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Integrated Micro Watershed Management for Enhanced Crop Productivity, to Improve Bio-Diversity and Local Eco-System - at Village Kambrial, District Attock - Pakistan

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Abstract

Climate change, rising population, rapid urbanisation and changing water consumption patterns present unprecedented challenges for the water sector over the next two decades. Adverse impacts of climate change on water resources is contributing towards water scarcity, environmental degradation and poses enormous threat to food security and to ecosystem. Agriculture is the mainstay and major component of Pakistan's national economy and at the average contributes about 24% per annum in national GDP. The agriculture sector is also a mean of livelihood for more than half of Pakistan's population. Pothohar region of Pakistan, being a vast rain fed zone, is stretched over an area of over 2.2 mha and has been blessed with plenty of rainfalls (ranges from 650 mm to 1200 mm). Due to typical topography of Pothohar, the huge fluxes of surface runoff are generated during Monsoon Season which are not only lost but also causes sever land degradations. To promote agriculture in the region, these surface waters needs to be harvested wherever feasible and should be utilized for subsequent agricultural purposes and to improve the ecosystem and fragile ecologies. Moreover, since entire Pothohar is watershed area, therefore, necessary intellegent watershed management is essential to ensure better investments returns on water harvesting systems. As per AR-5 (IPCC-2014), Pakistan is one of the most vulnerable country to the adverse impacts of climate change. Therefore, under the predicted climate change vulnerability, micro watershed project was planned and completed at village Kambrial, located at Pindi Gaib Tehsil of district Attock through which around 70 Acre Feet of rain water was harvested. The rain water so collected was used for tunell vegitable farming, high value fruit orchards and for other local and seasonal crops.

Keywords: Adverse Impacts; Climate Change; Ecosystem; Ecology; Environment; Energy; Food; Water Resources; Micro Watershed; Rain Water Harvesting

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1. Introduction

Pakistan is one the front state which is going be imapcted by the adverse imapcts of climate change on its already scarce water resources. It is estimated that global population is projected to reach 9 billion in 2050, thereby, water demand for food production and for other aggricultur activities will increase exponatially by over 50% in 2030 and 70% in 2050 (UN-Water, 2013). World over, on the average, agriculture is the largest user of water with irrigation accounting for nearly 70% of all freshwater withdrawals (UN-Water, 2016), but in Pakistan, agricultur activities consumes 80-85% fresh water. Therefore, good water goverance has become inevetable for Pakistan to avert ever increasing water demand by resorting to / and harvesting and managing all the available water resources. Pakistan can make use of natural ground profile / layout for making efficient area based rain water harvesting plans, besides having other prudent water resource management interventions.

The potentials of mciro watershed management, area based rainwater harvesting and off-channel storage in entire Pakistan and Pothohar region are describles as under;

1.1. Large Water Storage Sites to consider Rohtas and Soan Lakes / Dams - for Rain Water Harvesting

Sizable water storage can be achieved by developing / having various on and off channel small lakes and reservoirs, as shown in figure 1.

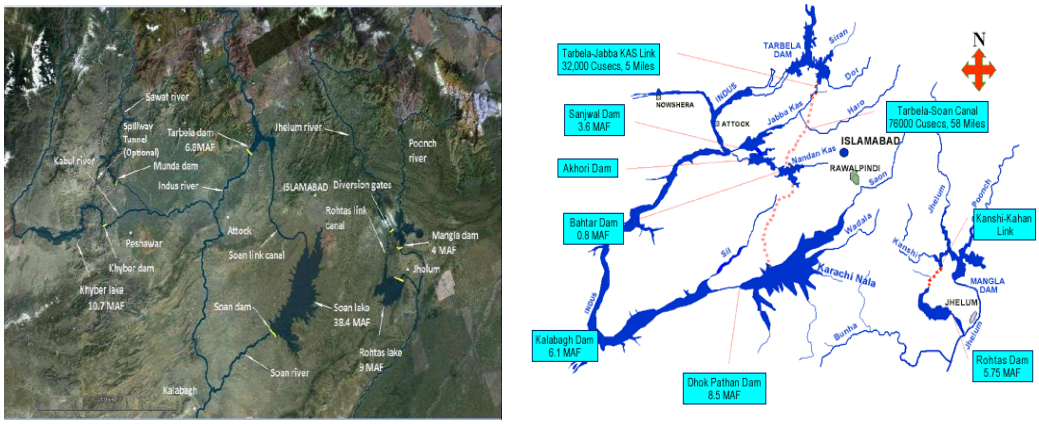

Figure 1. Google map lay out plan of various potential water storage sites- for small lakes and dams on river Soan- District Rawalpindi

1.2. Water Potentials - Rodhkoi during Monsoon- Pakistan

Rodhkoi is a phenomenon through which slopes of mountain ranges of various mountains provide a sizable watershed area during rainy seasons, particularly, during monsoon season, The Rodhkoi water potentials in the entire country are shown table 1.

Table 1. Rodhkoi Water storage potentials - Pakistan

Province	Potential, Area - MA	Potential Water - MAF	Ratio of Water to Area (acre feet/acre)
Fedearl	0.67	2.84	4.2
KPK	2.13	4.56	2.1
Punjab	1.41	2.71	1.9
Sindh	1.36	0.72	0.5
Baluchistan	11.56	7.85	0.7
Total	17.13	18.68	1.1

Source: *Mater Feasibility Studies for Flood Management of Hill-Torrents, NESPAK, 1998. (Source: WRRI, NARC)*

1.3. Supply side water management for Pothohar-small and medium dams

Pothohar region possesses enormous area based water storage sites which can store large amount of rain water, details are given in table 2 and figure 2.

