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Research paper

Afghanistan electrical energy and trans-boundary water systems analyses: Challenges and opportunities

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ABSTRACT

Afghanistan is a major country in the central Asian region and its ability to become a bridge between south and central Asia is critical to any form of development and inter-regional collaboration particularly in the energy sector. History has not been kind to Afghanistan and it is a less developed country with poor governance and weak institutions. However, today there are opportunities to overcome the legacy of the past and seizure the vicious circle of economic regressions and political violence into enhanced political stability and economic development.

Afghanistan has sufficient energy resources to provide reliable electricity to its people and industries. Based on MEW estimates it has about 318 GW of renewable energy production capacity. Along with renewables there are significant hydrocarbons and coal resources. But despite the possession of these resources the country has remained underdeveloped with a low electrification rate of only around 30–38%. The deteriorating security conditions remain the main impediment to all the development incentives including the energy sector. The energy sector has technical, financial and institutional constraints. In addition, the trans-boundary water management issue remains a key obstacle for hydropower potential utilization.

Almost all rivers of Afghanistan are shared with neighbor countries and except with Iran there is no trans-boundary water sharing agreements with other recipient countries. This has hindered hydropower utilization of Afghanistan. Furthermore, considering weak financial institution of Afghanistan it is a distant possibility for Afghanistan to finance the hydropower projects by its own. Therefore, water sharing disputes resolution with neighboring countries should be the first priority for Afghan government to attract global financial institutions investments.

Cooperation grows from communal interests, and south and central Asia are united in the common benefits that both regions will get from energy trade and eventually regional prosperity. Afghanistan is well placed in adjacent proximity to the major hydropower and gas producer states which are desperate to diversify and reach central Asian markets. The country could become a hub of energy transit between the energy deficit south Asia and the energy surplus central Asia.

The qualitative research approach has been followed to analyze and find out the key problems and opportunities of the sectors along with PESTLE and SWOT analyses.

1. Chapter one: Background and introduction

1.1. Chapter introduction

This chapter provides the overall background of Afghanistan electrical energy system. Furthermore it highlights the research objectives, problem statement and motivation.

1.2. Background

Afghanistan is a land-locked country located within central and south Asia. Afghanistan has 32.53 million populations with $20.04 billion Gross Domestic Product (GDP) (World Bank, 2015). Because of its strategically important geographic location throughout the years this country has been a victim of political, strategic and economical battle field between fierce empires.

Starting from the invasion of Alexander the Great in 330 BC (Mehrabi, 2012) followed by several others such as Genghis Khan, Mughal Empire, Timur, Persian empires and continued by British Empire invasions in last century 1839–42; 1878–80; 1919. British

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Acronyms and abbreviations

ADB	Asia Development Bank
AEP	Annual Energy Production
AFG	Afghanistan
APA	American Psychological Association
BBC	British Broadcasting Corporation
Bbl	Barrel (42 US gallons)
BP	British Petroleum
BWT	Boundary Water Management Treaty
CAPS	Central Asian Power System
CASA	Central Asia South Asia
CF	Capacity Factors
CHN	China
CRE	Community centered Renewable Energy
DABS	Da Afghanistan Breshna Sherkat (National Utility)
Et al	Et alii (And others)
Etc	Et-cetera
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GHI	Global Horizontal Irradiance
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GoA	Government of Afghanistan
GW	Giga-Watt
HR	Human Resources
HVDC	High-Voltage Direct Current Technology
ICE	Inter-Ministerial Commission on Energy
ICES	Inter-ministerial Commission of Energy Secretariat
IJC	International Joint Commission
IMF	International Monetary Fund
IPI	Iran–Pakistan–India Pipeline
IRN	Iran
KM	Kilometer
kWh	kilo-Watt-hours
kWh	Kilowatts hour
MCC	Metallurgical Corporation of China
MEW	Ministry of Energy and Water
MoE	Ministry of Economy
MoF	Ministry of Finance
MoM	Ministry of Mines
MW	Megawatt
MWh	Megawatt Hour
NATO	North Atlantic Treaty Organization
NCAR	National Center for Atmospheric Research
NEPS	Northeast Power System
NREL	National Renewable Energy Laboratory
PAK	Pakistan
PESTLE	Political, Economic, Social, Technological, Legal and Environmental
SADC	Southern African Development Community
SCO	Shanghai Cooperation Organization
SEPS	South East Power Grid
SPG	Western Power Grid
SWOT	Strengths, Weaknesses, Opportunities and Threats
T&D	Technical and Commercial
TAJ	Tajikistan
TAPI	Turkmenistan–Afghanistan–Pakistan–India Pipeline
TCF	Trillion Cubic Feet
TCM	Trillion Cubic Meter
TUM	Turkmenistan
TUTAP	Turkmenistan–Uzbekistan–Tajikistan–Afghanistan–Pakistan
TWh	Terawatt-hours
UK	United Kingdom
UN	United Nations
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
US	United States
USAID	United States Agency for International Development
USD ($)	United States Dollar
USGS	United States Geological Survey
USIP	United States Institute of Peace
UZB	Uzbekistan
WB	The World Bank
WBG	World Bank Group
WM	Water Management

Empire has invaded Afghanistan three times seeking to block the Russian Empire influence and to demonstrate its supremacy in central Asia (Stewart, 2011). Then in (1979–89) after the Soviet Union invasion it has become the center field of the Cold War (Stewart, 2011) and currently remains under the US-led invasion started from 2001. For them these were "The Great Games" for some Afghanistan portrayed as the "Graveyard of Empires" (Bearden, 2001). But ultimately the Afghans have endured huge losses as the real victims of all these atrocities and are still suffering. The recipe of continuing instability is indefinite occupation in a land that long has been remained hostile to occupiers.

Because of the decades conflicts almost all of Afghanistan's energy (Generations, Transmissions and Distributions networks) infrastructures and related academic institutions have been destroyed. Since the start of reconstruction process in 2001 International Community has pledged USD 62 billion aid for Afghanistan reconstruction in 2002 to 2013 period (Poole, 2011). Although, since last 15 years preliminary steps have been taken to develop Afghanistan energy system but the sector still remains vulnerable and underdeveloped. And still more than 70% of the population lives without connection to electricity grid. The current administration of Afghanistan considers investment in energy field as an influential sector to the country stability and long term economic growth.

Afghanistan possesses rich energy and other minerals resources; a United States Geological Survey (USGS) suggests more than one trillion USD worth of untapped deposits while Afghan government foresees more than three trillion USD of untapped worth mines. The resources are sufficient to fundamentally change the country energy, economy and security situation (Risen, 2010). Hydroelectric power potential of Afghanistan is estimated in excess of 23,000 MW[1] along with excessive solar and wind energy potential (DABS, 2011). Based on Afghanistan Power Sector Master Plan, in 2032 Afghanistan electricity peak demand will reach around 3500 MW (Fichtner, 2013). Only renewable energies utilization is more than sufficient to fulfill Afghanistan electricity demand.

However, Afghanistan electrical energy sector is still facing huge challenges and complex set of problems associated with unstable security condition and higher dependency on import power from neighbor countries (Turkmenistan, Tajikistan, Iran, Uzbekistan, and Kyrgyzstan). Where, Northeast Power System (NEPS) a key transmission link to the capital Kabul and north region in 2011 has imported 70% of its required power supply (Irving and Meier,

[1] MW equals one million watts.

2012). In 2001 after USA and NATO involvement in Afghanistan the country needed an urgent supply of electricity so the priority has not been given to indigenous power generation because of longer completion duration it needs which made Afghanistan hugely dependent on import power. The decision has been criticized by many Afghan experts as it made Afghanistan dependent on others despite the ample resources it has.

Afghanistan energy consumption is lowest amongst the world, the electricity consumption per capita per years is around 100 kilowatts hours (kWh)[2] and around 30% of its population have access to the utility grid. In 2014 the peak demand was 750 megawatts (MW), though the unsuppressed electricity demand was estimated 2500 MW. The country is importing nearly 80% of the electricity from neighbor countries. Load shedding is quite common practice used to equalize the supply with the demand (ADB, 2015).

Afghanistan strategic location has the potential to become an energy transport hub. It can bridge the south Asia with central Asia an energy-hungry and energy-rich regions respectively. The major energy-rich countries namely Turkmenistan, Tajikistan, Uzbekistan, Kazakhstan, and Kyrgyzstan some are sharing the border with Afghanistan to its west and north. The encouraging factor which adds more importance is the desire of central Asian countries to diversify its energy market as currently vastly dependent on Russia (Romanowski, 2014). This will bring potential energy transit fees (economic growth), regional stability for the sake of mutual interest and will fulfill Afghanistan energy demand in short terms.

The fault streak between south Asia and central Asia has incurred substantial political and economic costs for the region and even worldwide. It caused the isolation of Afghanistan for large span of period and suppressed the economic growth of the country. It has offered a productive ground for the excitement of political and ideological extremism at the expense of the Afghans lives and the world. It has depressed the region from the advantages of promoting the economic ties, trade and integration. The absence of energy transit with all the associated benefits in mid is a broad illustration of the costs it incurred.

Afghanistan stands at a cross-line and so is the around region. The last ten years events have lightened up the sharp recognition of the problems which isolation, poverty and autarky could offer. This produces an opportunity for supporting the country to overcome its political and economic woes, which is in the best interest of the region and Afghanistan neighbors alike. The human and financial resources needed to back this opportunity are substantial equally are the risks, surpassed only by the potential success benefits and the failure costs to take action. Among these, the energy sector cooperation is a vital element of the regional opportunities.

1.2.1. Afghanistan electricity regulatory body

Afghanistan electricity sector is managed together by Ministry of Energy and Water (MEW) and Da Afghanistan Breshna Sherkat (DABS). MEW is responsible for water and energy sectors which are the two main economic development sectors for the country. According to Afghanistan National Development Strategy (ANDS) the ministry is responsible for overall electricity and water sectors related issues mainly development of policies and plans for energy sectors, new infrastructural projects planning, procurement and implementation, bilateral energy import and export agreements, transmission projects and etc. (MEW, 2016).

DABS is considered as a national electricity utility company. It is an autonomous and independent company and is a limited liability, with all its shares owned by the Afghan government. The company shares are distributed between different ministries namely (Ministry of Finance 45%, Ministry of Energy and Water 35%, Ministry of Economy 10% and Ministry of Urban Development and Housing 10%). It has been reformed on May 2008 for better management of electricity sector assets nationwide under the mission statement of providing reliable and safe power with reasonable prices to improve national economic growth with integrity, efficiency and transparency. It manages electrical energy generation, transmission, import and distribution on commercial bases throughout Afghanistan (DABS, 2016a).

1.3. Research problem statement

Cheap and reliable electricity plays a key role in the country's industrialization. It improves the economy, employment, welfare, and the living condition of communities. Sadly, despite having abundant energy resources, only 30–38% of households have access to electricity. Nevertheless, the electricity is currently among the basic needs of humans. Several industries have been closed due to unavailability of electricity (Glasse, 2013; Watson, 2011). This added on unemployment, poverty and further nurtured the instability.

Afghanistan indigenous resources have remained untapped and very little focus has been given to internal electricity production. The government from last 14 years has mainly focused on import power from neighboring countries. And currently around 80% of Afghanistan electrical energy comes from import resources (ADB, 2015). This has caused a heavy economic burden on Afghan society and economy. Furthermore almost every year the electricity tariffs have been progressively increased.

