

Sustainable water resources planning and management of Kabul River Basin under population growth and changing climate

Mohammad Hassan Hassanyar

Abstract—The aim of this study is to look at the water management structure of Kabul River Basin of Afghanistan. Due to rapid population growth, the demand for water is increasing. To meet the suitable water demand without any consideration from supply side, integrated water resources management offers holistic policy tools to sustainable use and managing of water resources. However, the IWRM principles requires coordinated holistic approach with incorporation of wide range of stakeholders include women for maximizing the benefits from water use through the economic instruments and minimizing the possible risks of freshwater. The implementation IWRM principles are big challenge for government of Afghanistan because it requires skilled human capital, accurate data and information for decision making. The basin population rapidly increased at the rate of 2.7 percent over period of 2008-2015. the near future climate of basin changing with of 2 percentage decline of annual precipitation which is directly impacts on renewable water resources. Both changes, increase of temperature associate with evaporation and downward trend of precipitation intensify on reduction of water availability in the river basin. In addition, rapid population growth and climate change make multiple pressure on basin's water. The precaution measures must be undertaken for sustainable planning and integrated water resources management strategies at basin level in the lights of IWRM principles with building strong capacity, commitment of government bodies as well as real stakeholder's participation.

Index Terms— climate change, population growth, IWRM, Kabul River Basin,

I. INTRODUCTION

Afghanistan geographically divided into five big river basins such as Amu, Northern, Harirod, Helmand and Kabul river basins. The Kabul River Basin drains water from the Shibar Pass, high elevation of Panjshir valley and Kunar valley through the eastern and western plain valley and lastly cross the country and draining to Pakistan. At the eastern mountains, rivers take their sources in high mountains covered by snow and glaciers that maintain water flow throughout the spring and summer. The eastern part of the Kabul Basin is under the influence of the monsoon rainfalls. The Kabul basin covers 12 percent of the national territory, but alone it drains one-fourth (26 percent) of the total annual water flow of Afghanistan [1].

Water resources management is a key sector to Afghanistan's economic growth. However, inadequate water supply services is and obstacle to other relevant development sectors such as agriculture, industries and environmental issues. In addition, the government is unable to manage and develop the water

resources policies, secure and reliable agricultural, domestic and industrial water supply within the river basin [2].

Furthermore, the current water management structure not reformed, the governance organization still running in old administrative order, this system make slow the designing and implementing of new water related projects, the structure order has key weakness; first, the low level of communication and sharing data and information within the ministry and other water related stakeholders. Secondly, top policy actors such as ministry of energy and water, ministry agriculture, irrigation and livestock, ministry of public health, ministry of rural rehabilitation and development design policies based each ministry desire at small scale, if we think the development option of each unit how to meet the demand and requirement of all population's needs. Here is dire need of strong communication between different ministries in term of sharing data, information and timely planning together with integrated vas fragmented management system.

Since 2002, the government of Afghanistan try to take new initiatives actions for better water management. Later, the government approved new water law and developed country water strategy to establish the new policy framework for transition from a centralized to a decentralized institutional structure and bring reforms in water management and governance institutions [2,3]. Unfortunately, the new water law has itself problem regarding of new initiative operation of water related projects for example, ministry of energy and water is responsible for planning and management of water resources at all, meanwhile ministry of agriculture, irrigation and livestock is responsible for operating irrigation water and infrastructures, here is unclear power for management and governance of the resources. However, water use in country divided in three distinct sector; mainly irrigation, municipal use and small portion used by industries.

More than 80 per cent of the country's water resources have their origin in the HinduKush mountains which function as a natural storage of water in form of snow during winter and thus support perennial flow in all major rivers by snow melt during spring and summer. Recent estimates indicate that the country has 75 billion cubic meters (BCM) of potential water resources of which 55-57 BCM is surface water and about the 18-20 BCM is groundwater resources [3]. The average water availability per person is 2280 m³/year per capita, but this strongly vary in temporal and spatial distribution of water within the basins as well as entire of country [2]. The high dependency on agriculture products, low water management options and lack of reservoirs, water infrastructures, and ongoing land degradation particularly sensitive to the effects of severe floods and droughts [4]. On the other hand, the rapid population growth, economic development and improved standards of living will be the main drivers of water scarcity in

Mohammad Hassan Hassanyar, Doctoral Student, Graduate School of Engineering and Science, University of the Ryukyus, Okinawa Japan. No.+818083635212.

