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**Natural Resource Use in Central Asia: Institutional Challenges and the
Contribution of Capacity Building**

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(EXTENDED ABSTRACT)

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Abstract

The spatial pattern of glacial retreat in Central Asian highlands are more intensive in last decades and impact on water resources are noteworthy in arid regions of Kyrgyz Republic. This research is an effort to assess the recent glacial retreat in Chon and Kichi Naryn catchments. The study conducted for period of 45 years (1965-2010) using 1:25000 scale topographic maps and ALOS/AVNIR satellite imagery shows that glacier area decreased by 21.3% in total. The dramatic changes have happened in south-facing glaciers than north facing glaciers with areal loss of loss of 23.6% and 19.8% respectively. The accelerated changes in glacial retreat will have compounding effect on shortage of water in densely populated areas and also increase in frequencies glacial induced hazards.

INTRODUCTION

The issue of water availability and the probable potential effects of climate change on water resources are of paramount importance to arid and semi-arid regions of Central Asia. In the last decade the consumption of water increased exponentially at regional and local level, which will further turn water supply security as major challenges to these countries the supply initially will be affects by accelerated shrinkage of glaciers threatened by climate crisis in upcoming days. Majority of the catchment area of the region fall within irrigation (Report of Eurasian Development Bank, 2009) and water demand in this region will increase in connection to food and energy security will further intensify the water war between the states in the region. Expected decrease in glaciers will lead to reduction in river runoff in summer resulting in deficit of water in Central Asian region. The stable retreat of modern glaciations happens because of global warming and ambiguous change of precipitations in high-altitude zone of Tian-Shan. There are few research yet done on comprehensive understanding and evaluation on current state of glaciers in Central Asian region. The present study aim is to fill this knowledge gap in Central Asian region while contributing contribution to recent retreat of glaciers due to climate change in Naryn basin.

DATA AND METHODS

The satellite imagery was acquired during ablation period with minimal cloud cover were used in the study to reduce potential uncertainty in glacier mapping. The boundary and termini positions were delineated 1:25 000 topographic maps based on aerial photography collected in 1960s and ALOS AVNIR-2 satellite data sets during 2008 – 2010. The topographic maps were scanned at 700 dpi and digitized contour interval and identified spot heights were used to produce a DEM (Digital Elevation Model) for the study area. The remotely sensed images were co-registered and orthorectified using the corrected topographic maps. ALOS/AVNIR-2 (70×70 km) were used consists of four bands from a visible to near-infrared radiometer with a spatial resolution of 10 m (JAXA, 2009). The ALOS data was ortho-projected using topographic map (1:25,000) and Shuttle Radar Topography Mission (SRTM3). The data was further rectified by using 50 ground control points, evenly distributed across the image.

The outlines of glaciers were extracted manually using visual interpretation of pan-sharpened ALOS (AVNIR-2) images (2008–2010) at high resolution (10 m). The areas of the extracted glacier polygons were computed using ArcGIS 9.2 resulting in a total sample size of 15 glaciers in the Akshyirak massif, 126 in the Borkoldoy, 130 in the Jetim, 89 in the Jetimbel, 80 in the Naryn, 41 in the Sook, 95 in the Terskey (south slope glaciers) and 78 in the Uchemchek

mountain ranges. Validations of some glaciers were done during field visit from 2010 to 2012 by using GPS ground check points.

RESULTS

Characteristics of glacier distribution

The characteristics of glaciers distribution in the study area was analyzed by finding the statistically relation between topographic parameters (mean, min., max. elevation, area size class, slope, aspect) and extracted and delineated glacier polygon data from ~2010. Majority of the parameter have clearly shown the evidence of regional characteristics of glacial distributions. For example, the relation of glaciers' area and aspect demonstrates the tendency of majority of large glaciers to be concentrated in northern aspects. Thus, 513 glaciers with areas of 435.2 km² that account for 74.3% of the total area are located in the three sectors, northwest, north, and northeast.

