Research Article

Agricultural Economy of Skardu is Based on Glaciers and Snow Melting –A Case Study of Burgay Watershed

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Abstract | About two-third of the annual precipitation in Skardu occurs during the winter months (December to April). In general, monsoon period is dry, and only 18% of total annual precipitation occurs during the months of July-October. Burgay watershed is situated upstream of Satpara Dam. Water from this watershed is distributed among the communities according to historically agreed distribution patterns. Water availability vary from season to season. The objective of the instant study was to assess the glaciers/snow water dependence of agriculture activities which have implications for livelihood of the communities. The data collection including flow discharge measurement out of the watershed was regularly measured during September 2015 to November 2015 and March 2016 to September 2016. The results show that during the winter months (November, December, January, February, March and April) flow discharge was relatively low that ranged from 0.76 to 0.82 cfs. In summer months (May, June, July and August) the major flow is generated by snow/glacier melt. The glacier melt increases with increase in air temperature and maximum flow discharge of 31.25cfs was observed during the month of June and then decreases with decrease in air temperature. In general, the snow/glacier melt was the major contributor (79%) during the summer months and spring water contribution was 21%. However, in winter months only spring water is available for drinking and domestic use and hardly any water is available to meet irrigation needs. Based on crop water requirement; severe water shortage estimated during the months of March and April to the extent of 3.12 and 6.87 cfs respectively for irrigating the existing cultivated area. These results show that agriculture in Burgay watershed is highly dependent on snow/glacier melt. The study concludes that agrarian economy of the Burgay watershed is highly dependent on glacier/snow and farmers face sever water shortage at the time of crops sowing in March/April when glacier/snow water is not available. It is therefore recommended to construct water storages at community as well as at farm level as well considering lifting of ground water or river water to meet irrigation water requirements at the crops sowing period.

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Introduction

Skardu is the capital of Baltistan region. The Skardu valley is 10 kilometers wide and 40 kilometers long at the confluence of the Indus River, flowing from near Kailash in Tibet and through neighboring Laddakh before reaching Baltistan (Pakistan Travel Places, Skardu Valley, 2017). It is situated at an altitude of nearly 2,500 m and the town is surrounded by grey-brown coloured mountains, which hide the 8,000 meters' peaks of the nearby Karakoram Range. The climate of Skardu is moderated in the summer due to its high mountain topography that restricts the intense heat of lowland Pakistan to reach there. Because of the mountains blocked of summer monsoon, summer rainfall is thus quite low in Skardu. During April-to-October temperatures vary between a maximum of 27 °C (81 °F) and a minimum (in October) 8 °C i.e. 46 °F (FFK, 2017). However, these mountains result in very severe winter weather. Temperatures can drop to below −10 °C (14 °F) from December to January, midwinter period. The lowest recorded temperature was −24.1 °C (−11 °F) on 7 January 1995 (Pakpedia Encyclopedia Skardu, 2017). The source of water for drinking, domestic use and irrigation for valley dwellers is Satpara Reservoir and 11 watersheds. The main source of water in the Satpara Reservoir and 11 watersheds is snow/glacier melt particularly in summer.

The glaciers and snow in the Northern Regions of Pakistan are the important source of water Pappas, G. 2011 for domestic, irrigation and industrial use in the country like other countries of the South Asia. Likewise, Skardu is heavily depending on glacier/snow melt to meet the water requirement for its agriculture which is a mainstay of the local economy and livelihood and other domestic uses of the water. The communities whose economic dependence is on water from glaciers melting could be at risk for their survival due to retreating of glaciers resulting in water scarcity. This grim scenario has veen reported by a number of researchers. Salik et al. (2015) argued that extreme weather events due to increasing temperature are increasing glacier melting. Sharma and Sharma (2008) stated that above 1000 million people in Asia to face declining freshwater by 2050 and Himalayas' Glacier melting to retreat glaciers placing the people at risk for existence. (Wong, C.M., Williams, C.E., Pittock, J., Collier, U. and P. Schelle, 2007) and Zulfiqar M. (2018) also offered similar arguments and scarcity of water in near future. Historically, cultivable land of Skardu has never been cultivated to the extent of 100% cultivated area mainly due to shortage of irrigation water at sowing time.

About two-third of the annual precipitation in Skardu occurs during the winter months (December to April). In general, monsoon period is dry, and only 18% of total annual precipitation occurs during the months of July-October as reflected in Figure 1. During the period (1992-2013), the annual precipitation in Skardu ranged from 106 to 495 mm with overall average of 250 mm and coefficient of variation was 39% as given in Figure 2.