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coming decades [5]. Due to economies grow, the demand for domestic water, agriculture and industry will increase. On the top of these drivers the climate change is major challenge for environment and water resources in Afghanistan. To assess the climate element such as temperature and precipitation change required to do comprehensive climate modeling, the climate modeling is the only way to predict the change of climate elements and water resources within the basin.

In this study, the most important aims of this study are literature review the current water management structure of Kabul River Basin, to analyze current population growth of basin and, to analyze the current and near future climate parameters such as temperature and precipitation of the basin. Therefore, the study outcomes could be used for designing of new policies and better decision making at the future water related development projects.

II. MATERIALS AND METHODS

A. Study area

Kabul River Basin located in eastern part of Afghanistan. The basin is trans-boundary river that is shared between Afghanistan and Pakistan. The river basin geographically lies between the coordinates of 33.8° - 36.3° N latitudes and 67.8° -71.5° E longitudes with the total drainage area of 53832.8 km²[1]. This basin covers almost 10 provinces of the country, including Kabul capital located in this drainage area. Kabul city is the most populated city within the country. However, growth of population may need more water for drinking, food production.

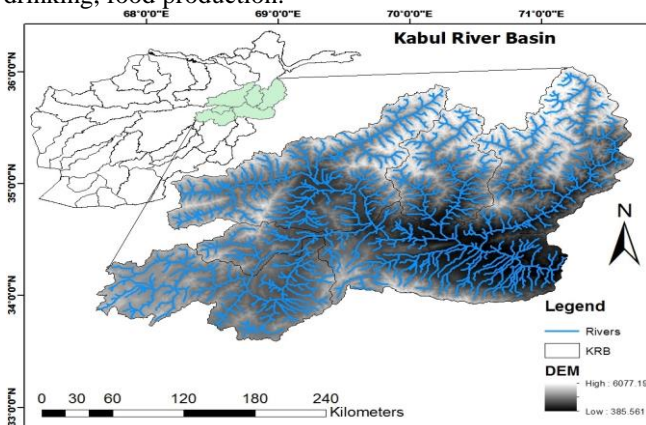


Figure (1) location map of the study area with weather stations.

The main river streams such as Ghorband, Panjshir Alingar and Kunar rivers are feeding from HinduKush mountain which is initially establishing the upper catchment of Kabul River Basin, water drains from Ghorband, Panjshir upstream to low plain area Nangarhar and lastly Kunar province [1]. The Digital Elevation Model (DEM) map represent the elevation of study area. The DEM map was downloaded from USGS public geoportal database with 90-meter resolution. The DEM map of the basin clipped by ArcGIS 10.1, as can be seen the DEM illustrates high mountains and low plain area. while elevation with ranges of 6077.19 to 385.56 above mean sea level [6].

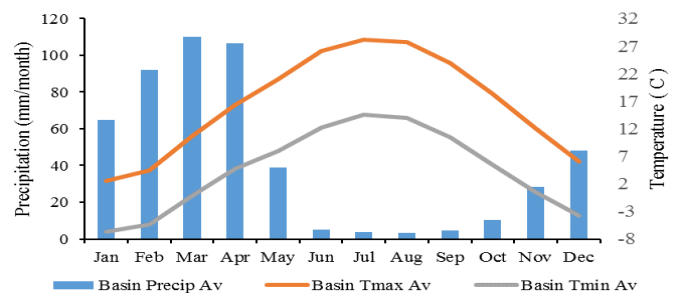
B. Data collection

In this study, the baseline climatic data collected from the Afghanistan Meteorological Authority (AMA) and for future projection Global Climate Models (GCMs) data set of CMIP5

of fifth assessment report under Representative Concentration Pathway RCPs (4.5 and 8.5) scenarios was used and, the population information collected from demographic and statistic unit, civil division of Central Statistics Organization (CSO) of Afghanistan.