Table 1. Derived glacier parameters (~2010) for the eight mountain ranges

Study area	Akshyi - rak	Borkol- doy	Jetim	Jetim- bel	Naryn	Sook	Terskey	Uchem- chek	
Area (%)	0.1 – 0.5 (km ²)	2	11	15	24	46	14	18	19
	0.5 – 1 (km ²)	10	27	30	54	38	72	22	30
	1 – 2 (km ²)	18	14	6	17	0	14	8	24
	2 – 5 (km ²)	23	26	29	5	16	0	24	13
	5 > (km ²)	47	22	20	0	0	0	28	14
Aspect (%)	N	2	32	48	55	39	58	3	40
	NE	0	20	15	16	33	16	7	12
	E	0	0	2	6	4	6	9	0
	SE	0	5	5	0	0	4	39	0
	S	0	2	1	0	0	0	32	0
	SW	9	2	3	1	0	6	3	0
	W	9	8	2	2	6	4	2	14
NW	80	31	24	20	18	6	5	34	
Number of glaciers measured	15	126	130	89	80	41	95	78	
Glacier in ~1962 (km ²)	39.9	142.0	125.1	58.7	33.3	31.4	91.0	64.0	
Glacier in ~2010 (km ²)	32.9	112.5	97.8	44.3	23.6	24.9	71.9	52.6	

The distribution of glaciers classified according to area class (0.1-0.5 km², 0.5-1 km², 1-2 km², 2–5 km², >5 km²) for eight mountain ranges from 1965 to 2010. In three mountain ranges, the distribution of each glacier size class is almost similar: glaciers with areas of less than 1 km² occupy 78% of the Jetimbel mountain, 86% of the Naryn mountain, and 84% of the Sook mountain and no glaciers are larger than 5 km² (Table 1). In the Akshyirak mountain, small glaciers with areas less than 1 km² occupy 11.5% and larger glaciers more than 5 km² occupy 48% of the total investigated glacier area. In other the Borkoldoy, Jetim, Terskey and Uchemchek mountain ranges, the distribution of glacier size classes nearly similar: glaciers with area of less than 1 km² occupy from 39% to 50%, and larger than 5 km² glaciers occupy from 14% to 28%. The unusual distributions of glacier-area are found in the Borkoldoy mountain (5170 m), in the Terskey mountain (4840 m) and in the Jetim mountain (4825 m) and lowest glacier located in Uchemchek mountain range (3510 m). The average height of glaciers found in the study region is 4223.

Changes in glacier area from ~1965 and ~2010

The retreat of glaciers extracted from repeat satellite imagery were marked everywhere in upper Naryn basin since ~1965. This fact is derived from the feature of glaciers' form as well as by repeated observation, moreover comparison of remote sensing data of different years. In short span of time period approximately 1965 to 2010 total areas of the 654 studied glaciers had decreased by 21.3% of the value from 585.4 to 460.5 km². The glacier area decreased by 17.4% in the Akshyirak mountain, 20.8% in the Borkoldoy, 21.9% in the Jetim, 24.6% in the Jetimbel, 28.9% in the Naryn (North slope glaciers), 20.8% in the Sook, 20.9% in the Terskey (South slope glaciers) and 17.8% in the Uchemchek mountain ranges (Figure 1), and the greatest decrease in areal extent of studied glaciers was in the Naryn mountain (28.9%), followed by the Jetimbel (24.6%) and Jetim mountain range (21.9%).