Table 2. Water storage capacities of various potential small lakes and reserviours - Pothohar region

Source/ River	Location (District)	Storage, MAF	Area under irrigation- Acres	Purpose
Charah/Soan	Rawalpindi	0.07	19400	I.W.P
Morgah/Soan	Rawalpindi	0.01	42000	I.P
Papin/Soan	Rawalpindi	0.05	31400	I.P
Bhaun/Ling	Rawalpindi	0.03	17700	I.P
Chaanit/Soan	Attock	0.09	8000	I.W.P
	Total	0.25	118,500	-
Key: I: irrigation, P: Power, W: Water,				

Agriculture is the mainstay of national economy and averagely contributes about 24% per annum in national GDP. The agriculture sector is also mean of livelihood for more than half of the country population. However, due to rapid increase in population, reduced water availabilities for agriculture (due to increased sectoral competition), projected climate change scenarios, the agriculture sector is most vulnerable and concert efforts are required to sustain and rather improve its potential. The productivity of agricultural sector is also important to ensure food securities at affordable rates and to reduce rural poverty by improving associated livelihoods.

Pothohar being the larger rain fed zone of Pakistan is stretched over an area of over 2.2 mha and has been blessed with plenty of rainfalls (ranges from 1200 +mm in Islamabad to 650 mm in down towards Chakwal). Due to typical topography of Pothohar, the huge fluxes of surface runoff are generated particularly during short

period Monsoon Season and is not only lost but also causes sever land degradations due to erosion process. To promote agriculture in region, these surface waters needs to be essentially harvested wherever feasible and should be efficiently utilized for subsequent agricultural purposes. Moreover, since entire Pothohar is watershed area, so necessary watershed management is essential to ensure better investments returns on water harvesting systems. To further improve water availability and to improve overall environment and ecological perspective, domestic wastewaters can be recycled after necessary treatments.

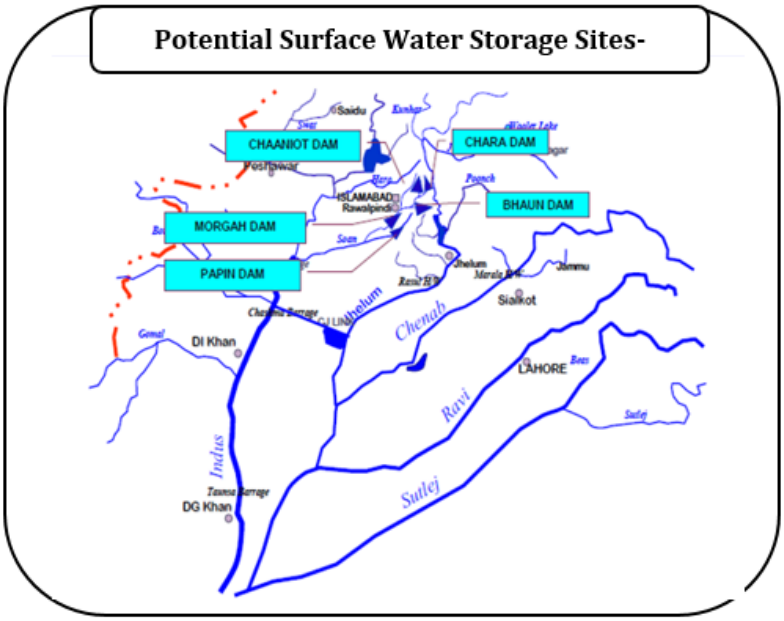

Figure 2. Showing lay out plan of proposed water storage sites in Pothohar region

Therefore, keeping in view the alrming state of future water availability scenarios, a micro watershed management project was planned in village Kambrial, tehsil Pindigheb and District Attock.

2. Literature review

In Pakistan, agriculture or agro based bussinesses are not progressing well and possesses its downwords trends with declining share GDP, even having these decling trends, agriculture is still figures out as one of the largest sector which contributes approximately 21 percent to GDP and is providing livilyhood to 44 percent of its population. Pakistan has the largest irrigation canal network and its agriculture is conviently classified as an irrigated industry. Approximately, out of 23.5 million hectares of its total cultivable land, 19.62 million hectares falls into the catageory of irrigated area, which is about / contributes 90% of its total agriculture products. In Pakistan, approximately 60-70 population rely on agro business. In world over, like in other under developed and developing countries, poverty in Pakistan is very much hinges on the development of agriculture activities/practices and unfortunately, very less emphasis has been laid on modernization of

agriculture industry which is causing / increasing poverty index. Therefore, it is evedent that development of agriculture will be a principal vehicle for minimizing and gradually alleviating rural area poverty (GOP, 2008).

World's population is increasing and it is estimated that by 2050, the population will reach upto 9.1 billion and will cross over 10 billion by close of the century. Agriculture is the main stay and economy of developing countries based on agriculture (UNFPA,2011). Therefore, climate smart interventions are essentially needed to enhance the crop productivity and yield to ensure the food security for the growing population. The integrated watershed development program with participatory approach was envisaged and practiced from 1980s. The integrated micro watershed management focused to enhance crop productivity, crop yields, improving local ecosystem and livelihood generations for the target communities in related watersheds (Wani, 2006) alongwith ensuring water availability, through area based rain water harvesting means, improving soil conservations and controlling soil de-gradation phenomenon

The increasing trends of global population would put further stress on food security, thereby demanding enhanced food production which will consequently demand for more water which has already become a scarce resource. The adverse impacts of climate change have further aggravated the water availability scenarios (Molden, 2007). Even in urban areas, rain water harvesting has become inevitable in many of the Indian megacities, as these cities face severe water supply problems due to massive urbanization. The current approaches to counter this problem of water scarcity also includes ground water aquifer recharge through various rainwater harvesting interventions (Srinivasan, 2010)

In Pothohar region of Pakistan is consist of undulating grounds which form natural ravines and water ways to harvest rain and flood water. The Pothohar area is best suited for establishment of water banks, which can be charged with area based rain water harvesting, treated wsatewater and ground water. Creation of geogrphic specific water banks will not only provide irrigation water, but will also improve the local ecosystem and biodiversity. The area offers tremendous potentials for improvement of water resource managemnt, both surface and ground). Water resource Management implies, improvement or remodeling of exsiting natural water reserviours and constructionof new storage reserviours, both off channels and on the run of the river. Numerous small size dams, ponds and reserviours in the entire area may harest large quantum of rain water. It is woth noting that each millimetre of water harvested /collected, stored, conserved and saved in these areas can produce wheat by an average of about 10 kg/ha (Marshal and Holmes, 1988).