C. Climate of the Kabul River Basin

The upper watershed of Kabul River Basin is mountainous area, the climate of the basin influenced by mountains weather conditions, changing in the temperature of mountains areas directly reaches to low land area by wind blowing. As can be seen in the figure (3a) the high-altitude geography of basin represents the cooler the lowest elevation areas is warmer (3). The monthly distribution temperature at station level figure out that the summer months (July) are hottest time entire the year and during the winter months, weather getting too cold specially in month of January, details are showed in figure (2).



Fig(2) Average monthly temperature and precipitation in Kabul River Basin.

In addition, distribution of precipitation at the Kabul River Basin is shown in figure (2). The average monthly plotted precipitation shows highest values spring months and lowest occurrence of precipitation in the summer months. On the hand, spatial distribution of precipitation demonstrates the higher elevation of the river basin such as HinduKush mountains receive more precipitation than low land valleys such as Jalalabad province entire of Kabul River Basin, more detail of precipitation shown in fig (3b). in addition, the basin receives about 1200 mm in annual scale, of precipitation in higher elevation such as HinduKush mountains and low land such as Jalalabad and Logar provinces receives 205 mm in annual scale, lowest amounts of precipitation in basin level.

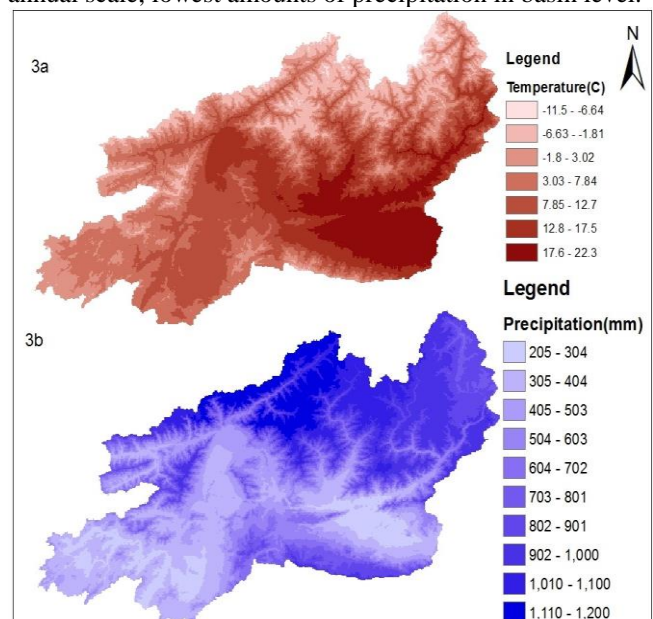


Fig (3) Annual temperature and precipitation in Kabul River Basin.

III. RESULTS AND DISCUSSION

A. Population growth and water demand

Despite having the accurate demographic statistics and information in Afghanistan, the estimated demographic data represents rapid population change, World Bank and UN population division estimated the country population growth at the rate of 2.8 percent in 2015 [7,8]. However, the recent demographic data of Kabul River Basin collected from central statistic organization office [9]. The estimated annual population plotted Fig (4). The population data illustrates rapid change in size, the growth rate calculated by 2.7 percent during the period of 2008 to 2015. This rapid change in population size directly increase demand of water and food. However, the water per capita vary from 50-100 liters per person per day in urban to 25-50 LPD in rural area [10]. A capital city of Kabul, Jalalabad and Parwan provinces are fast growing, the water per capita assumed 60 LPD in across the basin, hence the annual water consumption calculated 226126 cubic meter in 2008 and 275096 cubic meter in 2015. In addition, trend of population growth expected to continues in next decades, while another roughly 2 million people adding by coming decade, hence, here is extent link between population and water consumption. Despite the progress on water management, the water demand increasing. The policy makers should take into consideration the future water demand based on the rapid population change in the Kabul River Basin.

