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A Case Study of Climate Change Impacts Assessment on Ghowr Pozalich Small Hydro Power, Afghanistan

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Abstract

In this study, climate change impacts on Ghowr Pozalich's small hydropower are conducted and this paper downsizes the investigation and centers on water resources for power generation. Small Hydropower (SHP) has developed as an energy source that is acknowledged as renewable, effortlessly created, reasonable, and safe for the environment. As of now, hydropower accounts for nearly 16% of the world's total control supply and is the world's most prevalent (86%) source of renewable electrical vitality. Hence, direct impacts on the sector of hydroelectricity are implied. Although run-of-river SHPs are also going to be impacted by the climatic variations, the research suggests that run-of-river SHPs can generate energy even in cases of declined river discharges and concludes on the slight impacts on power generation under specific water level variations. These highlights have expanded small hydropower improvement in esteem giving rise to a modern slant in the renewable vitality era. The protest of the inquiry is to examine climate alter impacts on energy generation delivered by run-of-river small hydropower plants with the utilization of future stream flow. The deferring impacts depend on such variables as neighborhood hydrological conditions and geographic highlights. There are numerous areas where runoff and hydropower era will increment due to expanding precipitation, but too numerous locales where there will be a decrease.

Keywords: climate change, Ghowr Pozalich, Hydrology, hydropower generation

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1. Introduction

Climate change alters is one of the awesome challenges of the 21st century [1]. A community's socioeconomic improvement and living benchmarks are all subordinate to power and the higher the standard of living, the higher the request for power. Power is the primary level of requirement for any financial movement in arrange to carry out generation [2]. The request for electrical vitality is expanding day by day, so the fast increment within the request for hydropower vitality and the perilous issues of worldwide warming and the going increment within the cost of fossil fuel is renewable energy. Renewable energy assets have expanded in cost, so that vitality can be gotten from a source in such a way that, despite being renewable, it has less negative impacts on the environment [3]. Small hydropower plants are one of the renewable energy sources that have maintained their importance because the energy is easily generated from water, it is easy to operate, and it is cheap. And it is an environmentally friendly resource. With these benefits, the demand and implementation of small water power plants are increasing throughout the world [4]. Because the big dams of electricity generation are not completed in the planned time due to the lack of national budget and environmental problems, filling this gap has also played a major role in the increased use and implementation of small hydropower plants, which in developing countries, less investment, less construction period, and harmony with the living environment are considered good. Because of the above advantages, micro-obese power plants have attracted the attention of both groups (developed and developing) of countries [4]. North America and Europe have already taken advantage of the hydroelectric potential. On the other hand, African, Asian, and South American countries have failed to use the existing water energy potential which is shown in Table 1.

Table 1. Installed Capacity of Small Hydropower Projects in the world [1]

Name of the Continent	Capacity in MW	Percentage (%)
Asia	32641	68
Europe	10723	22.3
North America	2929	6.1
South America	1280	2.7
Africa	228	0.5
Australia	198	0.4
Total	**97997**	**100**

Small-scale power plants are a good way to meet the shortage of electricity in developing countries, with China being a good example. China gets its two hundred and sixty-five gigawatts (265GW) of energy from three hundred forty-three thousand (43,000) small hydropower plants, which is a huge amount of energy production [5]. The Ghowr Pozlich Power Generation Project, which has a power generation capacity of 4.05 MW, is located on the river Harirod in Ghowr province and Chaghacharan district. Taking advantage of this economic potential will not only meet the electricity demand but also increase the economy and living standards of the country and especially the region. All in all, the number of small hydropower plants with a production capacity of more than one megawatt is small, and some of them are in serious need of rehabilitation. The Ministry of Water and Electricity should take concrete steps in this regard [6]. The implementation of renewable energy production projects in Afghanistan has many economic and social benefits; working land, access to electricity, social development, and reducing the negative effects of the climate at the international level. The Islamic Republic of Afghanistan is asking for cooperation from the international community so that our country can develop in this area and the next twenty (20) years, ninety-five percent (95%) of the country's energy production will come from renewable energy sources [7]. The Ministry of Water and Electricity has prepared the Law on the Regulation of Electric Energy Services and the Renewable Energy Policy to achieve the strategic goals of Afghanistan, which foresees the main contribution of renewable energy in development programs [8]. This arrangement will be executed in two stages. The primary stage will be actualized between the years 2015 and 2020 and amid this period will make a solid environment for renewable vitality advancement, private sector participation, and investment. In the second phase, which will be implemented between the years 2021 and 2032, renewable energy will be launched in a commercial form based on the experience gained in the first phase. Competitive elements are introduced. Afghanistan needs reliable energy sources for stability and development and fortunately has dedicated sources of renewable energy (hydro, solar, wind, biomass, and geothermal) [9]. Using the country's electric energy is the right of everyone based on the law on the regulation of electric energy services, so the production of electric energy should increase because the goal of renewable energy development is the development of Afghanistan's energy sector. Accordingly, the Ministry of Water and Electricity is the key ministry for the leadership and development of Afghanistan's energy sector to attract the confidence of investors in this sector. It was mentioned in the section on hydropower projects that the three decades of war in Afghanistan have stopped all the infrastructure projects, so the projects of small hydropower plants have also faced a long obstacle. Fortunately, it was said that around the year (2001), work started again in this area and various organizations implemented projects on a small production level in the villages, but still more efforts are needed to