Furthermore, trans-boundary water management remained as a major challenge for Afghanistan energy and agriculture sectors. Afghanistan is sharing four major rivers with neighbors which have huge hydropower generation capacity (23,000 MW) but due to lack of regionally cooperative water usage frameworks for trans-boundary water management the utilization of this energy potential has remained hugely untapped.

It seems that there is a gap between the true realization of Afghanistan energy potential and the current policy making in the sector. The constant investment on import power has been questioned by many experts.

This research analyzed Afghanistan electricity current issues and discussed the long term solutions focused on indigenous power production mainly renewable energies. This research will further highlight the importance of energy resources exploitation. The research will also discuss regional energy issues, trans-boundary water and cooperation opportunities which are vital for regional economic development and stability.

1.3.1. Research questions

I. Are the indigenous energy resources enough to meet Afghanistan's electricity demand?
II. What are the key problems and opportunities in Afghanistan energy and trans-boundary water management sectors?
III. How will Afghanistan be able to meet its energy demand and target?
IV. How will Afghanistan be able to emerge as a regional energy transit hub between central and south Asia?

1.4. Research aim and objectives

- Undertake a critical review of the literature surrounding Afghanistan's energy and trans-boundary water situations and its socio-economic impacts.

[2] The kWh is a unit of energy corresponding to one kW of electricity nonstop consumption for one hour.

- Critically analyze and evaluate the suitability of Afghanistan's present and future energy resources to meet demand and supply, both conventional and renewable. Evidence of strategic planning tools (e.g.SWOT and PEST) will provide both a micro and a macroeconomic perspective.
- Assess the impact of sustainable energy resources on the future energy policy of Afghanistan, considering especially how collaborative methods with neighboring countries might assist in making this possible.
- Make recommendations as to how Afghanistan might improve its present deficit in conventional energy resources through technology, cultural aspects, finance and collaboration.

1.5. Research personal motivation

It is really painful to witness human beings live a struggling life. The life which they are not entitled to as the creator provided them with a nature which can fulfill their all basic needs. The electricity and water is among those basic needed commodities which can help reduce many of the struggles and offer people the basic living standards requirements. The majority of Afghans are living without electricity despite of the fact the country has excessive energy resources. The demand in 2032 is estimated around 3500 MW. Whereas, the country has 23,000 MW of hydropower, 67,000 MW of wind-power, and 222,000 MW of solar power production capacities which cannot only fulfill Afghanistan own electricity demand but can be exported to other countries.

This has always stimulated the author's feelings and provided the required energy for this research. The authors expect that the implementation of the recommended steps in this research will help satisfy the country electricity demand which will subsequently improve the country's economic and social conditions.

2. Chapter two: Literature review

2.1. Chapter introduction

There are very limited academic publications available at the moment about Afghanistan energy and trans-boundary water sectors. The necessary discoveries from the available publications about the focused sectors have been included in the first part of the literature review chapter. In addition an important aspect of Afghanistan hydropower energy production is trans-boundary water management agreements with its neighbors on shared river basins rich on hydropower potentials. Trans-boundary water management agreements are vital for Afghanistan electricity sector and it is one of the key challenges for Afghanistan government ahead. Therefore, literature based trans-boundary water management issues and solutions are included in this chapter as well.

Furthermore, the social, economic, regional and global cooperation key aspects of energy and its impacts have been discussed. In addition as Afghanistan seeks its geographical location as an energy transit hub between central and south Asia the energy connection with stability of the region, and as well as a motive of cooperation and conflicts between nations have also been included in this chapter.

2.2. Energy socio economic impacts on Afghanistan

Electrical energy is the backbone of socio economic growth. Electricity plays an essential role in an economy, for both consumption and production of services and goods. Electricity is important for scientific and technological developments which are vital motives for the improvement of living standards across the globe (Apergis and Payne, 2011). Electricity infrastructures have emerged as key prospects in the growth of Afghanistan as industrialization and economy are closely linked with energy access (Bochkarev, 2014). The global demand for electricity is increasing driven by immense growth of population, countries industrialization, widespread urbanization, and living standards improvement incentives (Yoo and Lee, 2010).

Shoaib and Ariaratnam (2016) have studied social and economic impacts of Community centered Renewable Energy (CRE) schemes on Afghanistan communities and towns. The study has found that CRE projects had positive social impact and were able to provide sustainable energy to the rural communities. While they had modest impacts on economic growth as these projects had limitation in terms of magnitude, job creation and businesses improvement. Yoo and Lee (2010) have linked electricity with the improvement of living condition, economic growth, and poverty eradication. Energy has become one of the main need of life and a strong foundation of modern economy.

In addition, Sadiqi et al. (2012) analyzed hybrid stand-alone power system for Afghanistan rural areas. The study has found that renewable energy (micro-hydropower, wind, and solar) based hybrid stand-alone power systems are highly cost effective and appropriate for rural areas than diesel power generation in Afghanistan. The study encouraged investment in rural communities and suggested that a combination of solar, wind and micro-hydropower will provide investment suitability and return. Afghanistan is a mountainous country and most rural communities are inhibited along different rivers flows with having wind and solar potential so to utilize all these three energy sources a hybrid standalone power system can be a reliable and profitable solution for rural community's electrification (Sadiqi et al., 2012).

Some researches insist on Afghanistan indigenous energy production (Bochkarev, 2014; Harsch and Smith, 2012) as the country possesses renewable and hydrocarbon energy resources which can be supported by import energy from energy rich countries located at Afghanistan neighborhoods (Turkmenistan, Tajikistan and etc.). They recommended the development of holistic energy policies both on national and regional level for the transformation of Afghan energy sector and to facilitate regional energy transit plans.

Parthemore and Rogers (2010) have linked the security of the countries with the security of natural resources in the 21 century. The developing countries, local communities and global economy rely to a huge extent on the availability of energy, potable water, minerals, arable land and other resources both renewable and nonrenewable to meet the demand of population growth in the world. Yet these resources availability is facing complications. Meanwhile, Apergis and Payne (2011) examined the causal relation between economic progress and electricity consumption for 88 countries under four World Bank income classification index (high income, upper middle income, low income and lower middle income) in 1990 to 2006 period. The result shows unidirectional causality in low income countries (which includes Afghanistan) between the consumption of electricity and economic growth. This suggests that it is likely that energy preservation policies which decrease electricity consumption might have an adversative influence on economic growth.

Halkos and Tzeremes (2014) analyzed the connection between Gross Domestic Product (GDP) levels and electrical energy consumption from renewable energy resources in 36 countries. The finding revealed a direct connection between renewable energy consumption and GDP improvement for most of the countries. Meanwhile for developing economies the relationship was nonlinear, in some countries it tends toward "M" shape. This is because of the instable market the industries are in. While, the continuity of energy availability will most likely make the GDP progress smoother.

Energy is of vital significance to the economic growth and welfare of the nations. Based on Iwayemi (1998) there is a strong connection between national economy and energy sector. Energy consumption, pricing, and supply have huge impact on economic and social development and welfare of the nation. On the other hand unsustainable consumption and production placed energy as an integral part in the climate change fight as its consumption creates emissions of greenhouse gases (GHG) (Goldthau, 2013).

Developing countries social and economic development is closely linked with electrical energy availability. Electricity cannot only light homes and improve welfare but will also encourage investments which will ultimately create jobs and decrease poverty. Bochkarev (2014) highlighted the key internal challenges of Afghanistan energy sector particularly in terms of supply, infrastructures, and pricing. He focused on the potential of Afghanistan to become energy corridor and link energy surplus states with energy deficit ones.

2.3. Energy resources as regional cooperation and conflict

The natural resources are on declining strain around the world. Extractive technologies advancement, growth of the population, and consumers demand have been laying unprecedented stress on natural resources, air, water, forests and the land. The continuous search for minerals and hydrocarbons is asserting exploration into further environmentally sensitive and technically challenged areas. As the pressure grows and so will the resources disputes and their potential to challenge security and peace in a progressively interconnected world is rising. Based on Keating (2015) the connections between conflicts and natural resources have been explained broadly and two recurrent themes vastly shown in the literatures are:

1. Armed conflicts are driven by control over resources.
2. Natural resources turned out to be the financial source of the conflict

Ross (2004) investigated 14 cross national civil wars and natural resources focused studies. He noticed certain deviations in regard to the type of resource and their battle effects. Several of the world's untapped natural resources are located in fragile countries where the menace of resources disputes fueling conflict is high. Countries like Afghanistan, Libya, Iraq, etc. are emerging from civil wars. It is important to understand resource governance and to avoid disputes over the extraction, ownership, and the use of natural resources from revolving to violence (Keating, 2015).

Historically from 1970 in some developing countries the resource possession have resulted curse instead of blessing. The growth of this constraint fueled conflicts and fed corruptions. Corruption is considered a significant contributing factor for the occurrence of resource curse situation. Now the experts believe that this can be prevented by proper governance of extraction and generated revenues which will blossom the economies and alleviate poverty (Kolstad and Søreide, 2009; Stevens et al., 2015). In the post-conflict sceneries, the resources revenue must be distributed in a way to prevent violence and peaceful relationships have been promoted. In addition the revenue management procedures must also alleviate the negative aspect of resource curse including corruption (Strand et al., 2010).

Boege and Franks (2009) pointed out the link between peacebuilding and rise in social tensions in post-conflict regions where resource extraction process can cause both scenarios to happen simultaneously. The former can expand in the form of infrastructures, jobs and revenues which provide hopes for the better future and the latter can emerge in the form of tensions of breeding new problems i.e. corruption and violence. Furthermore, vastly dependent countries on natural resources revenue tend to have negative or low growth and development levels and high degree of poverty and inequality.

Most of the fights are riddled with corruption; peace and stability efforts must be properly riddled with anti-corruption exertions. Church and Reiling (2009) highlighted the complexity of contemporary wars. They argued that, modern encounters are complex, and corruption results, reflects and enables from this complexity. Corruption creates wars economy as the involved parties rely on fraud, illegal syndicates and bribery to feed up their supply chain. Peace agreements might create winners from the same warlords and rebels who deployed the conflict as an income-producing event (this is the scenario in current Afghanistan). In opposition, ordinary civilians' lives are becoming even more difficult while corruption stops them to participate in the country economy, relish their basic rights and secure their families and property. Gylfason (2008) illustrated that corruption is usually more pervasive in resources rich states than in upper middle-income states. Furthermore the corruption might vary in regard to the types of the resources. Easily accessible resources regions might be more susceptible to corruption than resources required high investments.

Conflicts and corruption are directly linked. Resources may offer opportunities and incentives to involve in corruption and conflicts motivation. In policy terms extreme caution is needed during international aid funds to avoid worsening governance challenges (Le-Billon's, 2003; Rose-Ackerman, 2008). This is clearly visible in Afghanistan last decade's international community aid process as the corruption level progressively increased and infected both government and some of the international aid organizations which currently placed Afghanistan among the top corrupt countries in the world (Leonardo and Robertson, 2009), and paved the way for around 80% of international aid to flow back out of Afghanistan and did not contribute to the country economy (Hogg et al., 2013).

Goldthau (2013) highlighted the global impact of energy. He mentioned that the contemporary challenges of energy are characterized by interconnectedness globally. Externalities halting from usage and production of energy are no longer stay local or regional, but truly have global consequences. Additionally, current socio-economic schemes are categorized by a sophisticated labor division on a worldwide scale; countrywide energy systems display related interconnectedness with global or regional systems. Therefore Local energy production, consumption and transmission changes easily impact international value chains, or on welfare of other countries.