The rain fall pattern is changing and with vast variations which is adversely impacting the crop productivities in the entire Pothohar region. Due to food insecurity, the most vunerable communities are migrating to urban areas. Therefore, all out effrots are required to be made to fully utilize the ground lay out / topography for planing, desinging and execution of micro watershed management projects in the Pothohar region to ensure water availability. Over and above, the topography of the area helps in generating high velocities during precipitation which cauases massive scales of land degradation and errosion which is catastrphic for environments. All Agriculture based activities in the entire Pothohar region, therefore, hinges entirely on continuity of the rainfall pattern, which are not assured for the entire season. The un-predicted hydrological cycle is the main cause of drought conditions in the area. Therefore, the only handy solution lies on conserving the rain run-off for agriculture activities by way of creation of water banks, small localized

reserviour, dams / ponds, which will ensure around the year water availbility which will help the farmers for assured agriculture activities. The hravested water will help in eliminating the hazards environments, caused by delayed rains at the time of sowing and growing when the delay in non-availbility of water may result in the visible reduction of crop productivities and yield to less than half (Small Dam Organization, 2007).

There are multiple options to increase the crop yields, like increasing the use of fertilzers, cultivated area and ensuring required water availbility. The water availbility gets the precedence over other options which are capital intensive and therefore, for maximium crop production per acre water in-put is the most workable and essential option to increase the crop yieds (Bhutta, 1999).

3. Objectives

This micro watershed management project entails following objectives;

a. To highlight and promote sustainable and innovative irrigation techniques to reduce soil erosion and soil conservation interventions.
b. To evaluate area based rain water harvesting and its potential use for tunell farming and high value fruit orchards and for enhancing local crop productivities.
c. To study rechage of local ground water aqufier, improved biodiversity and local ecosystem
d. To present this model as a resource centre for knowledge sharing and capacity building for replication such interventions elsewhere in the region

4. Material and methods

4.1. Project area geographical location and profile

Kambrial village is located in Tehsil Pindi Gheb District Attock. Kamrial itself is Union Council headquarter. The geographical coordinates of kamrial are 33°17'13"North 72°34'36"East, with the population of 12437 nos (1998 census). There are 13 union councils (UC 48- UC60), with total population of 199439 nos (1998 censes). The project area location map is shown in figure 3.

Pindi Gheb is located at 110 kilometers from Rawalpindi and 102 kilometers from district Attock. Tehsil Pindi Gheb is bounded in North with Tehsil Attock, West Tehsil Jand, South Tehsil Talagang District Chakwal, and East Tehsil Fateh Jang. The River Indus bounds it on the north-west. The location of kambrial village is marked in red circle in the map, as shown in figure-3, above.

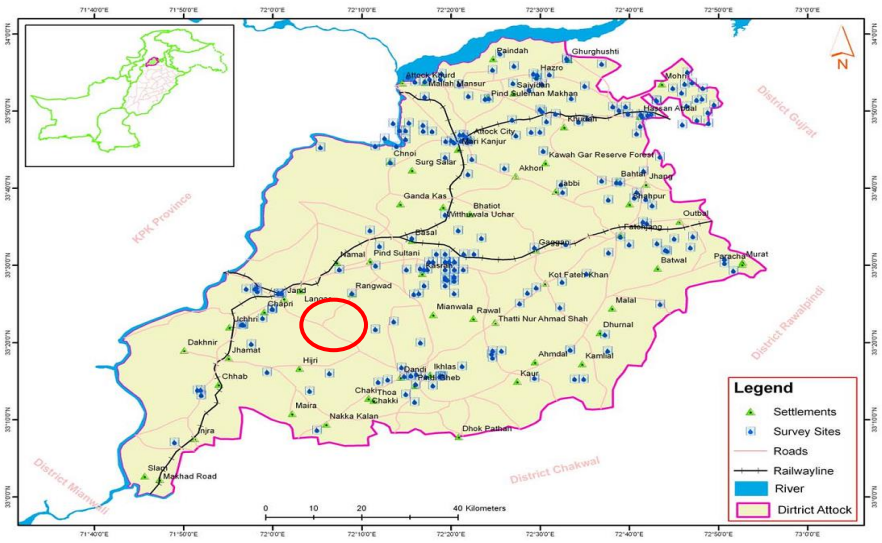

Figure 3. Location map of project area

4.2. Ground and weather conditions

The ground profile of Pindigheb tehsīl is comprosed of undulation and broken land tracts and land segments which are mainly formed by sand stones, crissed-cross by all sized of ravines which get sowllen in the rainy season. The small hillocks consists of small pebbles and gravels make the major components of ground layout / profile -sloping from east to west. The population in the area is in scattered form in the form of small villages whose livlyhood depends on scanty rainfall patterns. In the west, along the River Indus are the deep ravines and stony and pebble ridges which surround Makhad. The Sil river which flows near the town presents the vast tracts of cultiable lands which is earnestly being used by the local population for agricultur purposes.