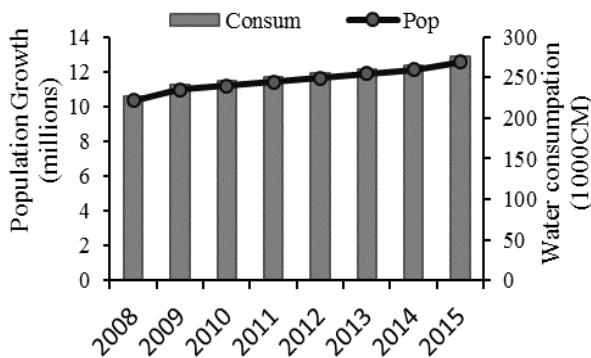


Fig (4) Population growth and water consumption 2008-2015.

B. Future climate of river basin

Future climate change becomes an interesting topic of in education, sciences with big concern for policy makers. The important issues of current century are global warming that caused by GHGs and aerosols which are produced by human activities. Many climate models with the different scenarios have projected the change of climate at the global scale and the regional level. The current study is focuses on the temperature and precipitation that are two important parameters for analyzing of climate change. The future projection is carried out under IPCC recent data set as CMIP5 as RCP 4.5 and 8.5 pathways for near future time series as 2021-2040 with relative to baseline of 1961-2010. And here addressed as 2030s or early period of projection.

In this study, the SimCLIM climate model was used for future scenarios projection. The model is user always follow the new IPCC data manual [11]. The analysis of spatial pattern projection for averaged temperature carried out under the two selected scenarios based on the recent IPCC fifth assessment data set. As can be seen, under RCP4.5 pathway the early period 2030s rate of temperature increase simulated

0.78°C at the eastern part of the basin and 0.85°C at the norther and western region of the Kabul River Basin. at the same manner, under the worse scenario RCP8.5 pathway the future trend of warming 0.85°C is shifting from northern and western part toward the eastern part the Kabul River Basin by early period of the century fig (5).

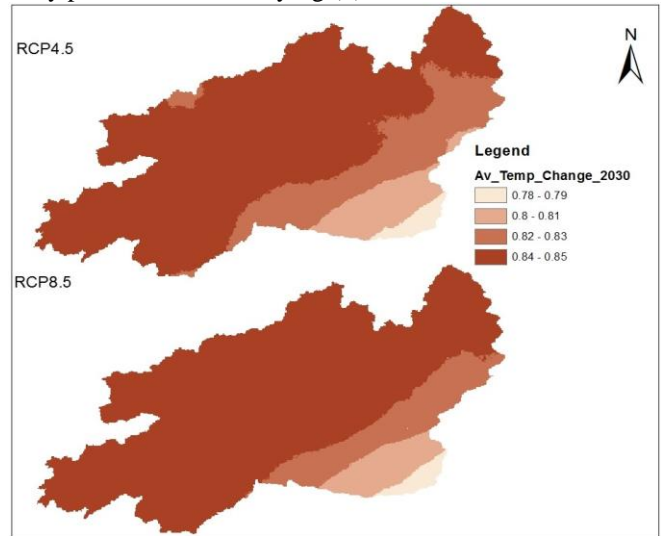


Fig (6) Future mean temperature change under RCP4.5 and 8.5 by 2030.

The future projection of precipitation is varying across the Kabul River Basin. For early-term future spatial analysis of precipitation showed both positive and negative trend at the study area, the maximum percentage of decreasing under both pathways RCP4.5 and 8.5 simulated 2.10 percent at the western provinces such as Maidan and Logar. In the contrast, the increasing of future precipitation projected at eastern part the Kabul River Basin. under RCP4.5 scenario larger parts Jalalabad provinces demonstrated upward of precipitation about 1.90 percent. Under the RCP 8.5 pathway the eastern part of Kabul River Basin specially Nooristan, Kunar, Khost and Jalalabad province turned to decreasing values as well as majority area of Kabul River Basin illustrated decreasing of precipitation at early projection fig (6).