Foreign policy experts consider energy resources as a foreign policy tool by both the exporting nation and importing nation and both are looking for the consequences of the opportunities and challenges linked to it (Bilgin, 2011; Crane et al., 2012). Energy tends to shape as a global security challenge and might even evoke the resource war among the countries to secure crucial energy access for their economies, military machineries and population (Klare, 2002). The understanding of local governance pattern, actors, dynamics and nature of the issue is vital for solving resource conflicts. Church and Reiling (2009) pointed out, when local people perceive outsider intervention (international broker) as ethically compromised or favored a particular group the risk of questioning the legitimacy of the negotiation goes high.

To endorse equity and enhance welfare remunerations the decentralization of natural resources revenue has widely been promoted. This has positive impact on peace building and corruption mitigation as the issue inters broader scope with larger participants (Keating, 2015). Meanwhile, Ribot (2003) mentioned that some revenue decentralized reform practices have not been succeeded particularly in Africa. He revealed that discretionary authority transfer and locally liable representation are necessary for these types of disputes in order to be successful.

Security and financial constraints limit the ability of governments to mediate the local disputes appropriately in insecure

places. Keating (2015) mentioned that resolving the conflicts over resource needs the understanding of wide collection of skills which include:

- Knowledge of resource governance and natural resources
- Understanding of political economy and local history
- Understanding of precedents
- State role awareness
- Ability to build trust
- Complex process management

2.4. Trans-boundary water management

Following the three decades civil war and political unrest Afghanistan deals with several environmental problems. As a land-locked country fresh water management is vital for Afghanistan considering the fact that most major rivers are shared with riparian states. Based on UNEP, Afghanistan is currently using less than one third of their available 75000 million cubic meters of water due to damaged or insufficient infrastructures. The 1999–2003 droughts degraded extensive natural resources, drained water level, eroded land, dried wetland, and damaged forest. To counter the drought and lack of water people has been excessively extracting underground waters to fulfill their agriculture needs which drastically declined the ground water level and put the environment under further pressure (Habib, 2014).

Based on Goes et al. (2016), basins of four rivers of Afghanistan are shared with other countries. From the four shared rivers only the Helmand River operates under transnational (Afghan–Iranian) water-treaty which also has implementation challenges (Goes et al., 2016). Hence, these rivers water usage possess regional measures (FAO, 2012). Most of these rivers have rich hydropower potential in Afghanistan part therefore, water management agreements are vital for the utilization of these potentials (see Fig. 1).

The negligence in water management sector has damaged Afghanistan economy and environment badly. Parthemore and Rogers (2010) have highlighted the environmental and socioeconomic consequences of lack of water management in Afghanistan. Thy mentioned more than 50% of Afghanistan GDP derives from agriculture and ranching. Regular droughts, with mixture of deforestation and unsustainable land usage have placed 75% of the land area at heavy desertification risk. This raised huge socio economic and environmental concerns and need to be addressed appropriately.

Innes and Booher (2010), along with Lockwood et al. (2010) suggested voluntary cooperative practices advancement for trans-boundary and national water problems solutions, in order to incorporate bigger geographic regions and indorse social wisdom amongst institutions that manage diversely affective social and natural systems (Berkes, 2010; Hamilton and Selman, 2005). These studies covered institutions collaborative aspect of watersheds and resource management. Though, this approach faces obstacles at larger scales as some parties follow different rules, laws, and practices (Margerum, 2008).

There is a promising global institutional trans-boundary water management framework available which includes international laws and procedures. The law recommends agreement between basin sharing countries, legal frameworks at regional level, like the 2000 Southern Africa Development Community (SADC) convention on trans-boundary waterways and the UN watercourse convention on 1997. These laws define the responsibility and rights of governments in regard to trans-boundary water and set basic standard for water allocation, usage, conservation and resolution of disputes (McIntyre, 2010).

With around the world over 260 water basins transcending states borders, it is barely surprising that the condition is broadly perceived as being hostility fodder. Alternatively, as the importance of water in every aspect of life such as environment, health, energy, economy, politics, culture and welfare is evident; it is highly beyond the scope of a single country to solve many of these problems unilaterally. And there is the need of neutral third party i.e. country or organization to broker water disputes. This presents an opportunity to transform the hostile situations into mutually beneficial solutions (Brels et al., 2008).

Water is assumed as an abundant resource as the three fourth of the earth surface is covered by water but in the reality fresh and drinkable water in most of the developing countries found scarce. The growing droughts adversely affected every continent. Based on National Center for Atmospheric Research (NCAR) since 1970 to 2000 the percentage of drought stricken land area has almost doubled. The growing menaces of droughts as anthropogenic earth warming develops and creates both increased dryness and temperature, further raised the concerns about water management (Dai et al., 2004).

Habib (2014) highlighted the rivers water management in relation to the geographic condition of Afghanistan. Afghanistan is landlocked country and relies heavily on its rivers as their main source of water. Quarter of Afghanistan territory lies 2500 m above the sea level. Snowfall and rain are the major contributors to Afghan rivers flow which make Afghanistan river flow seasonal. The high altitudes of Hindukush and Pamir mountains are the origin source of Afghanistan several rivers basins. As the below Fig. 2 illustrates the water flow in Afghanistan is divided into five basins:

1. The Helmand River
2. The Amu Darya and Panj (historically called River Oxus)
3. The Harirod and Murghab River
4. The Kabul River
5. The North Rivers

Historically trans-boundary water has erupted disputes among its neighboring countries as most of the rivers flow from Afghanistan toward central Asian states specifically Iran and Pakistan. Helmand River is the only river of Afghanistan which has a bilateral water management agreement signed with Iran in 1973. Where, Afghanistan has agreed to allocate 26 cubic meters per second water flow to Iranian side according to the treaty (Habib, 2014). Strategic and political considerations are considered as the main drivers for boundaries delineation globally. Lakes, rivers mountains and whole ecosystems have been allocated to jurisdiction of various states, countries, provinces, and etc. with little regard to the effective management of their environmental cycle. Some natural resources and freshwater do not recognize human made boundaries and need internationally coordinated procedures to effectively and sustainably manage them (Ganoulis et al., 2011; 2013).

The trans-boundary water management concept has recently taken more attention due to reduction of ground and surface waters linked with food security. This forced policy makers toward a more holistic approach. Furthermore, the rapid global climate changes have more influenced countries measures toward water reserves and international cooperation (Ganoulis et al., 2011; 2013).

UNESCO plays a key role in coordination of global water initiatives through International Hydrological Program (IHP). IHP established by UNECO in 1975 which is the unique global international scientific program focused wholly on water resources. The IHP is emphasizing on sustainable management policies formulation. UNESCO helps its member states with knowledge and expertise to develop trans-boundary water management policies (Ganoulis et al., 2011; 2013). The trans-boundary water management is a complex issue and as Fig. 3 shows 263 internationally shared

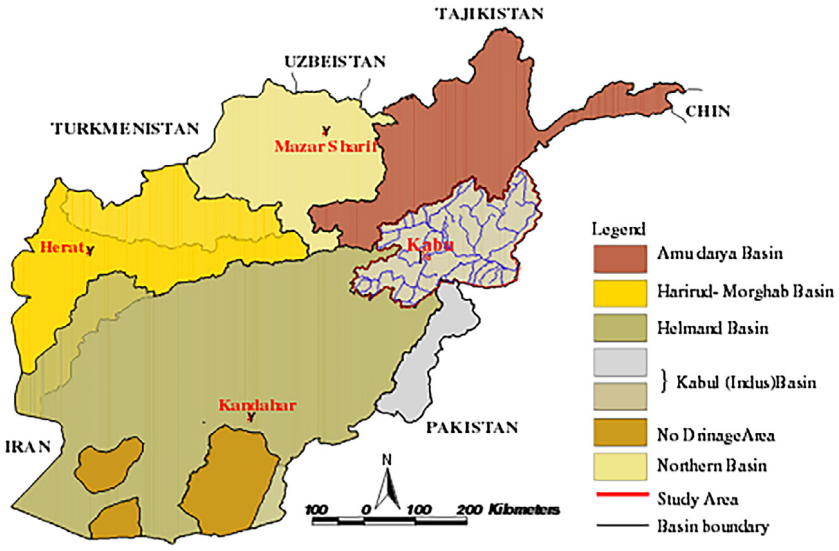


Fig. 1. Five main river basins locations (Lashkaripour and Hussaini, 2008).

Fig. 2. Afghanistan Rivers and geography (UNEP, 2009).

basins currently exists in the world. Fig. 3, highlights global shared river basins significance based on continent.

Water recognizes no boundary and currently there are some accepted laws and frameworks exist to help solve the trans-boundary water issues. The UN watercourse Convention of 1997, UN International Law Commission (on shared natural resources) and Helsinki Rules Convention 1992 are the legal frameworks or international laws for trans-boundary water resources sustainable protection and use including its aquifers (Ganoulis et al., 2011; 2013). These frameworks recommend sustainable development, equitable, precautionary, monitoring, cooperative and reasonable water usage principles.

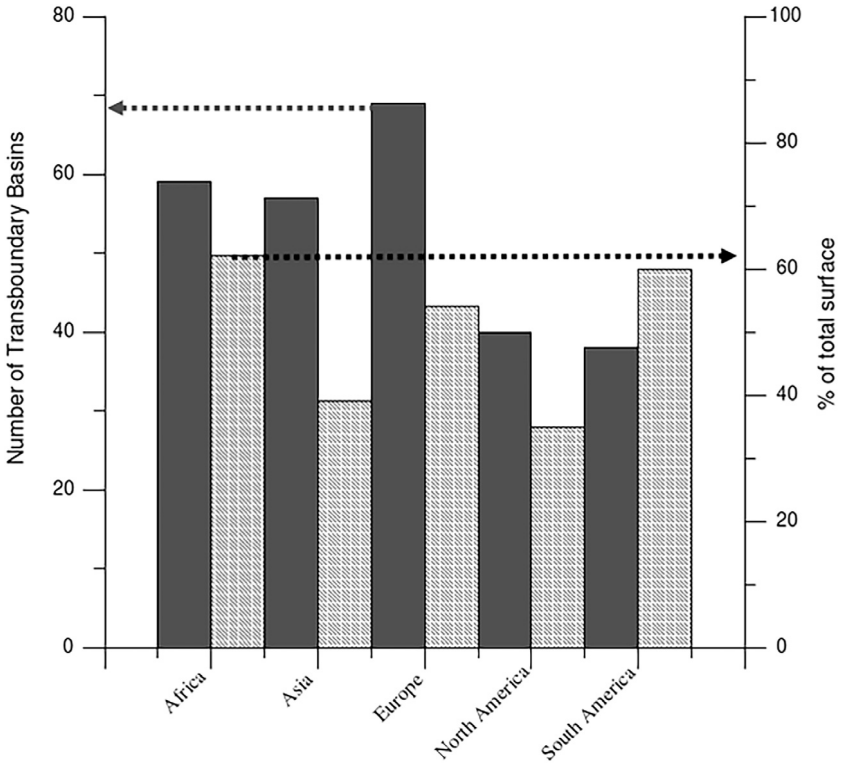


Fig. 3. Global shared river basins significance based on continent (Ganoulis et al., 2011; 2013).

The growing water stress and scarcity pushed many governments to secure the supply of future and present water use. National goals are more tend toward water security which linked with food security, energy and macroeconomics. National and regional security is often seen connected with water security and international stance on water regularly has political domains which reflect wider national intentions. The existing choices for trans-boundary water sharing are established based on universal legitimate principles like equitable utilization, without transboundary damaging effects to downstream nations and others such as historically utilized establishments. These principles must be completely understood by teams who are negotiating the transboundary water agreements and treaties (Appelgren and Klohn, 1997).