make full use of the available economic potential. Utilizing this financial potential will not as it were meet the request for power, but will moreover increment the economy and living benchmarks of the nation, particularly within the locale [10]. All in all, the number of Small hydropower plants with a generation capacity of more than one megawatt is small, and some of them are in serious need of rehabilitation. The Ministry of Water and Electricity should take concrete steps in this regard. Afghanistan's renewable energy sources with productive capacities are shown in Table 2.

Table 2. Afghanistan's renewable energy sources with a productive capacity [1]

Energy production source	Total generating capacity in MW
Hydropower energy	23,000
Wind power energy	67,000
Solar energy	222,000
Geothermal energy	(3,000 – 3,500)
Biomass energy	4,000

The Ghowr Pozalich power plant project has a power generation capacity of 4.05 MW with an annual energy production of 16.15 GWh.

2. Study Area

2.1. Provincial Profile of Ghowr Pozalich Small Hydropower

The study area is located near Badghab village and sixteen kilometers (16 Km) east of Chaghacharan city [11]. The project consists of a thirty-meter (30 m) high dam located in a narrow valley with a tunnel on the left side, which diverts excess water downstream. The power generation structure is located in the lower part on the right side. The Harirod River flows from west to east and divides the Chaghacharan district into two parts. The Harirud River is located in the Harirud-Marghab river basin, which is one of the five largest river basins in Afghanistan. The tributary area of the project is sixteen kilometers (16 Km) west of Chaghacharan, near Badgah village on the Harirud river [12]. The catchment area is located in a place where there are steep mountains on both sides. While it was mentioned in the project section that three decades of war in Afghanistan have halted all infrastructure projects, ninety small projects have also faced obstacles which are shown in figure1 [12].