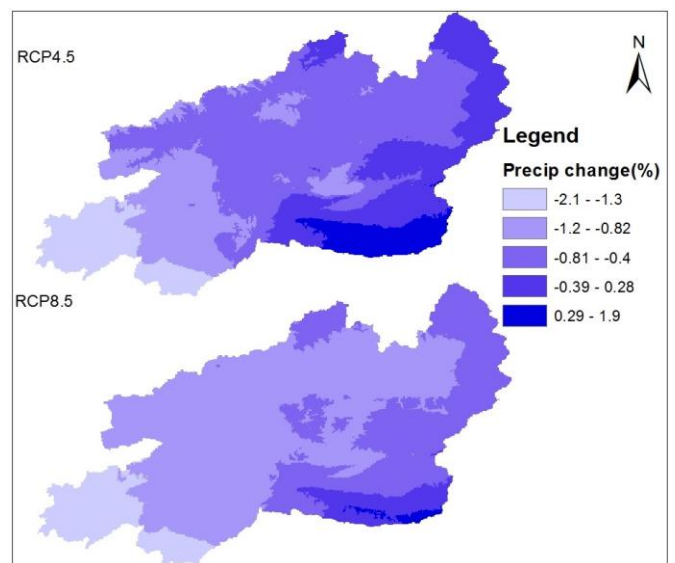


Fig (5) future precipitation change under RCP4.5 and 8.5 by 2030

In addition, both increase of temperature and decline of precipitation directly effects on water resource available at the river basin. for example, increase of temperature lead

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early snow melting and snow covers of the basin will be under threat as well may disappears. And negative change in precipitation pattern at the region alter the water distribution and river follow at the study area. Here is a dire need for water and related sectors to have proper policies for mitigation and adaptation to climate change impacts.

C. Current management structure and IWRM principles

In this study, tried to look at the current water management options at Kabul River Basin as well as governance system. As can be seen in the fig (7) governance structure of the basin shows the top down management system [12]. The recent reports from ministry of energy and water highlighted that; current water management structure of Afghanistan is based on IWRM approach but they not brought reforms in organization framework. Still it is difficult implement IWRM principles and tools with the current governance structure. However, IWRM tools not a blue print to directly apply for a river basin or watershed. It requires strong coordination and integration at different appropriate levels with softs and hard strategies, strong capacity building, natural boundary or transboundary, river basin scale with cooperation at the national and international level organizations. While having sophisticated, proper and effective policies to make efficient water use with resultant of maximum benefits from water use and reduce the wastes, economic loss and environmental degradation.

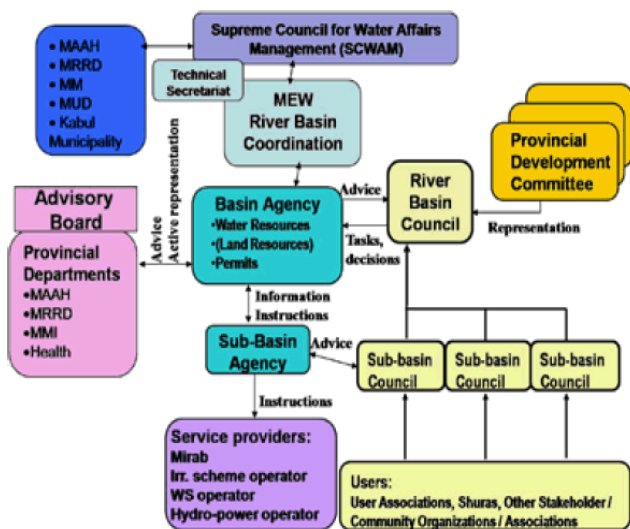


Fig (7) water governance organization, MEW2009, adapted, water sector strategy of Afghanistan.