Hensengerth et al. (2012) highlighted the concept of sharing the benefits of shared river infrastructures. The concept was focused to move toward sharing the benefits arises from shared water instead of water itself. Basically, dams play a vital role in the sharing benefits scheme through allocation of project benefits and costs for each states. Though, the role of dams in this regard needs a systematic exploration as it contains multipurpose interest as well as environmental aspects. As based on International Energy Agency only 33 percent of world available potential of hydropower has been exploited.

Water shortage is the outcome of stemming pressure from the growth of population, limited supply, unequal distribution, state of degradation and environmental change. These cause increasing conflicts and intensity among the countries on national and international level. The second factor which causes the conflict is often due to the inadequate management of water at national level. The effective management methods must address social and political characteristic of water based on geopolitical and regional realities. Uncertainty and variability of water supply hampered the transboundary water resources efficient management. Furthermore, countries have shown incentives to have control over the water resources before it reaches beyond their political and hydraulic control (Appelgren and Klohn, 1997).

As shown in Fig. 4, based on Brels et al. (2008) human induced water related activities can cause changes to the water flow (surface and underground), and might potentially source changes in the inland water system in other parts. For long term water access security it is in the interest of states to adopt an approach of regional responsibility and review enduring political water sovereignty positions. The substitute method in conditions of national conflict is to connect water with economic policies and to search for acceptable resolutions pursuing support of independent mediators from a global organization or a third party country.

Most of the trans-boundary water management practices are driven by the construction of mega hydro infrastructures such as hydropower dams and water reservoirs. Earle and Bazilli (2013) mentioned that such approaches have shaped discourses with the emphasis on national interest. This might has the negative effect on local communities who rely directly on these resources and might be forced to relocate, and lose the access to traditionally belong agricultural land (Kistin, 2007).

As the water resources are becoming rare, tensions between diverse users are intensifying, both at international and national level. Basins of more than 260 rivers are shared among two or more states. In the absence of proper water management agreements and institutions, the changes in a basin can cause huge transboundary tensions. As mega projects progress without bilateral collaborations can become a source of conflict, intensifying regional insecurity (World Water Counsel, 2016).

The continuous global population growth (some predictions suggest 50% increase in the next 50 years) water stress is becoming more problematic in future as the demand for fresh water goes beyond the supply. In addition the population rise associated with urbanization and industrialization has further increased the water demand and will result in serious environmental consequences (USIP, 2007; World Water Counsel, 2016).

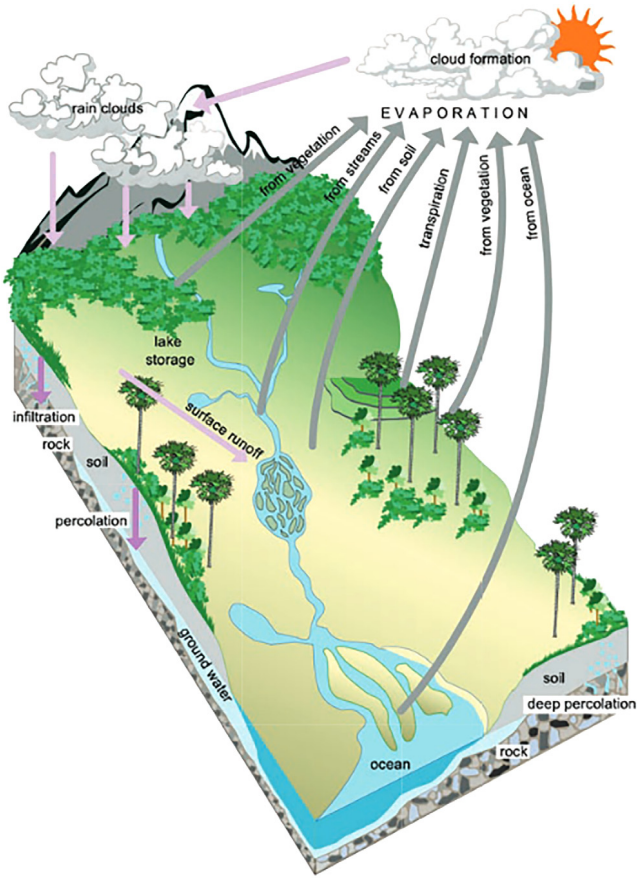


Fig. 4. Hydrological cycle schematics, shoes the effect of human induced changes on environment (Brels et al., 2008).

Many literature research in this field emphasizes on the benefits resulted from cooperation for both upstream and downstream countries (Koontz and Johnson, 2004; Moore and Koontz, 2003). Some scholars such as Forester (1999) and Innes and Booher (2010) have suggested that government agencies must push for cooperation rather than creating obstacles toward institutional growth spanning around this complex background. Wide range of factors, like community members attitude or region economic situation also shape collaborative opportunities in practice. Though, different state agencies and civil society leaders might be keen to overcome fragmentation and collaborate wherever opportunities arise (Daniel et al., 2013).

Appelgren and Klohn (1997) highlighted the importance of development of holistic trans-boundary water management international law and human capacity development of developing nations in this regards. International law must cover significant level of critical issues and consider the significance of challenge resolving issues between countries with different economic and political level, different cultures, varying manpower and institutional capacity. The low income stressed countries are more vulnerable and shared rivers often cross different category of people in different states. This highlights the requirement of improved basin equity and efficiency analysis and improving the capacity of negotiators to parity to resolve the shared water issue properly.

Water resources management is complex and challenging to manage because it passes through different politically controlled territories and several jurisdictional boundaries (Kliot et al., 2001). The literature recommends various solution structures for the governance of water resources with several institutions for the development of legal frameworks for treaties between states in this regards (Heikkila and Gerlak, 2005a, b; Lockwood et al., 2010; Rahaman, 2009). Based on these researches the summarized five internationally recognized shared water resources management principles derived from 1966 Helsinki International Rivers Rules and UN International Watercourse 1997 convention are included in Tables 1 and 2.

2.4.1. Trans-boundary water politics

Global food demand growth has stressed developing economies with food deficit and is facing growing difficulties in obtaining food. Million people are dependent on agricultural related jobs linked with trans-boundary water resources. Hence, regional and national food and water security are not only closely related to the shared water but are also related to a higher portion with global food trade (Appelgren and Klohn, 1997).

Allan and Allan (2002) and Earle and Bazilli (2013) have linked the trans-boundary water management to the politician willingness toward resolution. The commitment to defend sovereignty and country rights influence the speed, direction and quality of water management deals and water laws influences from political stance. The involved organizations derive the mandates from these laws and prioritize their tasks based on political desires. Based on Earle and Bazilli (2013) the multinational and national organizations legal provisions involved in water receive their legal mandate from the international agreements they are created based on. These organizations are anticipated to minimize the possibility of conflicts and solve disputes between their states and encourage sustainable socio-economic growth.

Appelgren and Klohn (1997) have highlighted the political stances of governments. In a global perspective unlike local or regional level control on water is based on long term strategic interests and national sovereignty positions rather than on short term economic advantages. Therefore, even the poorest countries are not likely to consent to change their strategic position for financial compensation and will stay reluctant to conciliate with national water security related issues. Similarly often the trans-boundary water issues arise with countries with unequal influence and power lead to high level of uncertainty and deviate cooperation and agreement compounded with the absence of mutual trust.

There are various potential reasons which have negative impacts on trans-boundary water agreements such as mistrust between states specially if there is power difference between them, or there is lack of support from key stakeholder in this type of negotiation. However, the cooperation level is over twice more than conflict in the 262 agreements reached throughout the world thus far (Wolf et al., 2003). Water is a precious source and globally states understand the importance of it.

With inadequate institutional capacity to deal with this issue, water shortages become a threat to regional and national security and might contribute to developing countries economic failure. Policy maker and politicians analyzing economic and social impacts of water shortages must cautiously balance the necessity for national development and regional cooperation benefits between neighbors with consideration of trade and other gains (Allan and Allan, 2002).

2.4.2. Global trans-boundary water agreements examples

The global background:

- Around 3800 bilateral, multilateral and unilateral, conventions or declarations are existed on water.
- The previous half century has observed over 500 conflicts over water, seven among them have witnessed violence.

Table 1
Trans-boundary water management globally accepted principles (Rahaman, 2009).

Principles	Details
Equitable and reasonable utilization	This principle enables each basin state to use an equitable and reasonable share of water resources within its own territory. Reasonable and equitable utilization is the foundation of shared sovereignty and rights equality, however, it does not necessarily translate to the allocation of an equal share of waters. There are several factors which need to be considered in determining a reasonable and equitable share such as the basin geography, hydrology, population dependency, socio-economics, the present utilization of waters, potential future needs, climate and ecological and availability of other resources, etc.
Not to cause significant harm	Based on this principle, no state in an international shared basin is allowed to use the water resources in their territory in a way that would result in significant harm to other basin states and the environment.
Information exchange and cooperation	Under this principle, it is the responsibility of all riparian states of an international waterway to collaborate and exchange information regarding the watercourse and the current and future planned usage of water resources.
Consultation, negotiation, and notification	Every state in a trans-boundary watercourse is eligible to prior notice, negotiation, and consultation in cases where the planned use by another riparian of a trans-boundary watercourse might cause serious harm to its interest or rights.
Peaceful resolution of disputes	This principle supports that every state in a trans-boundary-watercourse must settle the disputes peacefully in case a concerned state cannot reach an agreement via negotiation.

Table 2
Master plan estimated each stage investment details (Fichtner, 2013).

Overview on Investment type	Optimized scenario investment [m$]				
	Subtotal by project	Stage A	Stage B	Stage C	Stage D
Generation development	7329.6	327.6	348.5	981.5	5671.9
Major transmission projects	1726.8	595.0	676.9	212.9	242.0
Transmission development within the provinces	1040.1	290.1	439.8	215.1	95.0
Total	10096.4	1212.7	1465.2	1409.5	6009.0

- Based on UNESCO, nations of 145 countries have land within a trans-boundary basin. 12 countries have in excess of 95% of the territory inside trans-boundary basins. Nearly a third portion of the present 263 trans-boundary basins are mutual by over two nations (UN, 2006).

Water is a vigorous source of life and has been recognized for centuries to be a main cause of conflict and tensions between countries and nations. Over the 20th century the global demand for water has increased six-fold, prompting a number of experts to envisage that 21 century wars will be over water. Although fresh-water's tendency to stress relations amongst states often marks the headlines, the coin opposite side – water as a mediator of cooperation – occasionally catches enough attention. Nonetheless, researches have shown ample historical proof of water playing the cooperation catalyst role, rather than conflicts trigger. There are cases of practical agreements on water took place stretched between countries that were in battle on other issues such as the cases of Pakistan and India and Jordan and Israel (UN, 2006).

There are clear successful examples of solving shared river conflicts based on benefit sharing. Senegal, Mauritania, and Mali have reached agreement on River Senegal in 1972 based on cost sharing in relation to the benefits gained from the dam. Another successful example is United States and Canada agreement on Columbia River where, they shared both the dam's costs and the generated electricity (Thomas and Warner, 2015). Similarly, the Nile Basin agreements in Africa are good lessons learned in this regard for Afghanistan and its neighbors.

Sainz-Borgo (2011) analyzed Venezuela trans-boundary water treaties with its neighboring countries Brazil, Guyana and Colombia, from legal perspective. He mentioned that Venezuela water management with neighbors is based on equity with consideration of following three key aspects

- Inland watercourses
- Territorial sovereignty
- Environment protection.