4.3. Water availability

Water availability in Tehsil Pindi Gheb area is very low, mostly tehsil area depends on rain water for agriculture. Weather conditions remains harsh in the most of the year and there is no major water reservoir available in the area.

4.4. Integrated Water shed management project conception in Pothohar Region - A new Initiative for enhancing agriculture Productivity, Livelihood Generation and for Improved biodiversity

Pothohar region is one the of lagrest rain fed semi arid area of Pakistan, stretched over an area of over 2.2 mha and has been blessed with plenty of rainfalls (ranges from 1200 mm in Islamabad to 650 mm in down towards Chakwal and surroundings areas). Due to undulated / broken topography of Pothohar, the huge fluxes of surface runoff are generated particularly during monsoon season. This huge natural resource is not only lost without gaining enormous benefits but also causes sever damges to men and material, like loss of human life, damges to properties, and land degradations due to erosion process. The Pothohar region possesses

tremndous area based rainwater harvesting potentials which is essentially required to be harvested to promote agriculture activities, wherever feasible. Moreover, since entire Pothohar is watershed area, so necessary watershed management is essential to ensure better investments returns on area based rainwater water harvesting systems. To further improve water availability and to improve overall environment and ecological perspective, domestic wastewaters can also be recycled after necessary treatments. This will also reduce ground water contamination which was being caused due to sepage of un-treated domestic sewerage

4.4.1. In the backdrop of above, a pilot scale research project (micro watershed management) was proposed and planned, encompassing following activities and components;

a. The piece of land measuring 7-8 Acres, located in village Kambrial (for water storage reseviours) was offered by Mr. Khalid Sultan, a local landlord (Ex-Buearucrate) Who has already numerous such human & environmental protection initiatives in his credit.
b. The financial resources to the tune of Rs 20 million were provided by the minstry of food security - The government of Pakistan.
c. The construction works were caaried out under the suppervision of National Agrculture Research Centre (NARC) by employing local contractors.
d. The earth work was carriedn out by the landlord himself and the necessary heavy plant was provided by local government department on subsidized rates. The project was planned to be executed on / through participatory basis.
e. Establishment of high value fruits orchards, and vegetable tunnel farming over an area of 4 acres.
f. Rain gun fed wheat crop over an area of 3 acre.
g. Creation of market linkages for products disposal.
h. Short term Community capacity building programs.
i. Organizing FFDs, Seminars/ workshops for knowledge sharing with the view to replicate such interventions in the entire Pothohar region etc.

4.5. Micro watershed management project over view - Kambrial, district Attock

keeping in view the enormous agriculture potentials of the area, which could not be tapped due to non-availability of water, the micro watershed management concept was planned to harvest and collection of rain water. A comprehensive drip irrigation system was planned for pumping of harvested water through solar power driven pumping system. The details of all such interventions are given in the precceding paragraphs / in detailed methodolgy.

4.5.1. Methodology, including experimental design and data analysis

Following methodologies and construction activities were envisaged and followed;

a. Village Kambrial of district Attock was selected for this micro watershed management project, through area based rain water harvesting intervention, through intensive ground reconnicence and interacting with local landlords (land owners) keeping in view the suitable site selection criterion.

b. Baseline surveys (KAP - knowledge, apptitude and practices) was conducted to document local area needs, irrigation practices and willingness to develop such project in the area. Accordingly, survey of the proposed area (contours map in relation with the catchments area etc were prepared which included base maps of watershed and command area, showing locations and various proposed structures and ground lay outs / boundaries. The GIS map, as prepared, is shown in figure 4.

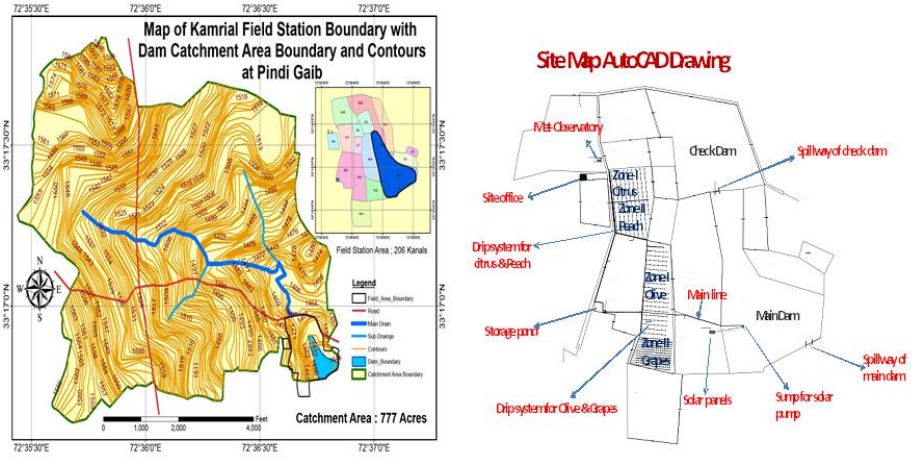

Figure 4. Project base map, showing various point and locations

c. Construction of water storage reservoirs, namely, check dam and main water storage reserviour was carried out with heavy earth moving plants, by reshaping/ remodeling the huge quantum of earth work in the existing non-perinial water course. The some portion of earthen embakments of check dam and main reserviour was stone pitched to guard against any seepage. Spillways at check dam and main rserviour were provid to allow overflow of stored water. Since, the soil of site had high porosity, therefore, 0.25 mm geo-membrane was laid on the bed of main reserviour. The total capcity of both the reserviours (check dam and main reserviour) 60 acre feet and 70 acre feet. The main purpose of check dam was to guard against sediments flow towards / into main reserviour.

d. Various earth work activities are shown in figure 5.