A good IWRM system means better policies for improved catchment management, enhanced water infrastructure as well as equal ensure services and good governance. The Global Water Partnership (GWP) defined; IWRM is process to promotes coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems [13]. Hence, IWRM emphasis on holistic approach of water and related resources management to maximize the social and economic benefits from water resources without any concerning outcome to ecosystem as well as environment. However, past water related planning and management was sectorial approach with highly top-down hierarchy. The segmented management systems create major inefficiencies

and inequities in the allocation of water, although there are many reasons why lack of holistic management fails to ensure that decisions are made to meet welfare maximization, social justice or environmental sustainability. In addition, IWRM emphasis on integration within the natural system and water stakeholders. The integration within the natural boundary must be undertaken between land and water, surface and ground water, green water and blue water, upstream and downstream as well as water quantity and quality [13]. Lastly, integration should be undertaken in a sustainable manner to ensure balance between supply and demand and resources protection.

The current water management systems make inefficiencies and inequities in demand and allocation systems. The system is face with the managing and governance gaps such as;

- 1- Information gap; The hydrological data only summed in discharge data but the other information such as basin information, supply, demand, allocation, investment, and revenues.
- 2- Administrative gap; The administrative structure is highly top-down system with low coordination, the coordination is low inside of the ministry as well as other related authorities and excluded private sector and users as well as stakeholders.
- 3- Policy and objectives gap; Different departments have itself water related policies such as municipal, and irrigation and, different authorities design their own objectives and rationale for water related projects, but no one think about unique and integrated objective for water governance to meet the demand of all sectors as well effective water allocation and resolving the conflicts in water allocation.
- 4- Funding gap; Financing for water is a challenge, ineffective investment in irrigation, potable water and power production. The donor investment is good but the less technical staffs make this investment in low quality [14].

However, effective decision require to have integration between planning and management organizations, between policies and legislation process, between the water related institutions and financial donors, between water stakeholders, within the water use sectors such as drinking, irrigation, industry and environmental flow, having a balance between demand and supply sides as well freshwater vs wastewater [13,15].

In 1992, both the United Nations Conference on Water and Environment (UNCWE) in Dublin and UN Conference Environment Development (UNCED) in Rio de Janerio affirmed; for water management, new objectives must be undertaken. At the same time, they confirmed set of principles as called Dublin or IWRM principles.

- 1- Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment.
- 2- Water development and management should be based on a participatory approach, involving water users, planners and policymakers at all levels;
- 3- Women play a central part in the provision, management and safeguarding of water; and
- 4- Water has an economic value in all its competing uses and should be recognized as an economic good [13].

In addition, the World Water Forums 3th, 4th, 5th, 6th and 7th in 2003,2006, 2009, 2012 and 2015 respectively, concluded;

water for people's life, shared water resources management, managing water under changing condition, uncertainties and risks with best possible solutions and water for future themes respectively. In all forums with different water related topics emphasized to real participatory approach for sustainable holistic approach of water management as well as ecosystem [16,17,18,19,20]. The main goal of IWRM is to manage water resource in sustainable manner in the light of accurate information and establish effective governance structure, policies based on coordinated and integration in collaboration of social equity, economic efficiency and environmental suitability as well as considering interests of current and future generation.

D. IWRM for river basin level

As river basin is geographic area which is water drain via streams from upstream to downstream. Basically, basin is a unit for water planning and development too. When it became more complicated due to low coordination, investment and less skilled staffs and unappropriated policies, regulations. In 2000, the second world water forum conference in Hague confirmed: sustainable river basin management requires comprehensive study for understanding of water related challenges, effective management in context of social equity, economic efficiency and the environmental sustainability. However, due to diversity in physiographic of different basins blueprint management is not recommended [15,21,22].

The Kabul River Basin planning and management should be considered at watershed level with possible investment at the national and provincial level, specially the provincial departments must have powers, financial independence to operate and implement the management initiatives, the basin planning and governance should be considered;

- 1- A conscience basin wide information; the staffs be responsible for the collection of water resources related information, facilitation of co-ordination and negotiation between stakeholders, preparation of comprehensive proposals, plans for water resources management.
- 2- A forum of decision-making: all water stakeholders must discuss and make actual decision for basin level management and governance.