Equitable utilization is the main principle followed by Venezuela's trans-boundary basins management with having unique frameworks and commissions for each country. Earle (2012) linked the success of trans-boundary water agreements with the capacity of the institution, managers, politicians, researchers, and financial institutes to work collaboratively.

Grover and Krantzberg (2015) highlighted the Canada–USA trans-boundary water management agreement cooperation and innovation which sets a good example of trans-boundary water cooperation between countries. USA and Canada share about 3200 KM water border and around 300 rivers, streams, and lakes define the USA–Canada border. The signed 1909 Boundary Water Management Treaty (BWT) and formation of International Joint Commission (IJC) for shared water protection between the two countries addressed most of the common concerns and shared interests related to these resources rather than issue-by-issue based negotiation approach. The team who negotiated these agreements believed that the shared water problems must be solved base on deliberations of permanent equal and bi-national institutions, instead of diplomatic negotiations (Crane, 2012).

The IJC commission works based on following three principles:

- Regulation: approves or rejects applications from states, individual or companies in issues related to shared water.

- Investigation: conflicts issues investigation, and submitting recommendation to the respective governments.
- Coordination/surveillance: monitor the implementation of agreed recommendations.

In addition, the IJC assesses the both government's progresses and plans in regard to Great Lakes improvement and protection (Krantzberg et al., 2006).

The development of water distribution infrastructures and reservoirs is vital for water security achievement. Nonetheless, it needs to consider environmental and social safeguards. Some past agreements that were lacking these considerations have become the source of conflicts instead of its resolution. The Nile River agreement between Sudan, Egypt, and Britain (on behalf of colonies upstream countries) allocated the full river flow to Sudan and Egypt. This has escalated tensions with the upstream countries who now demand to gain the equitable share of this river water resource (Earle and Bazilli, 2013).

3. Chapter three: The research methodology

3.1. Chapter introduction

This chapter discusses the study methodology and approaches. It justifies the reasons behind the selected methodology. It also includes the planning stages and timescale of this research.

3.2. Research methodology

The way a research can be approached has a profound effect on the quality of the study. Thesis could be based on qualitative or quantitative data or the combination of both. The choice of selection between these methods depends on the individual abilities and preferences, and the fitness of a particular approach with a topic (Creswell, 2014). There are quite large ranges of methods and approaches to choose from but the important aspect is to justify the chosen method and approach.

The Research Onion model developed by Saunders et al. (2007) is a useful framework to follow for appropriate research philosophy and strategy development by working from its outer layer toward the center of the onion model. It has six layers and every layer designates a detail research process. It can be applied to all types of research methodologies in diverse range of contexts (Saunders et al., 2007). The Research Onion model does not include the three philosophies of Axiology, Ontology, and Epistemology which are among important steps for research philosophy selection and planning (University of Derby, 2012). (See Fig. 5.)

The Ontology philosophy and the 3rd layer of research onion model as shown above have applied more deeply in developing this research. The Ontological philosophy helped to find the real dynamic of the energy and trans-boundary water sectors and its influence on the region and Afghanistan. This research has been developed pursuing qualitative research approach based on the review and analysis of literature such as books, journal articles, reports, and conferences related to Afghanistan electrical energy and trans-boundary water.

The reasons behind selecting this methodology come from the nature of the study as it covers the overall analysis and in-depth understanding of implicit facts in the energy sector and examines the reasons and ways of decisions making in the mentioned sector which can be addressed better based on this method than quantitative one. In addition, the qualitative method is characteristically flexible compared to quantitative method so it facilitates better adjustment and spontaneity of the interface amongst the study and the researcher. Hence, the qualitative method is more appropriate in this regard.

There is significant lack of credible data sources in Afghanistan and in most cases it is very difficult to achieve the required information because of the lack of adequate institutions. Meanwhile, with all the difficulties the main focus has been concentrated on the credibility of the information sources and in all cases the data has been achieved from governmental, and well known international organizations sources.

Some of the key data sources for this research development were Afghanistan Power Sector Master Plan developed in 2013, Inter-ministerial Commission of Energy Secretariat (ICES), the World Bank (WB), Asian Development Bank (ADB), Afghanistan National Development Strategy (ANDS), National Power Utility Company (DABS) and Ministry of Energy and Water (MEW) websites available data. For solar and wind energy analysis the USA National Renewable Energy Laboratory (NREL) international activities section available data has been utilized. In addition, the author personal work experience with Afghanistan energy sector helped to analyze and understand the issues more deeply.

For trans-boundary water issues analysis the key global transboundary water treaties have been analyzed as examples to emphasize on possible solutions for these complex disputes. In terms of energy Afghanistan has various resources which need to be discussed and analyzed. The main focus of this research is on hydropower, solar and wind energy. As these resources are easily accessible and environment friendly.

For the external and internal factors analysis which can affect this research subjected areas the SWOT and PESTLE strategic planning methods have been applied. SWOT analysis has been done for Afghanistan energy sector and PESTLE analysis has been done for Afghan trans-boundary water issue as it contains significant environmental and legal implications and PESTLE can better address these. The templates for both of these methods have been created using Creately.com online tools.

The referencing style is according to American Psychological Association 6th (APA-6th) edition.

3.2.1. Research planning

Below Gantt chart includes the research planning and timescale (see Fig. 6):

4. Chapter four: The research analyses and findings

4.1. Chapter Introduction

This chapter is the main part of this study. The key data analysis and findings are included in this chapter. Afghanistan energy resources overview, the SWOT analysis, the energy sector opportunities and constraints, and trans-boundary water analysis are all included in this chapter.

4.2. Afghanistan energy and resources overview

Energy plays a vital role in today's human life. Natural resources are used to provide the basic needs and improve the life quality of human being. But in many countries around the world natural resources access could not be taken for granted. Some energy resources have impact on neighbor countries and beyond. Most of the energy resources are used to produce income which tends to become problematic in unstable and ethnically diverse regions. This resulted in a so called resource curse, a paradox that some countries with possession of abundant resources still have less economic and social growth than those without it (USIP, 2007). Afghanistan is currently in the same paradox with abundant resources but still in deep struggles.

Afghanistan has various types of energy resources such as renewable energy (hydropower, solar, wind, biogas, geothermal

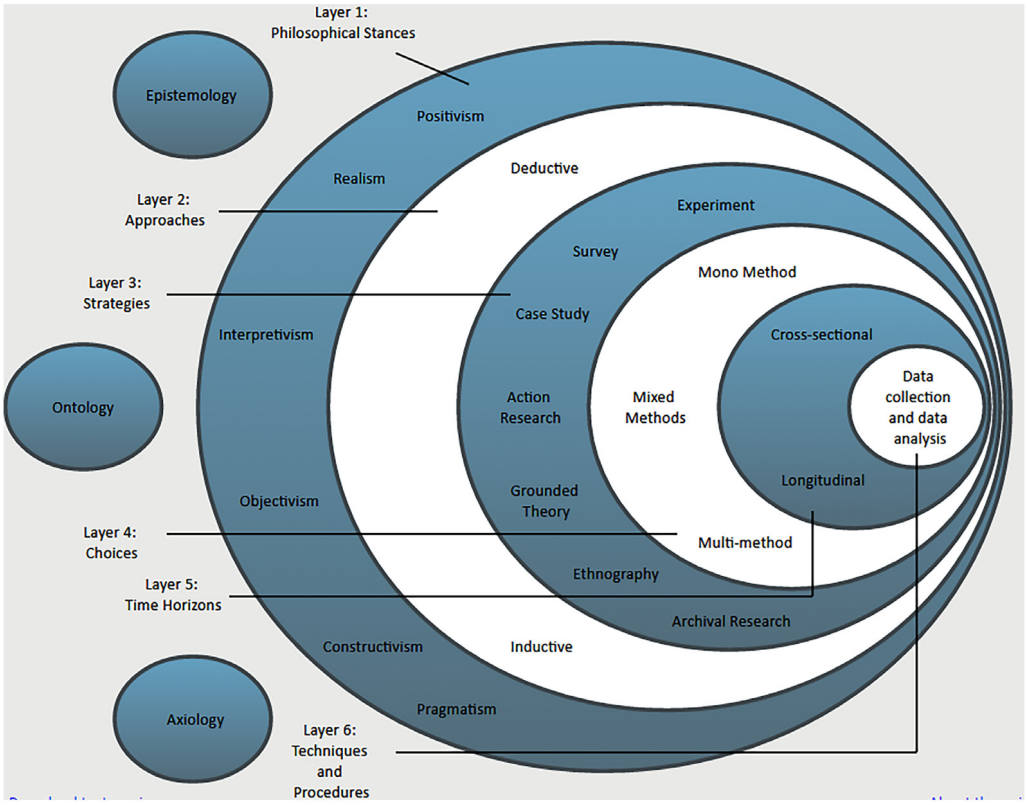
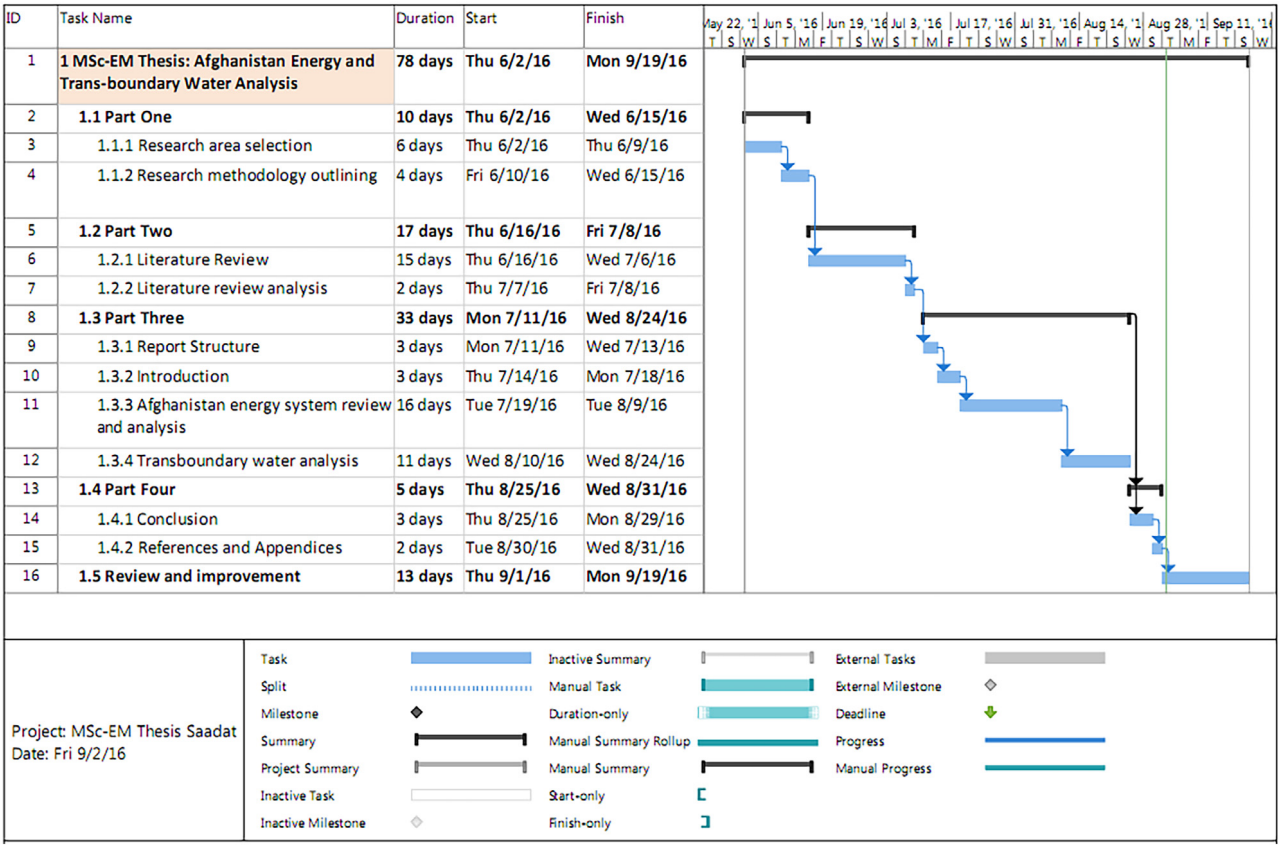


Fig. 5. Research Onion Model with three additional philosophies (Saunders et al., 2007; University of Derby, 2012).