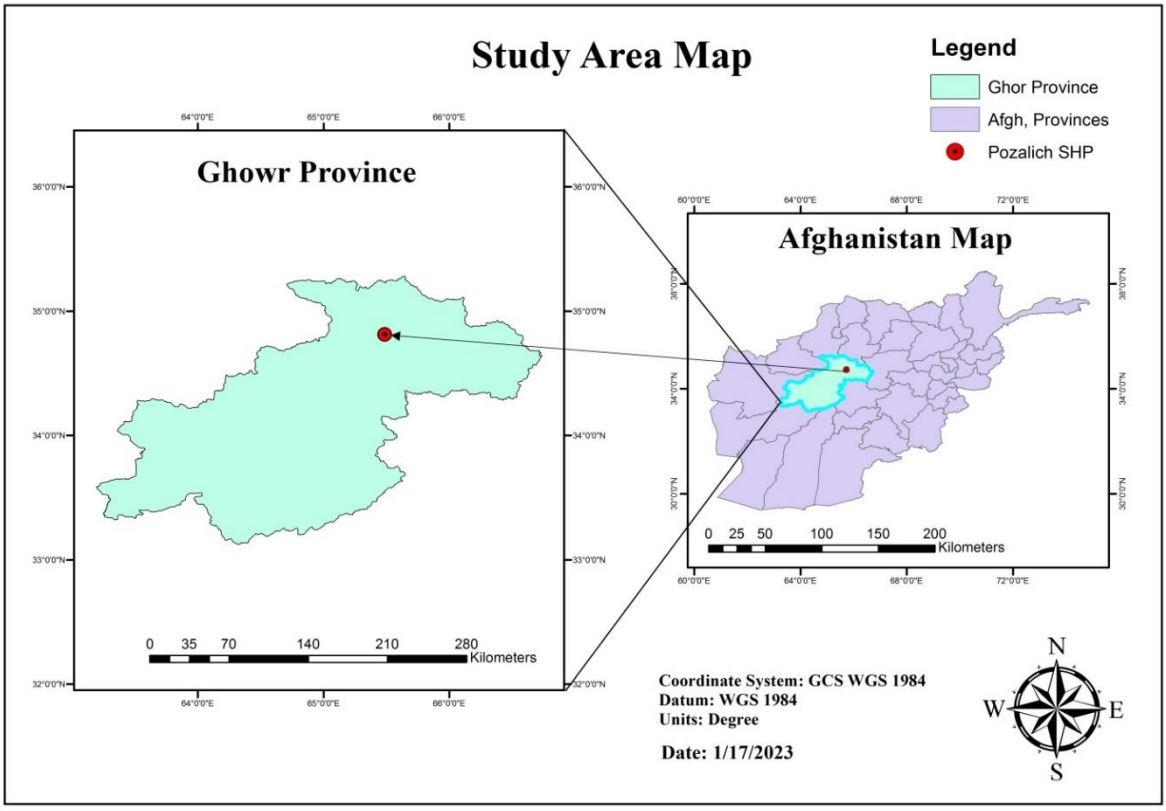


Figure1. Afghanistan Administrative Map and Ghowr SHP Location

3. Methodology

The SHP under investigation is the Ghowr Pozalich run-of-river small hydropower plant. To achieve the objectives, of this study, the literature mostly focused on climate change impacts in a general context and within Afghanistan for over the last 20 years was reviewed. Considering the review policy, authorized database search engines were used to filter the related scientific articles, conference proceedings, books, and reports from peer-reviewed and highly indexed journals. Based on the data from two measuring stations located at the end of the Ghor Pozlich Power Coat Project acquired from the Ministry of Energy and Water (MEW), the hydrological regime of the river can be assessed in different periods. This data is the Annual Mean Water Discharge (m^3/sec) of Chaghacharan Station between 1962-1980.

4. Climate change impact on small hydropower (SHP)

A few inquiries about discoveries distributed around the world include the climate change impacts on hydropower assets [12]. Nearly all of the hydropower ponders displayed in this paper have focused on expensive or medium spatial scales [13]. There are no specialized or financial reasons compelling the advance advancement of huge or medium-scale hydropower, but usually, they are built with a reservoir that would submerge plants and forests, reducing their carbon sequestering ability and then leading to methane emissions [14]. As a result, SHP stations, the larger part of which are runoff sorts without dams and supplies, play a vital role in rustic zap in numerous nations and are generally supported following a prosperous period of large or medium-scale hydropower improvement. See the noteworthy part of the SHP in the vitality framework of the long term, it is vital to pick up a better understanding of the impacts of climate change [15]. Since the centrality of hydropower time and its potential affectability to climate alter has as of now been set up in later time, a few quantitative gages of the specialized potential for hydropower have been established [16]. However, relatively few studies have addressed the specific factors of climate change's impact on hydropower. Based on previous studies, this paper focuses on the causal examination of these impacts and categorizes them as either coordinated or circuitous impacts [17].

4.1. Direct factor of climate change impact on hydropower

Global warming is one of the foremost climate change factors compared with other factors such as humidity, cloudiness, and precipitation. It has an important influence on hydropower generation and water resource supplies. Global warming increases global temperature patterns which then, in turn, alters the precipitation patterns [18]. One consequence of these alterations tends to be earlier spring snowmelt which has direct effects on hydropower generation [18]. It is well-documented that temperatures have been rising across the world and impacting the hydropower resource. Temperature is more likely to affect the operations of high-elevation hydropower reservoirs with low storage capacity [19]. High temperatures lead to more snowmelt and, often, more intense periods of seasonal precipitation. However, precipitation is not independent of rising temperatures which also leads to changes in power generation [19].