Figure 5. Showing various earth work activities at main water storage reserviour

e. Best watershed management practices for soil errosion in the catchments area were adopted, by planting 3000-4000 trees to avoid land degradation and to minimise sediments transport. dry stone masonary breast and retaining walls were constructed at steep slopes of terraced ground profiles which prevented land degradation at larger scales.

f. After completion of earth work and allied river traing works, both the reserviours were filled with rain water from the catchments area, during monson season.

g. Automatic met-observatory station was established to record metrological data on daily bases, as shown in the figure 6.

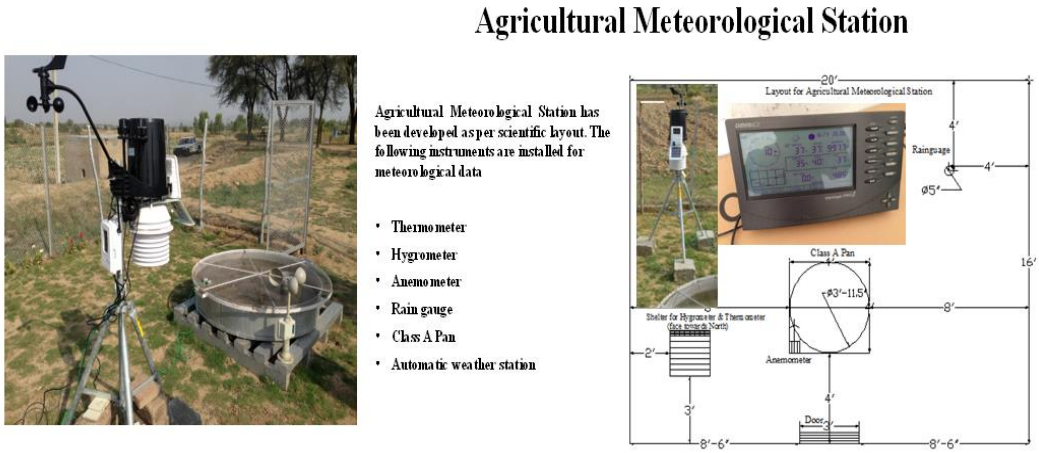

Figure 6. Metrological observatory post at project site

h. Accordingly, 70- and 60-acre feet capacity main storage reservoir and check dam was constructed, which involved following major activities;

1. Huge quantum of earth work, stone pitching acre feet capacity main storage Development of rainwater harvesting system (55 acres-ft) capacity.
2. Stone pitching on the selected portion of the earthen embankments.
3. Laying of 0.25 mm geo-membranes in the bed of main reservoir to stop water seepage due to high soil porosity.
4. Spillways at both the reservoirs for safe passage of over flow of rain water.
5. Installation of indigenously designed prefabricated concrete filter while (solar driven) water pumping.
6. The layout of entire system / components of both the reservoirs are shown in the figure 7.

i. Solar operated pumping system was installed, an alternative energy source, for up-lifting of stored water from main dam. Submersible pump was lowered in the indigenously designed filter to up-lift filtered water. The pumped water was stored in an elevated concrete water tank of 1.5 lakh gallon capacity, from where the water was made to flow on gravity through drip irrigation network for various crops, vegetable tunnels and high value fruit orchards (Olive, Grapes and persimmon) etc**.** The layout of solar system and drip irrigation system is shown in figure 8**,** 9 and 10.