ID	Task Name	Duration	Start	Finish
1	**1 MSc-EM Thesis: Afghanistan Energy and Trans-boundary Water Analysis**	**78 days**	**Thu 6/2/16**	**Mon 9/19/16**
2	**1.1 Part One**	**10 days**	**Thu 6/2/16**	**Wed 6/15/16**
3	1.1.1 Research area selection	6 days	Thu 6/2/16	Thu 6/9/16
4	1.1.2 Research methodology outlining	4 days	Fri 6/10/16	Wed 6/15/16
5	**1.2 Part Two**	**17 days**	**Thu 6/16/16**	**Fri 7/8/16**
6	1.2.1 Literature Review	15 days	Thu 6/16/16	Wed 7/6/16
7	1.2.2 Literature review analysis	2 days	Thu 7/7/16	Fri 7/8/16
8	**1.3 Part Three**	**33 days**	**Mon 7/11/16**	**Wed 8/24/16**
9	1.3.1 Report Structure	3 days	Mon 7/11/16	Wed 7/13/16
10	1.3.2 Introduction	3 days	Thu 7/14/16	Mon 7/18/16
11	1.3.3 Afghanistan energy system review and analysis	16 days	Tue 7/19/16	Tue 8/9/16
12	1.3.4 Transboundary water analysis	11 days	Wed 8/10/16	Wed 8/24/16
13	**1.4 Part Four**	**5 days**	**Thu 8/25/16**	**Wed 8/31/16**
14	1.4.1 Conclusion	3 days	Thu 8/25/16	Mon 8/29/16
15	1.4.2 References and Appendices	2 days	Tue 8/30/16	Wed 8/31/16
16	**1.5 Review and improvement**	**13 days**	**Thu 9/1/16**	**Mon 9/19/16**

Fig. 6. Research planning Gantt chart.

Current Sources of Power		
Sl. No.	Source of Power	Share in MW (%)
1.	Fossil Fuels (Diesel & Gas)	10%
2.	Hydro	8%
3.	Renewable Energy	2%
4.	Power Imports	80%
	TOTAL	100 %

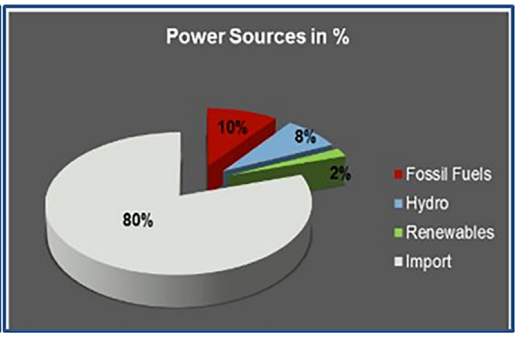


Fig. 7. Afghanistan current power sources (DABS, 2016b).

etc.) and non-renewable resources {natural gas, oil, coal and nuclear (Uranium) resources} mostly untapped. Nevertheless, with availability of all these internal resources Afghanistan is currently importing around 80% of the required electricity from neighboring countries. Afghanistan internal energy resources exploitation both renewable and fossil can change the country in midterm to energy self-sufficient and possibly an energy exporter (Bochkarev, 2014)

Afghanistan in terms of electricity consumption is amongst the lowest in the world. About 100 kilo-Watts-hours (kWh) per capita per year consumption with only 30–38% of the population have access to electricity grid. In 2014 the peak demand was around 750 MW, though the unsuppressed demand was much higher approximately 2500 MW. As Fig. 7 shows import power comprises 80% of the total available electricity and the electricity demand is increasing very fast. The load shedding is still the only option to equalize the supply with the demand. To meet this demand growth Afghanistan needs to invest on domestic resources such as hydropower, fossil fuel, and renewable energy production both through governmental and public–private sectors contributions (ADB, 2015).

The government strategy is to develop energy sector road map, strategy, policy framework and visualize investment in the sector according to national energy supply program till 2030. Based on current policy the government prioritized the internal resources utilization for electricity production parallel with import power infrastructures development. The main focus is on renewable energy and development of gas and oil fields to provide reliable energy for industries and household. The government has also developed regulatory frameworks for private sector investments. The Electricity Service Act 2015 is a prime example in this regard.

The sector has planned to spend more than $10 billion till 2032 and the expectations are to improve the electrification rate from 30% to 85%; increase indigenous power generation from 20% to more than 67%, interconnect and develop transmission and distribution networks, and strengthen the power exchange connections with neighbors systems.

The World Bank, USAID, and ADB are providing capacity support to DABS commercialization and institutional development in order to improve the electricity system operation and maintenance practices, revenue protection, corporate governance, procurement reforms, and planning.

Afghanistan has abounded **renewable energy resources**, estimation has shown it has 67,000 MW of wind potential, 222,000 MW solar power production capacities, and 23,000 MW of hydropower potential. Though, to date the utilization of these resources are minimal. Currently only 10% of overall energy demand is provided by renewable energies mainly hydropower. The developments of these resources are vital for Afghanistan energy sector.

Afghanistan **coal resources** have been not utilized yet. The Bamyan province located northwest of Afghanistan has significant coal resources. Some key mining projects were under pipeline since 2008, but yet to be started, such as Aynak copper mining project one of the biggest copper reserves in the world which contract has awarded to Metallurgical Corporation of China (MCC) for $3 billion. This project includes 200 MW coaled produced surplus electricity for national grid. The other promising project is Hajigak iron deposit which includes the development of 800 MW power plant. The realizations of both projects remain uncertain due to security and other legal concerns.

The country **natural gas** resources utilization is hugely underdeveloped. Based on Afghanistan Ministry of Mines and Petroleum and the United States Geological Survey (USGS), Afghanistan natural gas resources are estimated 444 billion cubic meters, this is in addition to previously discovered 75 billion cubic meters gas reserves. In order to encourage investment in this sector the gas investment framework and development plans are essential to identify, sequence and harmonize the extension program effectively (Harsch and Smith, 2012).

Exploitations of indigenous energy resources are important considering the rapid international aid deduction since 2014. Afghanistan is thus far not able to finance the basic governmental expenses. In addition, as an annoying fact, based on the World Bank around 80% of aid funds have flowed back from Afghanistan by international contractors, and imports and have not spent on Afghan economy which caused a huge economic fragility. Spending through Afghan government channel was more likely to influence domestic economy which did not happen due to corruption and ineffective governance (Harsch and Smith, 2012).

The below SWOT analysis of Afghanistan energy sector further classifies the sector internal strengths and weaknesses with external threats and opportunities. (See Fig. 8.)

4.3. Afghanistan energy sector opportunities

The opportunities of the sector as highlighted by SWOT analysis are summarized in the following key four categories:

- **Renewable Energies:** Though there are several other types of renewable energies potential in Afghanistan (Geothermal, Biomass, Biogas etc.) but for the sake of this report the following main three types are considered:
  - Hydropower Energy (including Trans-boundary Water Agreements).
  - Solar Energy.
  - Wind Energy.
- **Non-Renewable Energies:** Fossil fuel such as natural gas, oil and coal resources.
- **Import Power:** Easily accessible energy resources from central Asian countries.
- **Regional Cooperation:** Afghanistan as a major energy transit hub.

All four opportunities are discussed in details below.

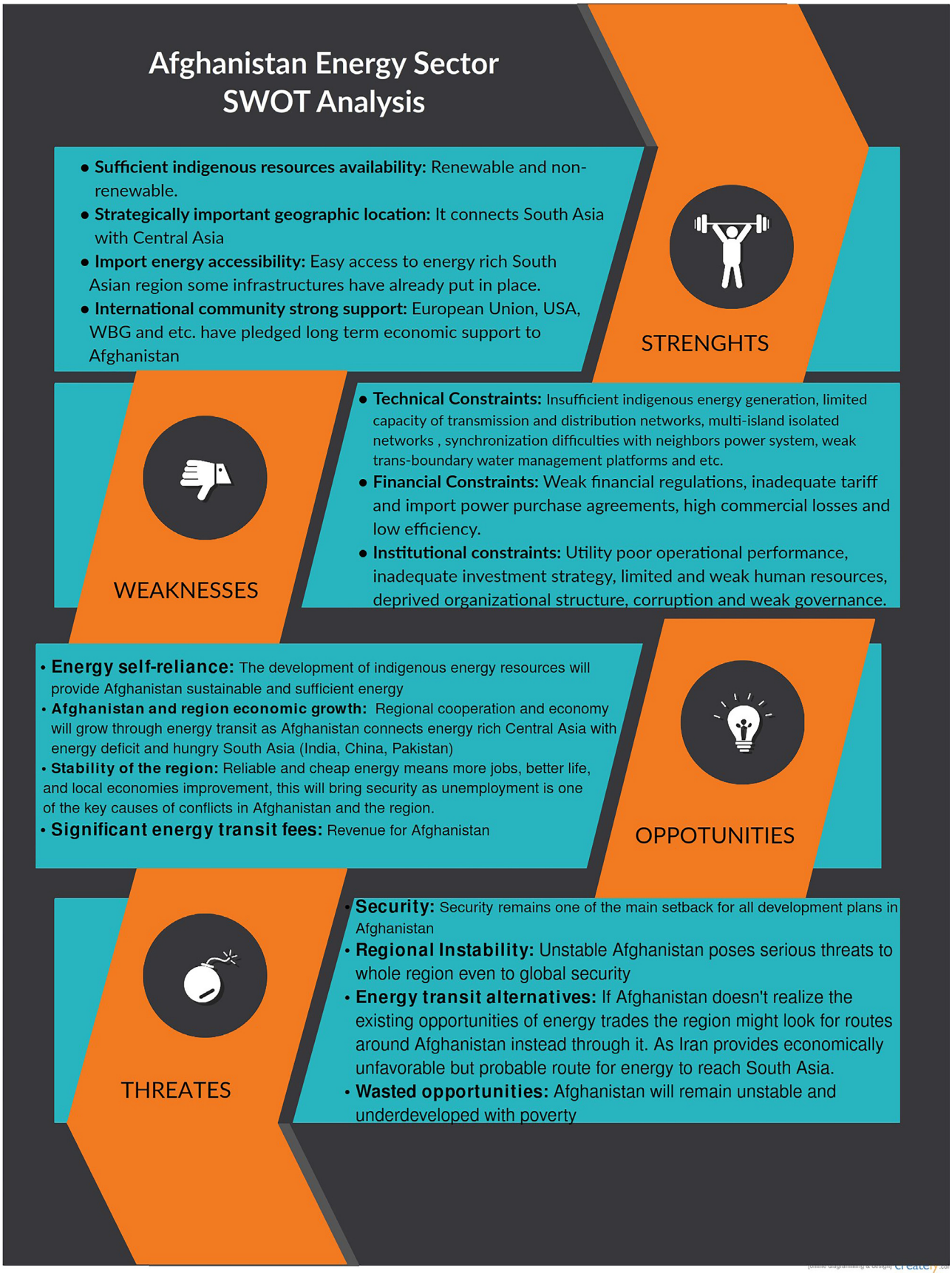


Fig. 8. Afghanistan energy sector SWOT analysis (Author's own work).