- 3- Demand side: water has economic value, managing water resources must be based on economic options make possible balance between supply and demand.
- 4- Financial: the budget may be based on water used charge, polluter pay or national budget plus donor support. The basin organization must encourage the users to invest or contribute on sustainable water services and make finance to basin organization as well as water infrastructure [7,8,17,22].

In addition, at the basin level sustainable management of water resources with highly competition between sectoral demands require full function of governance organization to build up the capacities of human resources as development process fig (8). The best applicable management options should be undertaken based on real basin information, must meet the social justice, conflict resolution and the nature friendly water regulation and legislation in corporation of cross sectoral, upstream and downstream dialogue and secure financial support at the lowest appropriate level of decision making with long term prospective. However, any water related infrastructure development project must be considered with current investment values and future pay back to the supply and meet the demand side in account for sustainable management of water resources with safeguarding of ecosystem services and environment as well.

IV. CONCLUSION

In conclusion, there are big challenges in managing and governance of water resources in Kabul River Basin, the highly top-down institutional order with low coordination, less professional staffs and unclear investment on water resources as well. The aim of this paper was to study the current water governance structure, population growth, and near future climate of the river basin. outcome of this paper illustrated the rapid population increasing, future temperature will rise and future pattern of precipitation leaning to decrease at majority of provinces. The consequences of the change put pressure on both current water resources and as well as management structure. Hence, adding population and climatic change may make environmental challenges at the basin level.

Despite having good soft and hard strategies for betterment of water resources management, here is unknown operation power between public departments, in the basin level more than 85 percent of water allocated to agriculture, and about 15 percent of water allocated to both municipal and industries. as the population is growing rapidly, the demand for water increasing from household use to agriculture production. This sectoral competition must be undertaken with different relevant ministries, the unknown interference in water related plans between ministries make inefficiencies to workable decision. Hence, ministries should have transparent, clear responsibilities for water management within the basin.

However, both rise of mean temperature make intense the evaporation which is associated with loss of water from water bodies and increase of the irrigation water demand too. On the other hand, the future precipitation demonstrated decreasing in values. This will directly impact on water bodies of the basin. as the main source of water at the Kabul River Basin originating from snow cover and precipitation any change in volume of precipitation make water resources scarcer at the basin and make conflict within the use sectors. Hence, by the near future here is a dire need to have proper development

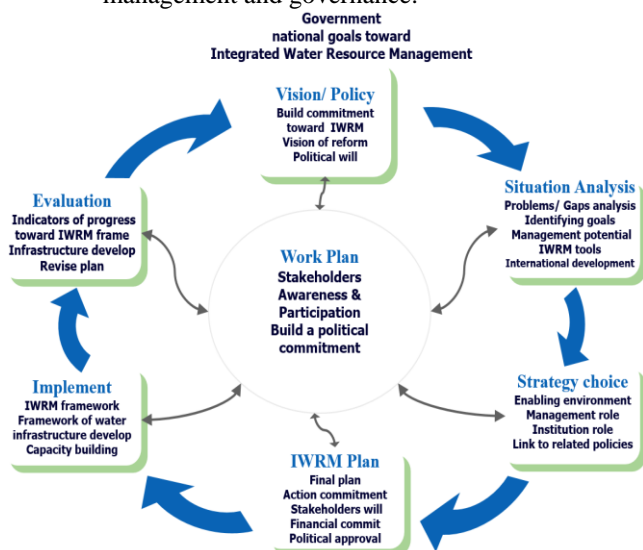


Fig (8) IWRM planning process, Adapted Cap-Net manual.

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option for managing of water and allocation of resources in sustainable manner.

To have timely response to both natural change and rapid population growth required long term dynamic and effective planning toward the sustainable water resources management framework based on the real information of the river basin. Indeed, the strong government commitment and support with possible financial and economic investment on the water resources, build up new role and regulation to meet the demand for water and improve supply side without any consideration, improve the livelihood of rural communities as well as institutional capacity building inside of organization.

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