4.2. Power/Energy Generation Analysis

The Ghor Pozlich Power Plant Project, which has a 30-meter high dam and is used to generate electricity from stored water, during non-rainy seasons, maximum production is carried out only during peak hours. In the case of case operation, the height fluctuation will be from 15m to 25m. When the sediments fill up to 20 meters (20m) of sediment, the

water pipes will be raised to a height of 20 meters (20m). The designed flow of the project is 20m^3/sec, so during the times when the river flow is less than the designed flow, it only performs maximum production during peak hours and less production during non-peak hours [19]. Three Kaplan turbines with a production capacity of 1.35 MW each and a design flow of 6.67m^3/sec will be used in this project. For the examination of power generation carried out here, the general generation productivity (83%) is expected. Here, for three-seat Kaplan turbines, the upkeep plan ought to be adaptable, so a 2% blackout rate is calculated for the energy generation [19]. It is known that the yearly energy generation is rising to 16,150 MW. When it is raining, the current is added to the outlined current, so the electric coil can create the most extreme introduced control. Monthly energy production varies from 543 MWh in January to 2950 MWh in May. This is clearly shown in Table 3.

Table 3. Average monthly energy production for the SHP under consideration [1]

Mounts	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Energy in MWH	543	576	2065	2855	2950	2855	1251	661	617	602	605	566
Power factor	0.18	0.22	0.7	1.00	1.00	1.00	0.42	0.22	0.22	0.2	0.21	0.19

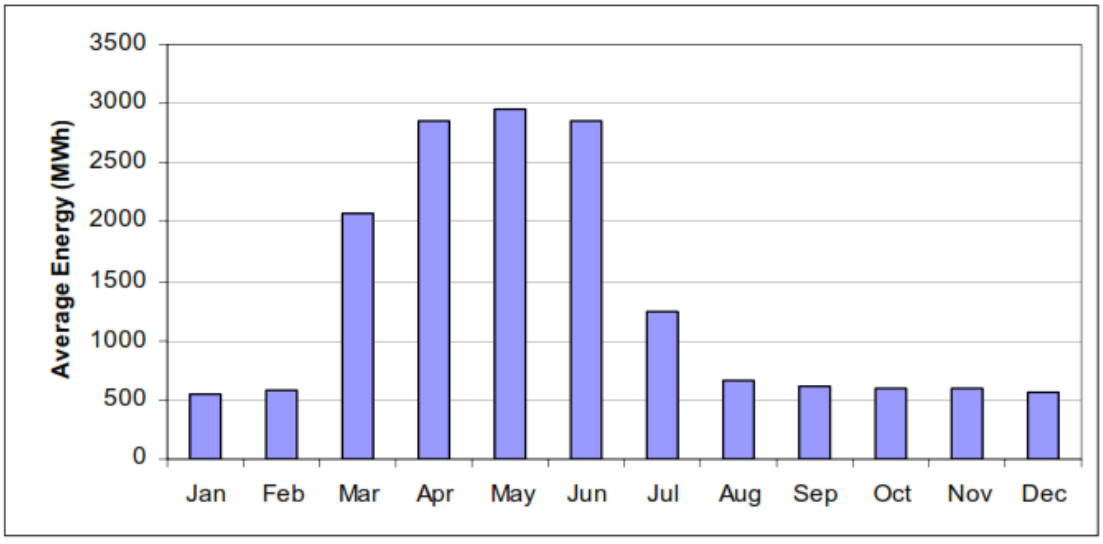


Figure2. Monthly energy production for the Ghowr SHP

5. Results

The Harirud River originates from the central mountains of Afghanistan, which are up to four thousand meters high. Because of the internal wars, there was no hydrological data on the process after 1980, but before that, there were nine hydrological measuring stations in the Harirud-Murghab river basin, seven of which were located in Harirud. Two measuring stations were located at the end of the Ghor Pozlich Power Coat Project. Both of these stations were the stations of Chaghacharan, and the second one was the state government station [1]. The hydrological data from these two stations were available for the years (1962-1980) which are shown in Table 4.