4.3.1. Renewable energy

Over the past 200 years the large proportion of world energy has produced from non-renewable sources like coal and oil. Meanwhile as the global energy demand is increasing these resources are drying out so the focus on renewables as the future source of energy is growing. International organizations estimations show that if the global demand for fossil energy continues at the current level the gas and oil reserves might run out in near future. Oil is expected to run out in coming 50 years, natural gas in next 70 years and coal is expected to stay a bit longer until next 250 years (BBC, 2014). Therefore, the need for sustainable and renewable energy generation is vital.

Renewable energies come from infinite resources of energy which rapidly replenish themselves hence could be consumed again and again. Renewable energy production is important for sustainable development of the world (USIP, 2007). Afghanistan has abounded renewable energy resources, based on Ministry of Energy and Water (MEW) estimations it has about 318 GW of renewable energy production capacity. The key of these resources are 67,000 MW of wind potential, 222,000 MW solar power production capacities, and 23,000 MW of hydropower potential. Though, to date the utilization of these resources are minimal (ADB, 2015; MEW, 2015). Though, currently only 10% of overall energy demand is provided by renewable energies mainly hydropower.

Afghanistan renewable energy policy has set an ambitious target of producing around 5000 MW of electricity from renewable energies till 2032 which reaches the 95% of overall energy demand envisaged by Afghanistan energy sector master plan (MEW, 2015). The renewable energy policy encourages public–private partnership in this sector. For the achievement of this goal Afghan government must facilitate the utilization of these resources specifically the water usage agreements with its neighbors and offer supportive incentives for private investment.

The energy market is evolving at faster speed globally. The rapid deductions in costs have made the solar and wind power more competitive in most of the sittings. This unlocked the prospective for unconventional hydro-carbonates. Yet many developing countries including Afghanistan with abundant resources are struggling to provide sufficient energy for their population and business.

The developed technologies in this sector are very much diverse to harvest these immense renewable resources, which make their utilization happen in various geographical locations of Afghanistan. Sustainability, adaptability and affordability are the main justifying factors for the use of renewable energy technologies in electricity generation (Shoaib and Ariaratnam, 2016). The World Bank is committed to finance and support all types of renewable energies, based on states technical and institutional capacity, resources endowment, environmental policy and availability of finance for tradeoffs and cost differences (World Bank, 2013). Therefore, the institutional development of Afghanistan energy sector is vital to utilize these resources.

Climate change and energy are interconnected based on World Bank (2013) around two third of greenhouse emissions are linked with the energy consumption and production, making the intervention of energy sector critical to the environment protection. This intensified the efforts about scaling up renewable energies, energy efficiency, technological breakthroughs, energy storage, and adopting policies and tools to cover universal externalities.

The four key sources (Hydropower, solar and wind) of Afghanistan renewable energies are analyzed below with further details.

4.3.2. Hydropower

Afghanistan is a mountainous country; with five key river basins originate from these mountains. The land altitude differences provide energy potential to the water flow which made the rivers of Afghanistan packed with significant hydropower potential. The mountains melting snow and rain flow create the major portion of the rivers water. As shown in Fig. 9 the four main river schemes are Kabul, Amu, Hilmand and Harirud rivers systems which majority hydropower potential is still not utilized.

Mountains are the key source of Afghan rivers water which needs a holistic analysis. The assessment of millennium ecosystem recognized the mountains importance to global water source. However, it also emphasized the diverse interests of people who are dependent on these resources, along with forests, plants, and minerals; beside the jurisdictions, sovereignties and usage (Debarbieux and Price, 2012). Based on mountains importance and shared value to surrounding environment and downstream population, recently around the world in the large extent the cooperative steps have been taken in regards to complex water resource system management (Bergmann and Bliss, 2004).

A preliminary technical survey estimated Afghanistan hydropower potential in excess of 23,000 MW (DABS, 2011). This is a promising sign for Afghanistan energy self-sufficiency considering the estimated 3500 MW of electricity demand of Afghanistan in 2032. Afghanistan electricity 20 years master plan from 2013 to 2032 has been categorized by four stages Stage-A focused on import power, was till 2015, Stage-B comprises the system development till 2020, Stage-C and D are long term developments stages cover until 2025 and 2032 respectively (Fichtner, 2013). The first two stages have been focused more on import power and internal networks reforms. The last two stages are mainly focused on indigenous power production mainly hydropower. The key sites have been identified by the master plan and the design efforts are in progress.

Around 20,000 MW hydropower production capacity is on the Panj–Amu Darya and its other tributary rivers along the border among Afghanistan, Uzbekistan and Tajikistan and need for trans-boundary water sharing treaties. Furthermore, some of these planned dams areas need population relocations and resettlements. These need extra governance efforts and funds. In most cases the affected local people is usually not openly represented in dam's negotiation which might cause backlashes. Therefore, complete compensation of adverse environmental and social effects needs conciliation with affected communities to ensure the full compensation and a portion of the benefits allocation to this category of people.

Currently Afghanistan is struggling with its energy, economy, unemployment, poverty and environmental issues on underground water ecosystems. As the outskirts of the country is increasingly facing security challenges and more and more people are coming toward main cities and due to lack of infrastructures, waste water treatment plants and proper sanitation systems the underground water has polluted and damaged badly. Majority of the cities population uses home built wastewater septic tanks and the often leakages associated with it has contaminated the groundwater which adversely contaminated the drinking water wells (Hydratelife, 2012). Development of hydropower dams will not only help to produce the much needed electrical energy and agriculture water for Afghanistan but will also help tackle the environmental issues associated with water management.

Water Management (WM) in all basins face many challenges amongst them are insecurity, downfall of the rivers flow monitoring system due to decades of wars in Afghanistan side since 1980, increasing droughts since 1999, inappropriate maintenance and operation of present water infrastructures, upstream water storage reduction due to reservoirs siltation (sediments), and possible future snow fall reduction due to temperature rise (Goes et al., 2016).

Dams can also play an important role for the mitigation of climate change and adaptation. Hydropower is accepted as one of the cleaner, efficient, advanced, cost effective and affordable electrical energy production. Besides, as the hydrological variability is

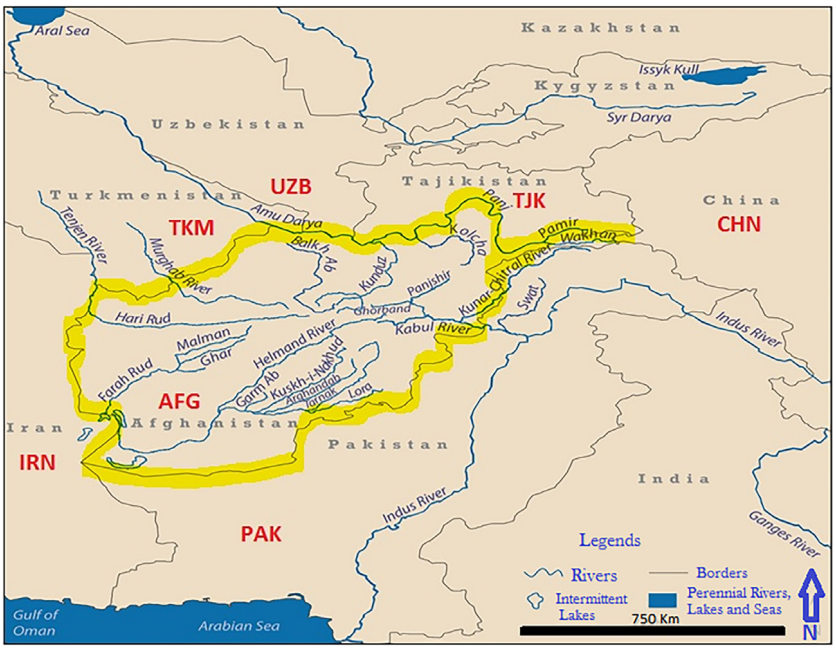


Fig. 9. Afghanistan rivers (UNOMAHA, 2012). Note: This figure does not infer the expression of territory, boundary and legal status of included countries.

anticipated due to climate change, dams could buffer flows and positively impact the hydrological variability management and climate change adaptation.

Considering the least utilization of Hydropower sources the World Bank Group (WBG) is widely supportive in this sector. To support countries manage environmental and financial costs tradeoffs, the WBG backup expensive energy opportunities with minimal environmental footprints globally. In case there is solid ownership of the client, concessional climate finance could be established to compensate the incremental expenses (World Bank, 2013). The key potential hydropower points have been identified by Afghanistan energy sector master plan. The key challenges ahead of development of these hydropower plant dams are the trans-boundary water management treaty between the involved countries, unavailability of capital investment budget, people displacement and other environmental studies.

To attain the target of providing electricity to a larger portion of Afghanistan requires a huge investment in all three major sectors of the energy generation, transmission and distribution systems. Afghanistan 20 years master plan estimated USD 7330 to 10,096 million for generation and network integration development, USD 1727 million for main transmission networks, and 1040 million for internal provincial network development until 2032 (Fichtner, 2013). Afghanistan is currently not at the position to fund these projects so to gain financial support from World Bank and other supportive agencies the institutional development, water usage treaties and environmental adverse effect mitigation plans are necessary.

Afghanistan has plans to utilize its rivers potential for irrigation and electricity generation. There are 8 possible dams planned to be built on Kokcha River and Kunduz River both are tributaries to Amu and Panj rivers. Tajikistan and Afghanistan also planned 10 probable dams on Panj River, which creates border between the two countries. If materialized this will be a positive move toward benefits sharing as mentioned in literature review part (2.3).

Most of the Afghan's rivers have hydropower potential, though this report analysis the Kunar river hydropower potential as highlighted by Afghanistan energy sector master plan.

Table 3
Kunar River basin hydropower potential (ICE, 0000a).

Kunar River basin estimated hydropower generation potential	
Site Name	Potential Generation Estimation (MW)
Shal	798 MW (7 Units × 114 MW)
Sagi	300 MW (5 Units × 60 MW)
Chunek	390 MW (4 Units × 97.5 MW)
Dab	450 MW (4 Units × 112.5 MW)
Lar Sultan	390 MW (3 Units × 130 MW)
Surtaq	410 MW (4 Units × 102.5 MW)
Total	**2738 MW**

4.3.3. Kunar river hydropower potential

Kunar river basin has rich hydropower potential sites. A primary survey has identified six possible sites for the construction of hydropower dams. As shown in Table 3 the sites are named Shal/Kunar-A (798 MW), Dab (450 MW), Surtaq (410 MW), Chunek (390 MW), Lar-Sultan (390 MW), Sagi/Kunar-B (300 MW) with total capacity of more than 2800 MW.

Though, the trans-boundary water sharing treaty with Pakistan remains a big obstacle toward implementation of these projects. Afghanistan government has asked from international partners and World Bank to facilitate the agreement with Pakistan side and provide technical assistant in this regard (ICE, n.d.-a). As mentioned in the literature review part (2.3) the third party organization or country plays a positive role in most trans-boundary water disputes solution.