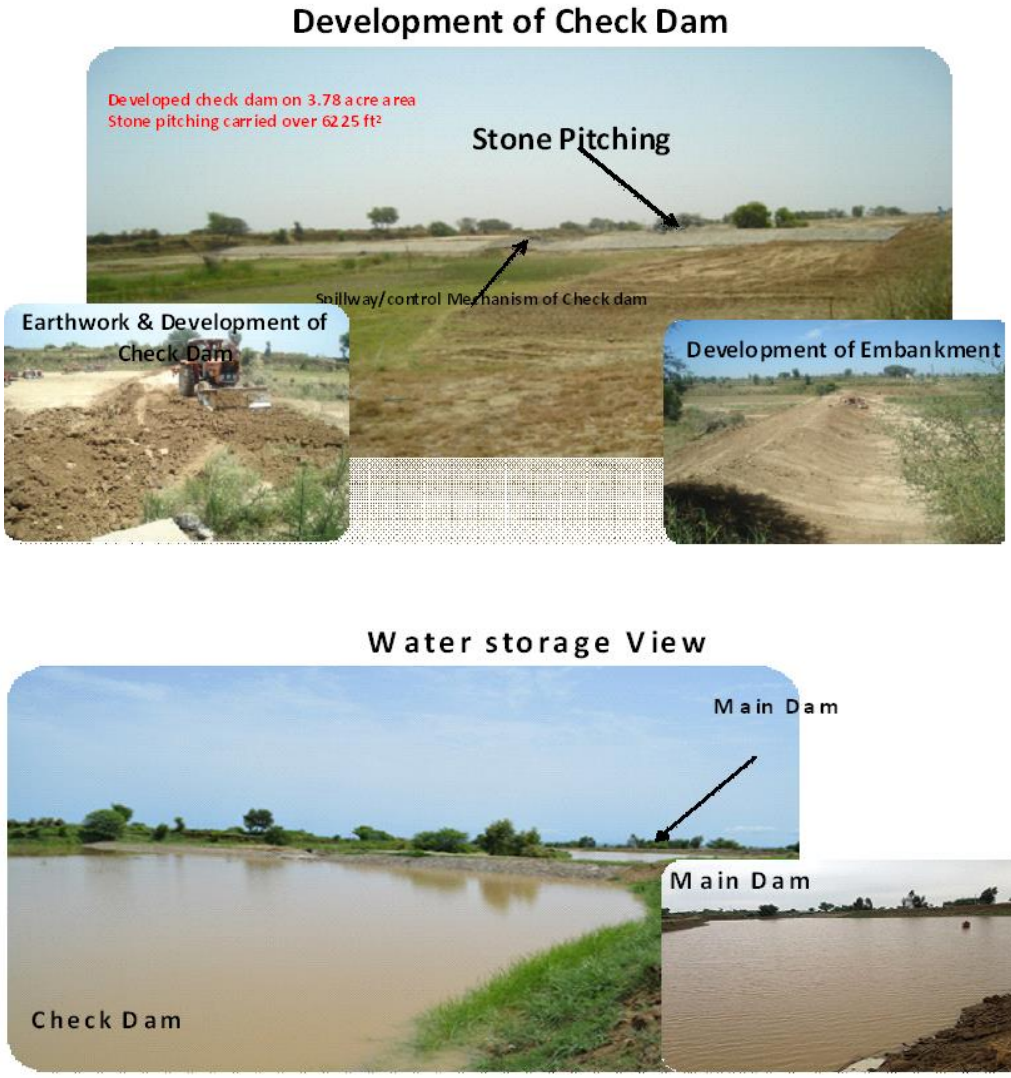

Figure 7. Main reservoir and check dam, showing various components

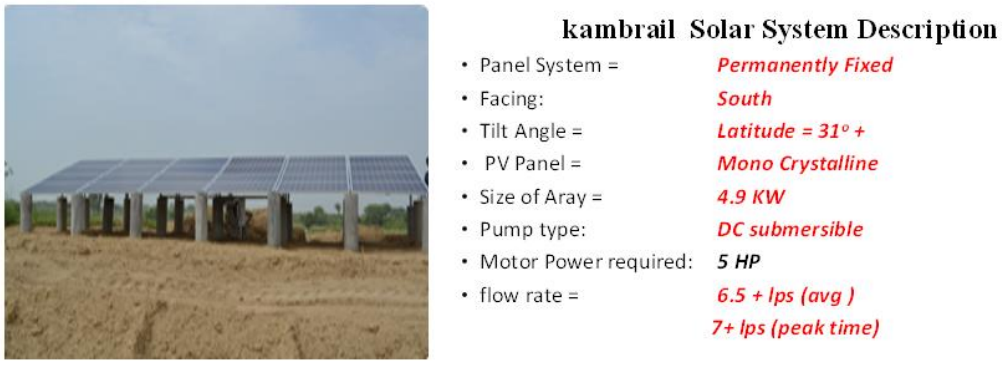

Figure 8. Technical data of solar system for water pumping

Figure 9. Water pump through indigenously designed water filter, operated through solar power system

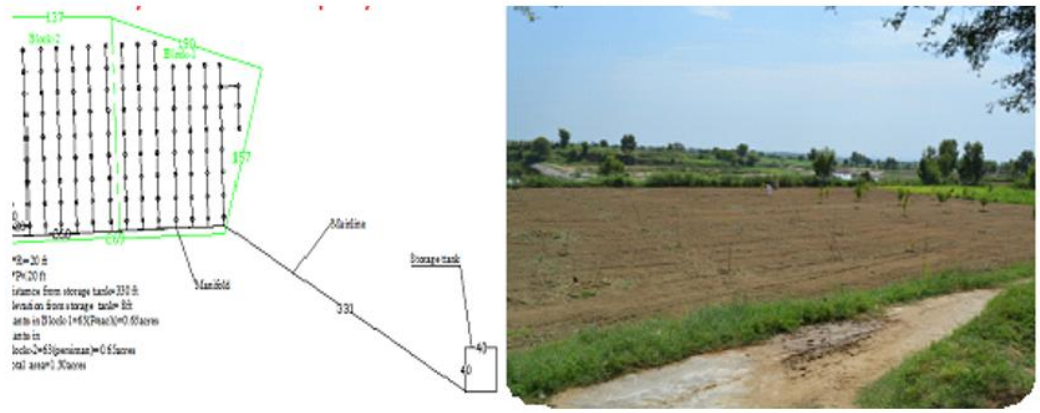

Figure 10. Layout of drip irrigation network for persimmon and peach fruit orchard

5. Results and discussion

5.1. Project outcomes - watershed management at Kambrial

Micro-watershed management is an excellent concept of boosting and enhancing agriculture productivity aimed to/at livelihood generations, improving bio-diversity and eco-system, recharge of ground water aquifer in water scarce area of village Kambrial etc. The photographic activity details are as under;

a. The moonson seaons sets in Pakistan from 15 June to 15 Oct, each year when lot of rains takes place. The rain fall intensity in the project area from 15 August to 30th August is shown in the table 3.

Table 3. Date wise rain fall intensity in the project area- 15August to 30th August

Meteorological Data Augest, 2014-Kamrial Field Station, Pindigheb, Islamabad									
	Max Temp (°C)	Min Temp (°C)	Avg Temp (°C)	Wind Speed. (km/day)	Daily Evaporation (mm)	Rainfall (mm)	Avg. Relatve Humidity (%)	Solar Radiation (W/m²)	Daily Suhshine hours
15, Aug	24	16	28.17	7.81	4.18	69.4	82.04	375.87	13:23
16	26	18	23.25	5.01	2.97	29.2	88.11	381.04	13:22
17	23	12	25.92	2.80	4.48	0.2	80.10	483.15	13:20
18	23	12	28.24	2.25	4.77		77.03	489.02	13:18
19	30	12	29.16	0.90	4.81		79.56	517.02	13:16
20	29	13	30.02	3.02	4.59		80.78	464.15	13:14
21	27	14	30.21	4.20	4.32		77.10	408.96	13:12
22	26	13	28.82	4.04	4.11	7.4	74.49	411.56	13:11
23	22	14	26.51	1.27	3.89		79.26	431.90	13:09
24	16	15	29.29	1.62	4.56		74.61	479.90	13:07
25	20	12	29.25	3.49	4.64	0.8	72.52	453.21	13:05
26	23	11	27.02	3.67	4.75	8.4	71.73	484.49	13:03
27	25	14	26.68	1.28	4.26		73.84	473.38	13:01
28	27	13	26.54	2.92	3.42		72.16	337.90	12:59
29	30	14	27.29	1.40	4.59		71.92	499.96	12:57
30	29	14	28.50	1.27	4.54		71.26	472.32	12:55
31	29	13	29.51	2.00	4.52		66.83	467.65	12:53
Avg.	29.20	14.87	27.12	2.98	4.33		74.80	450.83	
Total					77.73	115.40			