Table 4. Annual average flow (m^3/s) [1]

Year	Annual Discharge (m3/sec)
1962	22.2
1963	19.5
1964	31.8
1965	37.9
1966	14.9
1967	30.6
1968	30.2
1969	62.4
1970	16.6
1971	13.9
1972	30.6
1973	32.7
1974	20.4
1975	46.8
1976	43.8
1977	22.2
1978	27.8
1979	27.5
1980	38.2
Average	30.0

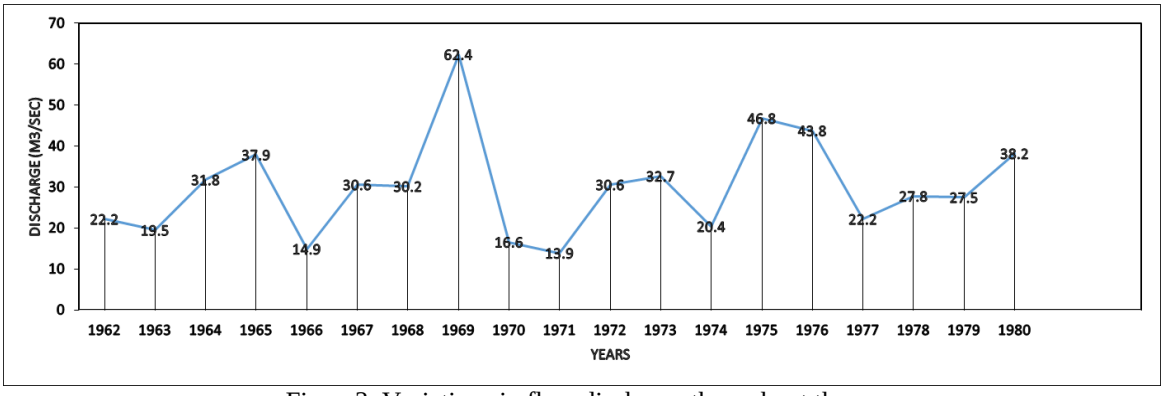


Figure3. Variations in flow discharge throughout the year

The amount of design current depends on the current field current. For projects that operate on the natural flow of a river and are connected to a large power grid, the optimal design flow is taken to be cited to a large power grid, the optimal design flow is taken to be 30% or more of the time flow [19].

5.1. Precipitation and Temperature

There are four meteorological stations in the vicinity of the catchment area, which are shown in Table 5.

Table 5. Metrological stations [1]

Station Name	Latitude (N)	Longitude (E)	Height (m)
Chaghacharan	34° 32′	65° 15′	2183
Ghalmin	34° 53′	65° 18′	2070
Lal	34° 30′	66° 18′	2800
Shahrak	34° 06′	64° 17′	2325

