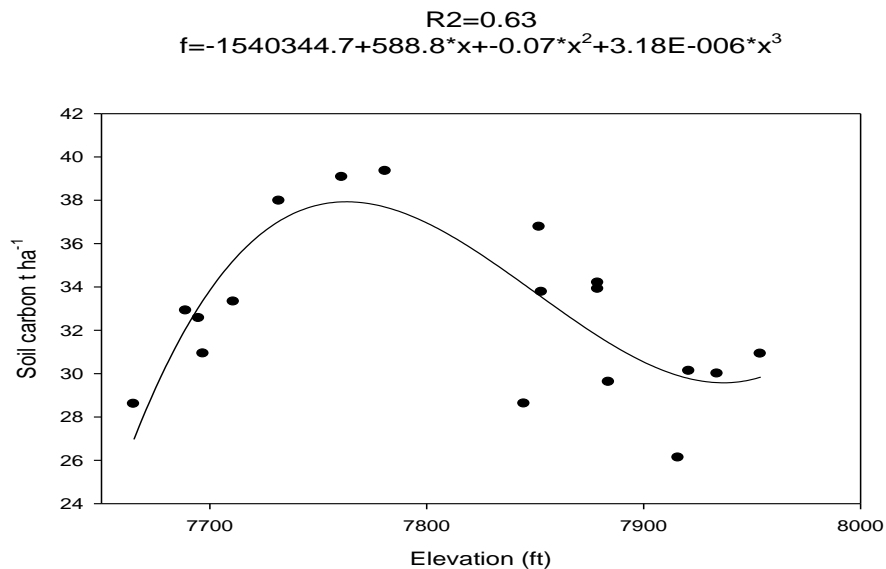
Figure 8. Relationship between soil carbon t ha^{-1} and elevation.

that the undisturbed range land has more carbon stored while range lands near to agriculture lands stored less in their soils. In Undisturbed range land SOC (tons hac^{-1}) ranges from 28.61 tons hac^{-1} to 37.96 tons hac^{-1}. The Mean SOC was 32.69 tons hac^{-1}. Range lands near to forests stored an average soil carbon of 35.62 t ha^{-1}. Range lands near to agriculture lands stored an average soil carbon of 29.77 tons hac^{-1}. These results showed that the undisturbed range lands soils stored maximum amount of SOC while soils of range lands near to forest lands stored less soil carbon t ha^{-1}. A regression model was developed between SOC tons hac-1 and elevation (Figure 8).

RECOMMENDATION

The present study stated that if the range lands were not disturbed, it will bring a lot of rest in global climate change. As shown in Tables 1, 2, 3 and 4 the maximum organic carbon was stored by the range lands near to forest land and range lands which are not disturbed yet. While in other hand the range lands which are disturbed or will be disturbed in near future will lose the ability of storing organic carbon concentration.

The areas were remote and due to raising human and livestock population, the area was affected harshly. So the forest department is directed to raise awareness in local people and give special attention to this new raising problem.

Conflict of interests

The author(s) did not declare any conflict of interest.

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