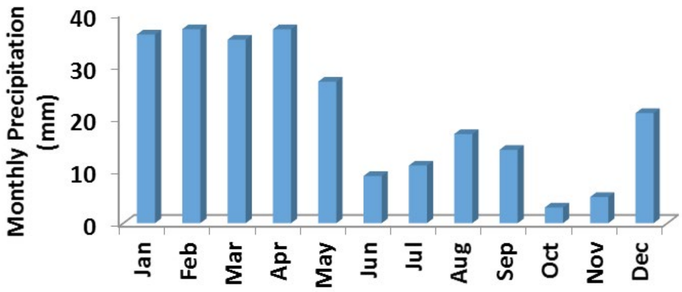

Figure 1: *Average monthly precipitation in Skardu during the period 1992-2013.*
Source: *GB official website and Pakistan meteorological department.*

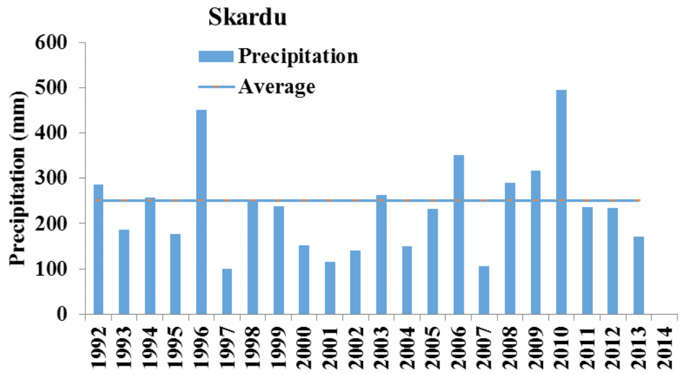

Figure 2: *Annual precipitation in Skardu during the period 1992-2013.*
Source: *GB official Websit, Pakistan meteorological department and current study.*

The average seasonal irrigation requirements of major cereal crops i.e. wheat, barley and maize were found to be 570, 430 and 443 mm. Irrigation requirement of Apricot was relatively higher 916 mm, followed by apple 773 mm and grape of 662 mm per season as depicted in Figure 3.

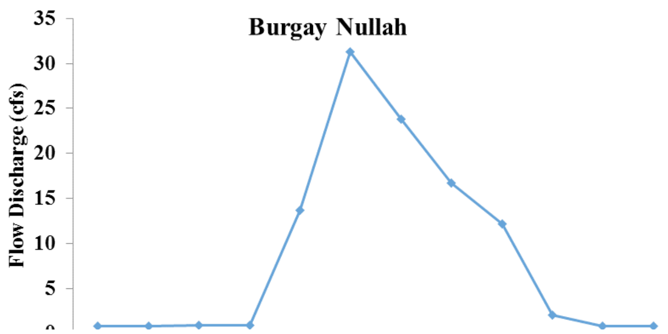

Figure 3: *Irrigation water requirements of different crops in Skardu.*
Source: *Satpara Development Project, Skardu.*

There are eleven (11) watersheds/nullah which provide water for irrigation and domestic use to the local communities outside the traditional command area of Satpara (Field Survey). The command area of these nullah includes Hussain Abad and parts of Shigri Khurd and Shigri Kalan union councils. Out of eleven, Burgay watershed is situated upstream of Left Bank Canal (LBC) of Satpara Dam. Water from this nullah/channel is being distributed among the communities according to historically agreed shares and distribution patterns. Water availability varies from season to season. Maximum water flow (due to glacier/snow melt) occurs during summer and is the main source of water for irrigated agriculture in the area. Water ponds have been constructed in some areas for storing water at night which is used during the day.

With the foregoing background, the present study was conducted with the objective to assess the extent/degree at which agriculture activities depend on glacier and/or snow melt water. As the economy of Skardu is mainly agriculture based, therefore the quantity of irrigation water availability determines the level of livelihood status of the communities living in Skardu. The data for this research was collected as part a study conducted for Aga Khan Foundation – Pakistan.

Materials and Methods

The research is based on the data collected from the Burgay Watershed. Traveling downstream along the Left Bank Canal from Satpara Dam, Burgay is the first watershed that crosses the Left Bank Canal. In Burgay watershed, spring water comes out from beneath the ground at an altitude of 2287 m. The watershed area of the Burgay is 36,022 acres with existing cultivable command area of 655 acres being irrigated by seven irrigation channels. In the upper reach of the main stream, two irrigation channels are off taking from the left side and one from the right side.