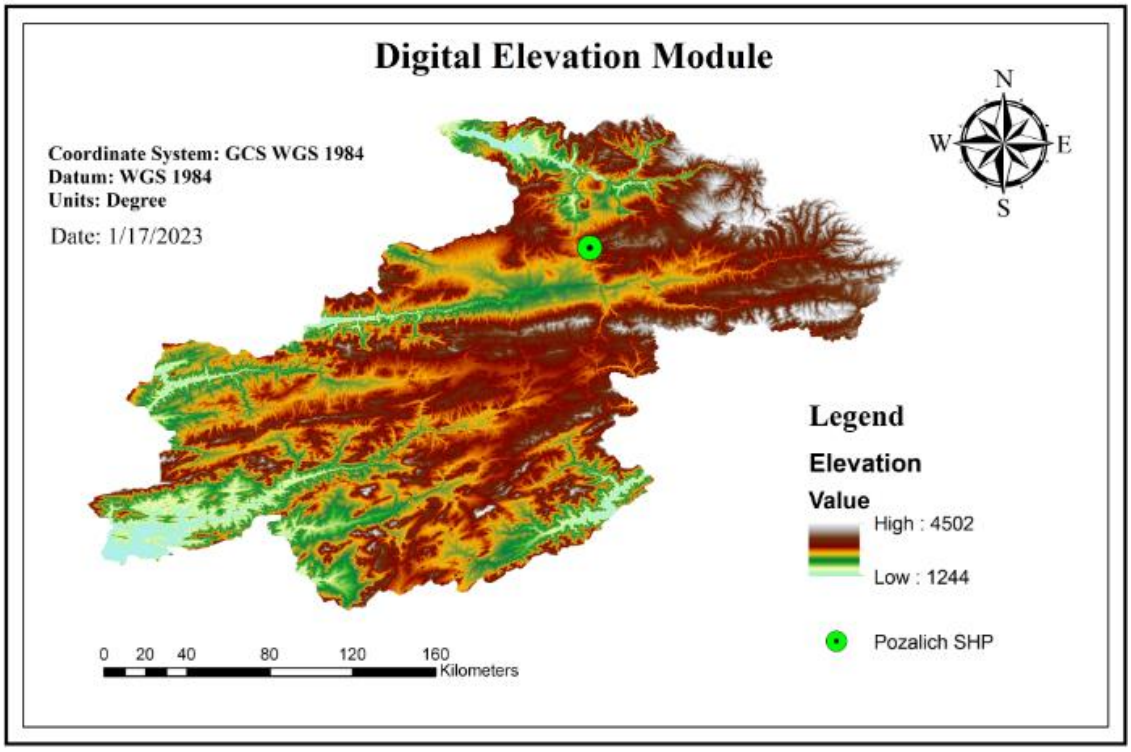


Figure4. The digital elevation module of Ghowr pozalich SHP

The average annual precipitation in four stations is 244 mm, and most of the precipitation is recorded as snow. Table 6 shows that the temperature reaches its lowest point in January and its highest point in July-August.

Table 6. The long-term average precipitation in (mm) [1]

Stations	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec
Chaghacharan	36	28	33	41	14	0	0	0	0	6	13	18
Ghalmin	37	35	43	45	20	0	1	0	0	5	11	23
Lal	39	45	51	65	31	2	0	0	1	9	22	24
Shahrak	58	48	53	38	17	2	0	0	0	6	19	35
Average	43	39	45	47	21	1	0	0	0	7	16	25

Station Name	**Chaghacharan**	**Ghalmin**	**Lal**	**Shahrak**
Annual Precipitation	189	220	289	276
Average		**244**		

Precipitation and temperature are very heterogeneous in the Harirod River due to its large range in elevation. The temperature is lowest in January and highest in July-August.

Table 7. The long-term average temperature in (C°) [1]

Stations	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec
Chaghacharan	-10.2	-8.1	1.9	8.9	12.9	17.9	19.2	17.8	12.3	6.4	1.2	-4.4
Ghalmin	-7.8	-5.0	3.7	9.4	13.6	17.9	19.8	18.6	13.6	8.5	2.6	-2.8
Lal	-13.2	-10.9	-2.7	4.5	9.2	13.9	13.9	17.8	15.4	4.5	-1.4	-8.54
Shahrak	-12.1	-10.6	0.8	7.9	11.9	11	17.7	16.4	11.9	6.2	6.8	--6.8
Average	-10.8	-8.65	1.9	7.7	11.9	15	18.2	17.1	12.0	6.4	2.3	2.3