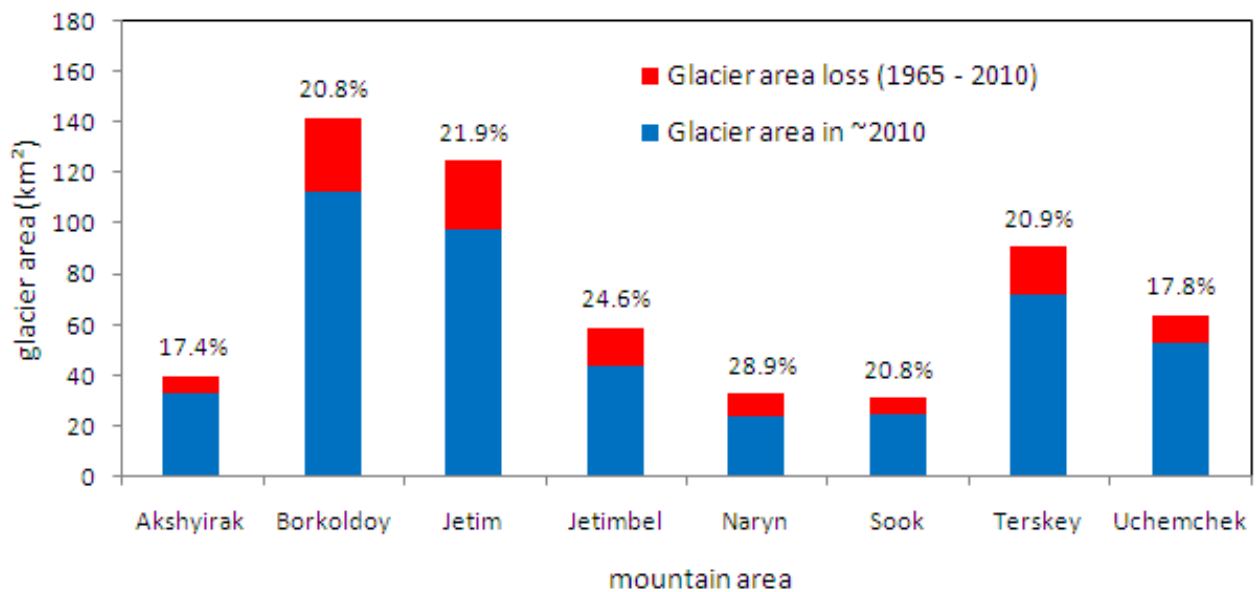


Figure 1. Changes in total glacier area in eight mountain regions for ~1965 and ~2010

Thus, total percentages of glacial loss in study area are to be further investigated in changes in the different size classes. The small glacial areas are sensitive to microclimatic changes and local glaciological factors (Jóhannesson et al., 1989; Kuhn, 1995; Nesje and Dahl, 2000). The relative abundance of glaciers in the different size classes strongly affects on the total percentage glacier area loss. About 89% of glaciers are less than 1 km² in area. Regions dominated by small glaciers are generally more sensitive to change because of the shorter response time to climate variability for small glaciers (Bahr D et al., 1998). In fact, comparing glacier size classes and glacier shrinkage, the Naryn mountain range, with its many small glaciers (<1 km²) experienced large glacier shrinkage (28.9%). In contrast, the Akshyirak mountain has many large glaciers (>5 km²) and glacier shrinkage was smaller (17.4%).

There are also dramatic differences marked in the changes between glaciers located on the northern and southern slopes. The northern slope having 513 glaciers decreased in total area by 19.7% and while the 78 glaciers found in southern slopes reduced in total area by 24.1% between. The first reason is more direct solar radiation in southern slopes in the study region which is favourable for glaciers' ablation. And second cause is mountain's asymmetry nature (Glacier Inventory of the USSR, 1977). Generally southern slope should have shallow steepness as northern slope but there are long flanks in southern slopes. This local typical configuration of

southern slopes will contribute to formation of larger glaciers but such types of glaciers' area are subjected to more ablation leading to large loss of area in the study region.

CONCLUSION

Glaciers of the Chon Naryn and Kichi Naryn basins decreased significantly in area between ~1965 and ~2010 with the total glacier retreat of 21.3%, due to increasing summer temperatures. The above glacial shrinkage is due to variation in regional climate and distribution of different size of glaciers according to elevation. The largest glacier shrinkage occurred in the Naryn range (28.9%), because of dominating small-scale glaciers and with north facing slopes. The strong glacial retreat can produce large quantities of water in short time period may cause hazard in down-stream area, and continuing glacier shrinkage will be the cause deficiency of water and energy in the region. The present state of glaciers are to be evaluated and monitored scientifically for reasonable development and utilization of regional water resources, water cycle models and regional economic planning. Hence more detail research are needed to validate the calculation made here with help reliable glacier field data. More simulation and projection are needed to understand trend of climate change and their impact on glacier properties and runoff variability.

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