In order to measure water flow round the year, a flow measurement weir in the upstream of Burgay nullah was constructed. It was located at an altitude of 2371 m. The width, length of the wing walls, height and thickness of the weir were 20.25, 16.0, 2.8 and 1.5 feet respectively. The flow discharge out of the watershed was regularly monitored during the period spread over September 2015 to November 2015 and March 2016 to September 2016. Flow was measured in all months except December to February. However, for these months the flow data was assessed based on November and March data assuming that variation in spring discharge is relatively low. The flow width (20.25 ft) at the weir was divided into 6 subsections, later flow depth and velocity at each sub-section was recorded. The flow depth varied from 0.3 to 0.6 ft and velocity from 4.8 to 6.5ft/s at different subsections. On the left side of the weir stone were deposited about 6 ft. wide. Therefore the flow net width on the weir was taken as 14.25 ft. The data were also collected through focused group discussions and key informant interviews. Secondary data were collected from Gilgit Bultistan Official Website and Pakistan Meteorological Department.

To validate the results obtained from the data collected on the weir during the year, Focused Group Discussions (FGDs) and Key Informant Interviews (KIIs) were conducted. In all one FGD and 10 KIIs were conducted. These interviews were arranged by the Local Support Organization (LSO) at his office.

Results and Discussion

Burgay watershed is one of the eleven watersheds in the vicinity of Satpara Dam Reservoir at Skardu. The watershed has both, the surface and perennial spring water sources. The communities living in the command area of Burgay watershed have been using water for their domestic needs and for crops production. As shown in Figure 4, during the winter months (November, December, January, February, March and April) flow discharge was relatively low that ranged from 0.76 to 0.82 cfs and the major contributor was spring water. In summer months (May, June, July and August) the major flow is generated by snow/glacier melt.

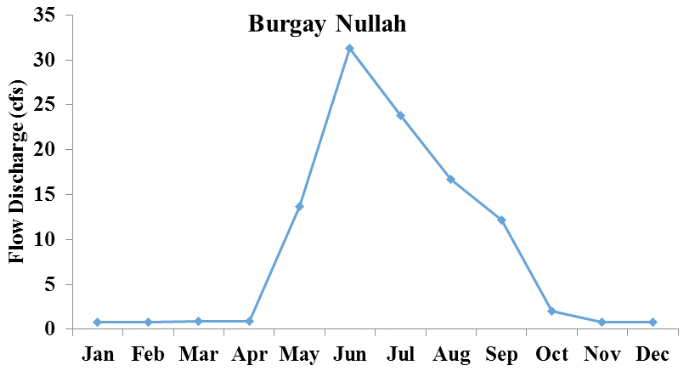

Figure 4: *Average monthly flow discharge out of Burgay's watershed.*
Source: *Field Data.*

The glacier melt increases with increase in air temperature and maximum flow discharge of 31.25cfs was recorded during the month of June and the flow then started decreasing with decrease in air temperature. During the summer months, the flow discharge is mostly contributed by snow/glacier melt ranging from 6.52 to 31.25 cfs with overall average of 19.58 cfs. In general, the snow/glacier melt was the major contributor (79%) during the summer months and spring water contribution was 21%. However, in winter months only spring water is available for drinking anddomestic use and hardly any water is available to meet crops production needs. The finding is in line with Zulfiqar M. et al. (2018) and with the information collected from the farmers whose experience revealed irrigation water shortage during crop sowing season from February to April and then abundance water during summer.

The relationship between mean monthly flow discharge and air temperature was developed as shown in Figure 5.

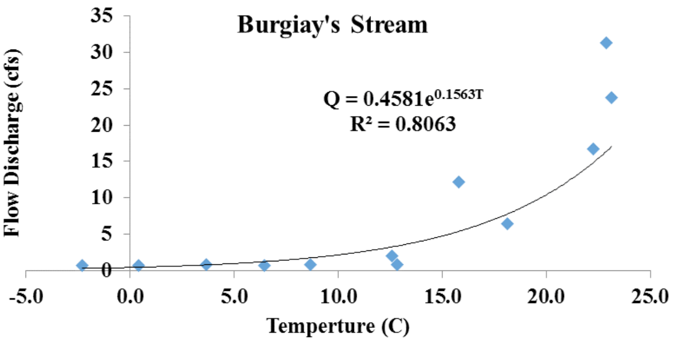

Figure 5: *Flow discharge vs air temperature of Burgay's watershed.*
Source: *Field Data.*

It can be observed from the Figure 5 that the snow/glacier melt increases with air temperature from 12.5 C° onward exponentially. Maximum flow discharge (31.25 cfs) was recorded with air temperature reaching 22.9C during the month of June and then decreases with decrease in air temperature.