b. This 115.40 mm rain contributed towards harvesting of approximately 70 acre feet of water in the main reseviour, which is a big gain in the water scarce area and this huge quantum was good enough for agriculture practices. This water reseviour can be termed as **"water bank"** which can further be augmented with treated wastewater and pumping sepage ground water etc.

c. Certain climatatic data was collected through the metrological station and the details are shown in table 4.

Table 4. Metrological field reading / data on various dates

Month	Max Temp (C°)	Min Temp (C°)	Wind Speed. km/day	Avg.Pan Evap(mm)	Pan Evap(mm) Total	Rainfall (mm)	Avg. Relatve Humidity (%)
Oct-14	28.50	16.74	3.30	2.69	83.45	49.60	72.60
Nov-14	24.28	8.68	2.90	2.58	77.45	3.40	59
Dec-14					**40.7**	**2.22**	
Jan-15					38.71	0.00	
Feb-15	19.31	8.50	3.80	0.03	32.00	139.00	68
Mar-15	26.50	16.80	3.57	2.52	78.96	129.33	74

d. Soil mositure was calculated by using standard scientific procedures and details of soil moisture is shown in table 5, below;

Table 5. Soil moisture of the reserviour site

Location	Sample Depth (cm)	pan Number	pan Weight (a)	pan + Soil Weight (b)	pan+ Dry Soil Weight ©	Dry Soil Weight (c-a)	Water (b-c)	Moisture% By Weight b-c/c-a x100
Kambrial	0-15	1	131.21	167.21	161.76	30.55	5.45	***17.84***
	15-30	2	133.57	198.54	182.33	48.76	16.21	***33.24***
	30-60	3	141.62	288.23	271.54	129.92	16.69	***12.85***
	60-90	4	136.48	258.87	236.65	100.17	22.22	***22.18***

e. This area based micro watershed management helped in collecting about 70 Acre Feet of water which is being used for various agricultural activities, as mentioned below;

Main crops, like wheat, peanut and maiz were cultivated and water requirements for the crops were made through drip irrigation net works. The water was pumped, operated by solar energy, and was stored in an naturally elevated water storage tanks. The yield of water pump is shown in the figure 10.

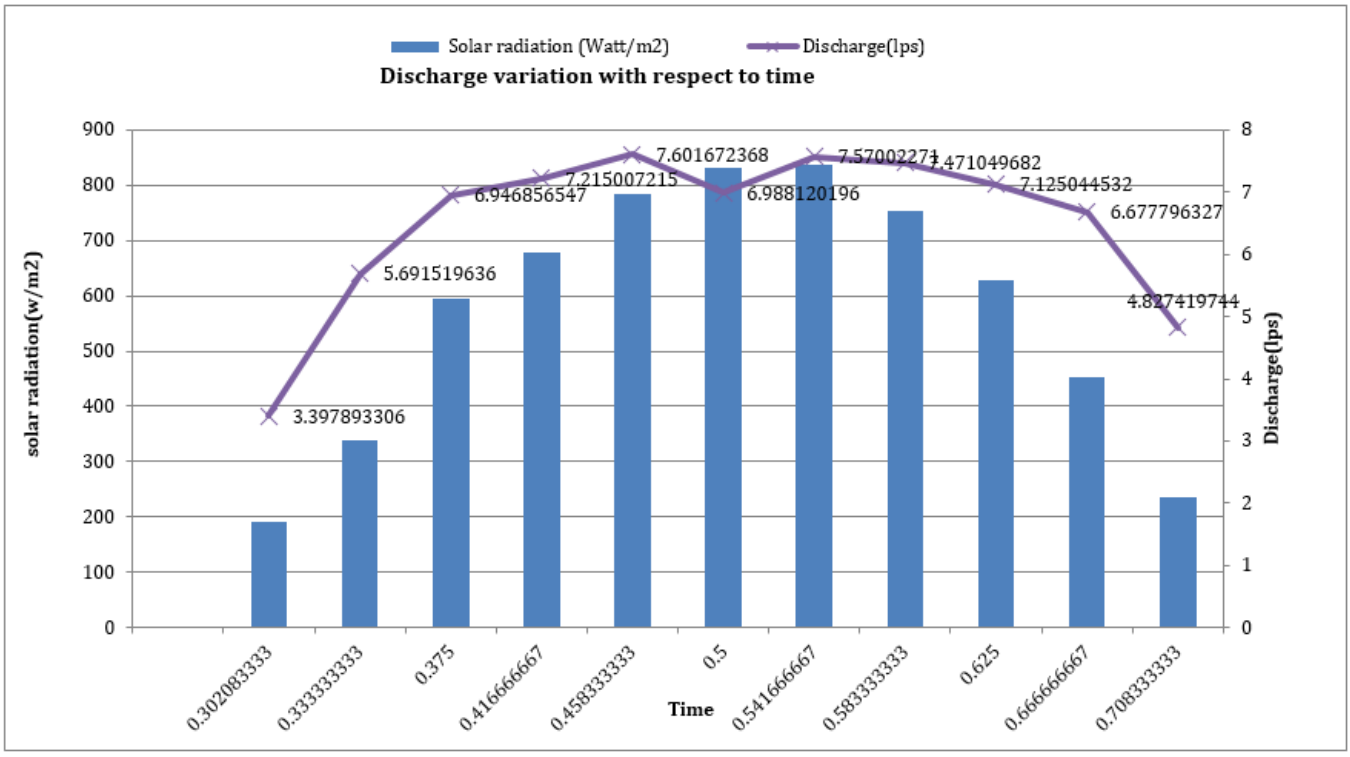

Figure 10. Showing water yield of solar energy operated pump

f. The tunell vegitable farming intervention was designed and water requirements were met through drip tubes, as per the water requirements. The details of vegitable tunell design is shown in figure 11.