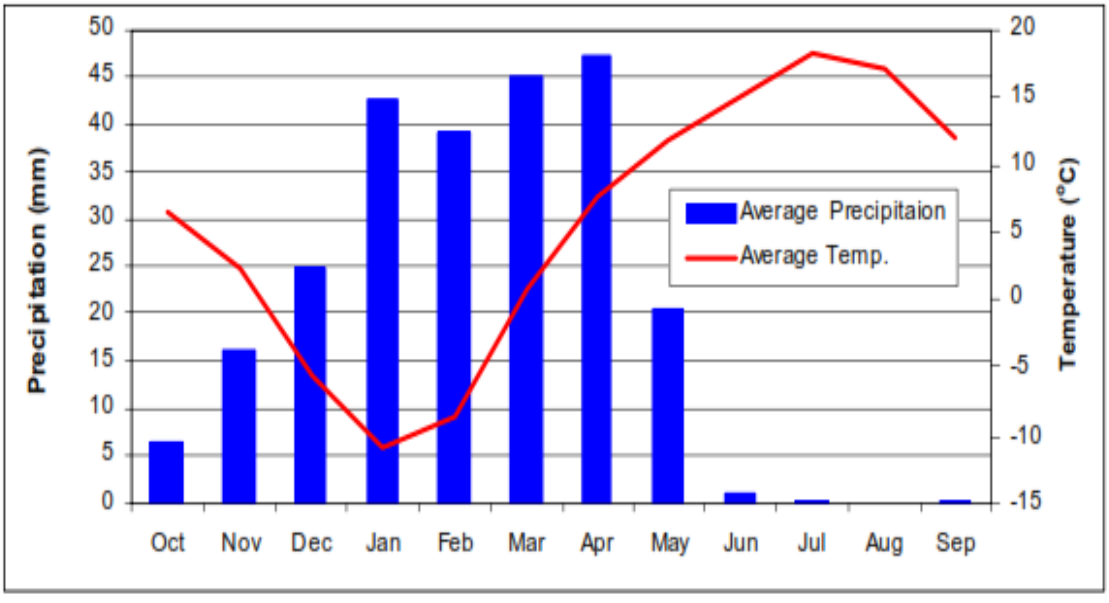


Figure5. The annual average variation in precipitation and temperature

7. Discussion

Both large and small-scale hydropower stations offer significant potential for near and long-term GHG emissions reduction. It is necessary to understand how to sustain and facilitate hydropower production under the adverse effects of climate change impacts. Despite many achievements that have been published on improving the understanding of

and how to cope with the climate change effects on water resources and hydropower, there are still large uncertainties with the dynamic hydrological processes.

Climate change and hydropower development interact with each other in the natural process, so any variation that occurs with one of them will lead to a change in the other. Several problems must still be further investigated. First of all, it is critical to improving the forecast and prediction of changes in the hydrological regime caused by global warming-related climate extreme events. With more spatial and temporal accuracy, these forecasts and predictions will help to make better and more accurate assessments of the hydropower development potential while coping with climate change. Secondly, all of the research presented in this paper was large-scale studies. Most of these studies lacked the unique local hydrographic conditions for project-specific research. Because of the diversity and distinctiveness of each hydropower station, it is extremely difficult to establish universal measures to mitigate climate change impacts. These results may provide more useful idiographic measures for local hydropower generation. In addition to technological efforts, government intervention in hydropower management and regulation should not be ignored. National, regional, and local governments can establish effective measures to promote the implementation of hydropower and other renewable energy projects, regulate and govern hydropower electricity utilization, assist managers with flood-control operations during high flow episodes, and improve water usage procedures during drought periods, and, to ensure the safety of environmental, eco-system, and socio-economic sectors.

With appropriate and feasible mitigation and adaptation strategies, hydropower can promote and enhance the development of local society and communities, and improve the quality of the environment and the socio-economic well-being of society.

8. Conclusion

Both large-scale and small-scale hydropower stations offer significant potential for near and long-term GHG emissions reduction. It is necessary to understand how to sustain and facilitate hydropower production under the adverse effects of climate change impacts. First of all, it is critical to improving the forecast and prediction of changes in the hydrological regime caused by global warming-related climate extreme events. With more spatial and temporal accuracy, these forecasts and predictions will help to make better and more accurate assessments of the hydropower development potential while coping with climate change. With appropriate and feasible mitigation and adaptation strategies, hydropower can promote and enhance the development of local society and communities, and improve the quality of the environment and the socio-economic well-being of society. Hydropower production depends on the available water volume. Climate change projections demonstrate increased stress on surface water resources in terms of

availability, duration of low and high water levels, and timing of seasonal peaks, especially at the end of the 21st century. Hence, direct impacts on the sector of hydroelectricity are implied. Although run-of-river SHPs are also going to be impacted by the climatic variations, the research suggests that run-of-river SHPs can generate energy even in cases of declined river discharges and concludes on the slight impacts on power generation under specific water level variations. It is known that the yearly vitality generation has risen to 16,150 MW. When it is down-pouring, the current is included in the outlined current, so the electric coil can create the most extreme introduced control. Month to month, vitality generation shifts from 543 MWh in January to 2950 MWh in May. Since the net head is twenty-five meters (25m) and the designed flow is 20 m^3/sec, the electromechanical devices for the project include three-digit Kaplan turbines, which are connected to special generators. Has been a typical layout of hydromechanical equipment is shown on the map. In addition to technological efforts, government intervention in hydropower management and regulation should not be ignored.

9. Recommendations

1. National, regional, and local governments can establish effective measures to promote the implementation of hydropower and other renewable energy projects, regulate and govern hydropower electricity utilization, assist managers with flood-control operations during high flow episodes, and improve water usage procedures during drought periods, and, to ensure the safety of environmental, eco-system, and socio-economic sectors.
2. As time passes, climate change impacts hydropower development and hydropower sustainability will increase and place greater stress on the entire energy continuum around the world. With appropriate and feasible mitigation and adaptation strategies, hydropower can promote and enhance the development of local society and communities, and improve the quality of the environment and the socio-economic well-being of society.

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