The Table 1 shows average monthly spring, snow/glacier melts flow discharges, domestic water use and irrigation water availability and crops demand of the existing cultivable area of 655 acres in the Burgay watershed. Severe water shortage persists during the months of March and April to the extent of 3.12 and 6.87 cfs respectively for irrigating the existing cultivable area. During rest of crops growing months, the water availability is more than the crops demand which can be used for irrigating additional area to grow more crops.

During Focused Group Discussions (FGDs) and Key Informant Interviews (KIIs), it was revealed that the original land owners and their descendants possess the irrigation water rights. The irrigation water right is usually not sold with the land. There is a formal water turn system coming from the old days. Currently the water turn is based on 15 days turn. However, water turn is not on logical sequence i.e. one after the other. The land sub division based on heredity further deteriorates the water turn sequence as an owner may receive land at various locations within a village. During the months of March, April and till mid-May water turn is strictly observed as the water quantity is much less during these months compared to its demand. Perennial spring is the main source during these months. However, from mid-May to August/September water turn is not strictly followed as in these months' irrigation water is in abundance due to snow/glacier melt. These results show that agriculture in Burgay watershed is highly dependent on snow/glacier melt. The perennial water flow is in very small quantity particularly at the time of crops sowing due to which cultivation is not possible on cent percent cultivable area.

Table 1: *Burgay watershed spring, snow/glacier melt flow and water demand.*

Burgiay Month	Water-shed Spring	Snow/ Glacier melt	Total Flow	Do-mestic Use	Irri-gation Supply	Crop De-mand	Excess/ Deficit
	Flow discharge (cfs)						
Jan	0.76	0.00	0.76	0.50	0.26	0.00	0.26
Feb	0.82	0.00	0.82	0.50	0.32	0.00	0.32
Mar	0.88	0.00	0.88	0.50	0.38	3.50	-3.12
Apr	0.88	0.00	0.88	0.50	0.38	7.25	-6.87
May	0.88	5.64	6.52	0.50	9.85	8.61	1.24
Jun	0.88	30.37	31.25	0.50	24.55	9.97	14.58
Jul	0.88	22.92	23.80	0.50	24.57	6.32	18.25
Aug	0.88	15.86	16.74	0.50	16.31	4.74	11.57
Sep	0.88	11.29	12.17	0.50	7.41	4.36	3.05
Oct	0.88	1.12	2.00	0.50	1.50	1.74	-0.24
Nov	0.76	0.00	0.76	0.50	0.26	0.00	0.26
Dec	0.76	0.00	0.76	0.50	0.26	0.00	0.26
Average	0.85	7.27	8.11	0.50	7.17	3.87	3.30

Source: *Field Data.*

Conclusions and Recommendations

From the results and discussions it is evident that the local economy of the Burgay watershed being agriculture based is highly dependent on snow/glacier melt. The irrigation water is insufficient at the time of sowing crops as at that time snow/glacier melt is not available. However, from the month of May onward when snow/glacier melt water is available, there is no shortage of irrigation water for producing crops. In future, as shown in the instant study and also argued by a number of other studies if snow/glacier melt water is not available, the agriculture based economy of Burgay watershed as well as livelihood of communities living in the command area of watershed will be at stake. It is therefore recommended that efforts may be made for water storage at community as well as at farm level to meet irrigation water requirements at the crops sowing period to sustainably maintain local economy and livelihood of the communities. Application of solar energy may also be considered for lifting of ground water or lifting river water to meet crops water requirement particularly during crops sowing months. Additionally, such crops may be introduced which have growing season from May to August when plenty of water is available and additional land could be brought under cultivation. This could further improve the local economy through additional agricultural production.

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Author's Contribution

Muhammad Zulfiqar, Muhammad Jamal Khan and Abdul Hakeem: Designed the study, held FGDs & KKIs, supervised flow discharge measurement and analysis of data.
Irshad Abbasi: Conceived the idea and guided during the period of study.
Himayatullah Khan, Arjumand Nizami and Jawad Ali: Checked the analysis, relevant literature reviewed and drafted research article.

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