Figure 11. Tomato tunnel for cultivation of hybrid tomatoes

g. The high value fruit orchards, consisting of pear, pomegranate, loquat, persimmon, olive and grapes, were cultivated, as shown in figure 12.

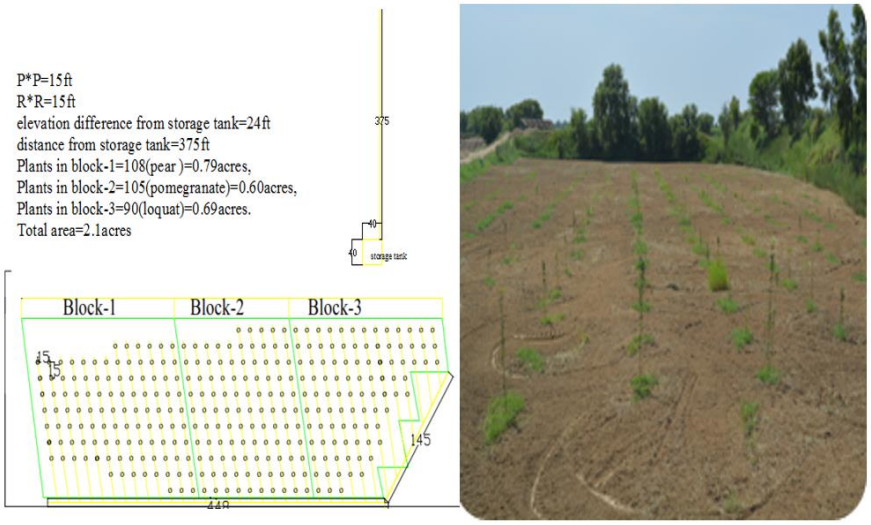

Figure 12. High value orchard of various fruits

h. Potatos were also cultivated and the details of various activities are shown in table 6.

Table 6. Tomato crop stataistics

sowing date	28/09/2014	
Harvesting date	20/01/2015	
Total Irrigation Time	21.5	hr
Discharge	3	l/sec
Volume of water applied	232.2	m3
Total yield	520	kg
Area under the crop	17.6	marla
Water Productivity	2.24	kg/m3
Recommended range	1.92-5.28	kg/m3

i. Value addition approach was envisaged and basing on this, check dam was used for fish breeding and intial fish seeding was implanted with following details, as shown in table 7.

Table 7. Details of fish breeding in check dam

Detail of fish Breeding in check dam - kamrial, Pandigab				
Fish Variety	Quantity	Fish size (in)	Fish price/ piece	Total cost
Rawo fish	250	6	18	4500
Gulfam fish	250	6	20	5000
Selver fish	250	6	15	3750

Akhrott fish	250	6	15	3750
	Total cost			17000

a. Enhanced biodiversity phenomenon was observed, in the form migratory birds, turtle and various kinds of reptiles.
b. Improvement in the local ecosystem and rising ground water tables in the surroundings areas of water reserviours upto 6-8 feet were noted

6. Conclusion

Water demands and needs are growing with the increase in population in many countries, particularly in developing countries. Area based rain water harvesting practices, coupled with value addition interventions will not only address the food insecurity problems, but will also discourage rural to urban migration and will improve biodiversity and local ecosystem. A total of 70-acre feet water was harvested in Kambrial project with the total cost of Rupees 20.00 million ($ 20,000 USD). There is dire need of initiating such projects in entire Pakistan, particularly in the province of Punjab, Baluchistan and KPK, to meet the ever increasing water demands. Government of Pakistan should encourage local land owners, having lands in the potential areas, by providing subsidies and technical backstopping. These micro watershed management projects will not only address the water scarcity problems, but will also contribute towards improving biodiversity and soil/land degradation issues.

Conclusively, such types of water area based rain water harvested reservoirs be established in the potential / target areas which will serve as "water banks" to be used in drought conditions for agriculture purposes. These geographic specific area water banks will also contribute towards improving ground tables in the surrounding areas, will enhance bio-diversity and local ecosystem.

7. Recommendations

a. Studies will be developed to estimate sediments, water productivity enhancements, and performance measurements of solar-based irrigation system and to evaluate developing water bank, by way of storing treated wastewater to enhance the capacity of water bank etc.
b. Relevant data of sediment transport, solar radiations and performance of high efficiency irrigation systems, water productivity evaluations, wastewater treatment effectiveness and reuse potential etc. Moreover data of meteorological parameters will also be taken on regular basis. Data of soil and aquaculture health will also be collected and evaluated for up-scaling.
c. This project should be declared as resource centre for capacity buliding for replication elsewehere in Pothohar region.
d. Relavant Government insitituions, donors and INGOs be persued for provisioning of subsidies to the local farmers for replication of this model in their own lands.
e. Public health department of Government of the Punjab should evaluate installing of drinking water treatment plant for provisioning of safe drinking water on the water reserviour site.

f. The federal Government (Pakistan) should encourage undertaking this intervention in all the areas for expoliting Rodhkoi potentials.

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