As shown in Table 4, the construction of these hydropower plants will cost estimated USD 4.2 billion. So the next vital step for bringing these power plants into operation is to finalize the bilateral agreement with Pakistan. The water sharing agreement is important because Afghanistan is currently hugely dependent on international donors' funds (World Bank, IMF, USAID, ADB, GIZ, and etc.) and donors are less likely to invest on projects which have bilateral disputes. (See Table 5.)

The transmission networks connecting these dams with current networks and load center will cost USD 197.2 Million. Below Table 6 indicates the cost of transmission networks for each stage.

Table 4
Based on Afghanistan electricity master plan, (optimized scenario) proposed hydropower plants in the first year of operation (Fichtner, 2013).

Planned year of operation	Hydropower Plant Name	Installed capacity
Completion planned at 2017	Salma	40 MW
finalizing expected soon	Kajaki Expansion	18.5 MW
2024	Kunar B	300 MW
2026	Kunar A	789 MW
2028	Kajaki Addition	100 MW
2029	Olambagh	90 MW
2032	Baghdara	210 MW

Table 5
Afghanistan electricity master plan, (optimized scenario) proposed hydropower plants capital cost summary (Fichtner, 2013).

Hydropower Plant Name	Capital costs [m$]				
	Subtotal by project	Stage A	Stage B	Stage C	Stage D
Salma HPP	200.0	200.0	–	600	600
Kajaki Expansion HPP	90.0	90.0			
Baghdara HPP	600.0				
Sarobi HPP	700.0				700.0
Kunar A HPP	2000.0				2000.0
Kajaki Addition HPP	300.0				300.0
Kukcha HPP	1400.0				1400.0
Gulbahar HPP	500.0				500.0
Kama HPP					180.0
Kunar B HPP	600.0				
Kilagai HPP					250.0
Olambagh HPP	400.0				400.0
Total	**4190.0**	**290.0**	**0.0**	**600**	**3300.0**

Table 6
Afghanistan electricity master plan, (optimized scenario) proposed hydropower plants network connection capital cost summary (Fichtner, 2013).

Hydropower Plant Name	Capital costs [m$]				
	Subtotal by project	Stage A	Stage B	Stage C	Stage D
Salma HPP	36.6	36.6	–		14.8
Kajaki Expansion HPP	1.1	1.1			–
Baghdara HPP	14.8				–
Sarobi HPP	13.2				13.2
Kunar A HPP	86.8				86.8
Kajaki Addition HPP	14.8				14.8
Kukcha HPP	70.3				70.3
Gulbahar HPP	11.4				11.4
Kama HPP					–
Kunar B HPP	33.0			33.0	–
Kilagai HPP	Already in place				–
Olambagh HPP	10.3				10.3
Total	197.3	37.6	0.0	33.0	126.7

The Afghanistan energy sector master plan suggests that after the completion of proposed hydropower plants projects the electricity available capacity will reach over 5000 MW in 2032 the step by step production growth has shown in Fig. 10.

There are funding opportunities available for energy sector. Specifically the World Bank Group (WBG) is determinedly committed to the development and utilization of hydropower resources across the region. As these projects can serve regional purposes and expand market, facilitate networks inter-connections and can be cost effective for all participants. The WBG understand the importance of these projects and developed key protocols and framework for sustainable water resource management (World Bank, 2013).

Afghanistan has the potential to develop hydropower plants with water reservoirs which serve multipurpose objectives mainly electricity, agriculture and environment with other transformative advantages. Therefore, it needs integrated incorporative water resource management. The hydropower plants pave ways for the better integration of the other types of renewable energies such as solar and wind, where the water will be stored for peak load or wind and sun depletion periods, as it can become online instantly without significant variations in the network. In addition, in off-peak periods where cheap energy such as wind or solar is available the reservoir water can be pumped to a higher potential and stored for peak time's compensation. Considering the abundant renewable energies resources availability in Afghanistan this types of hydropower projects are important for long term sustainable development of the sector.

4.3.4. Afghanistan solar energy

The weather satellite based collected data in 2005 shows large scale of solar assets for the western and southern regions, with high reflective and dry zones such as plateaus, deserts and pasture upland hillocks. The lower latitude and plateau terrains represent outstanding solar energy assets for Afghanistan. The country has basin sections with little rainfall and extreme dryness along with

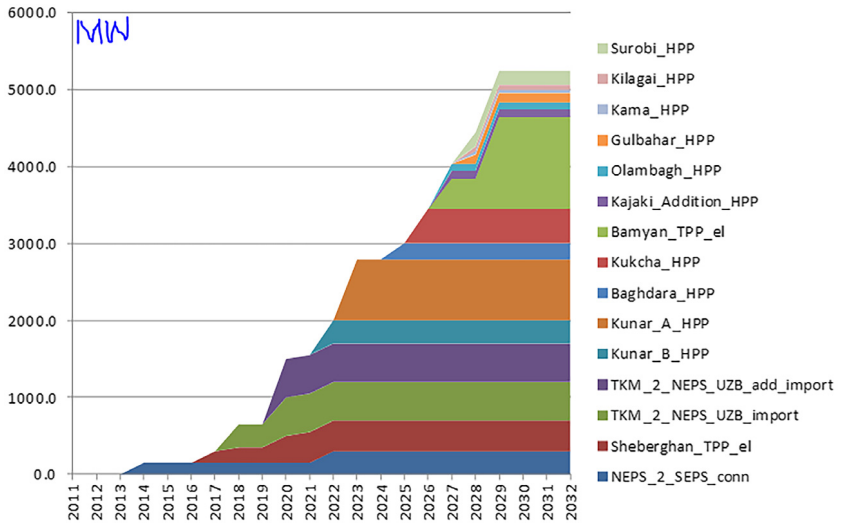


Fig. 10. Capacity expansion after each power plant operation with time span (Fichtner, 2013).

Table 7
Afghanistan wind potential sites category (Elliott, 2007).

Wind Resource Utility Scale	Wind Class	Wind Power W/m^2	Wind Speed m/s	Land Area km^2	Percent Windy Land	Total Capacity Installed MW
Good	4	400–500	6.8–7.3	15,193	2.4	75,970
Excellent	5	500–600	7.3–7.7	6,633	1.0	33,160
Excellent	6	600–800	7.7–8.5	6,615	1.0	33,100
Excellent	7	>800	>8.5	3,169	0.5	15,800
Total				**31,611**	**4.9**	**158,100**

Assumptions:
Installed capacity per km^2 = 5 MW.
Total land area of Afghanistan = 645,810 km^2.

high turbidity[3] air and elevations indicate huge renewable energy resources (Burns, 2011).

Afghanistan has around 300 sunny days in a year, which indicates a huge solar energy potential (MEW, 2015). USA National Renewable Energy Laboratory (NREL) analysis shows huge values of solar energy assets in central, eastwards and southern areas of the country in provinces such as Kandahar, Helmand, Ghor and etc. (NREL, 2007). The summer production capacity rises to 9.0 kWh/m^2/day which represent high solar zones and most of these zones are close to the population which makes the produced electricity easily accessible to consumers (Burns, 2011).

Over all the country has more than 220 GW of solar energy potential. Up to now negligible solar energy has been utilized in the state capacity. The 1.05 MW Bamyan Solar Power Plant is the biggest off-grid solar project in Afghanistan which operates as a hybrid system of PV, battery and diesel. The next major project in this regard is 10 MW solar power plant in Kandahar province, which procurement process is yet to be finalized (ICES, 2016). This shows very limited utilization despite the favorable climate and immense need for the energy in rural areas. (See Fig. 11.)

On average Afghanistan receives around 5.3 kWh/m^2 of solar energy with 0.42 kWh of standard deviation. This resembles to 1935 kWh/m^2 average yearly Global Horizontal Irradiance (GHI).[4] National maximum seasonal average GHI is 7.84 kWh/m^2 per day and the minimum is 2.38 kWh/m^2 per day. In some places wind and solar penetration can be reached 65–70% without major restrictions. This will result cheaper and environmental friendly energy access, lesser reliance on unstable and unpredictable import power, and increase the life of the domestic fossil resources in long terms (Ershad et al., 2016).

4.3.5. Afghanistan wind energy

NREL (2007) research shows significant wind power potential regions in Afghanistan specifically during winter. Locations with greater wind speed are valuable in winter season for Afghanistan in particular as the country observes peak demand during winter season. Based on Afghan renewable energy policy the wind capacity is estimated around 67,000 MW which encompass 36,000 km^2 windy terrestrial and on average 5 MW/km^{2}generation capacity (MEW, 2015).

As shown in Fig. 12 the wind energy regions are spread across the country among them the superb solar energy fields are located in Farah, Herat, and Nimroz provinces with wind speed in excess of 8.5 m/s. Most of these sites have high capacity factors (CF) in the range of over 42 while the world typical CF is in the range of 20–35 and the net annual energy production (AEP) in the range of 2418–3709 while the typical world AEP is around 1752–3066 MWh/MW (Ershad et al., 2016) these makes Afghanistan wind fields economically lucrative.

Based on above Table 7, Afghanistan excellent and good level energy resources are 185,100 MW which incorporate 31,611 km^2 land. This indicates significant potential and a promising sign for Afghanistan renewable energy future utilization.

4.3.6. Non-renewable energy resources (hydrocarbons reserves)

Afghanistan has ample underground resources along with other minerals hydrocarbons and coal can play a significant role in

[3] Turbidity is a key limit for assessing pollution in the air in local areas, and a core parameter controlling the solar energy attenuation arriving to the earth surface under clear sky without clouds (Gueymard, 2005).

[4] GHI is the total volume of terrestrial radiation falls on a horizontally placed surface with the surface of the ground.

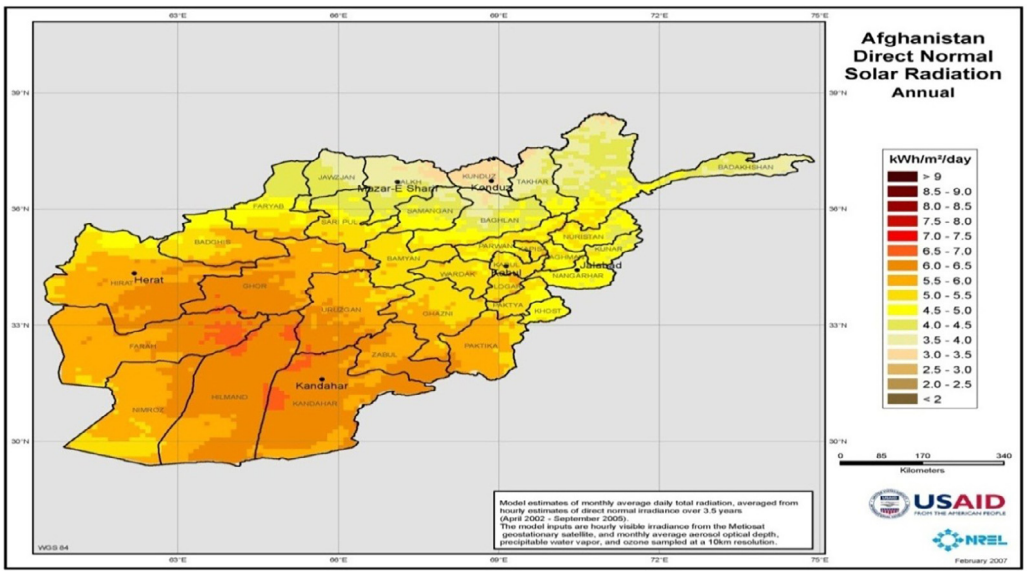


Fig. 11. Afghanistan solar energy radiation intensity map (NREL, 2007).

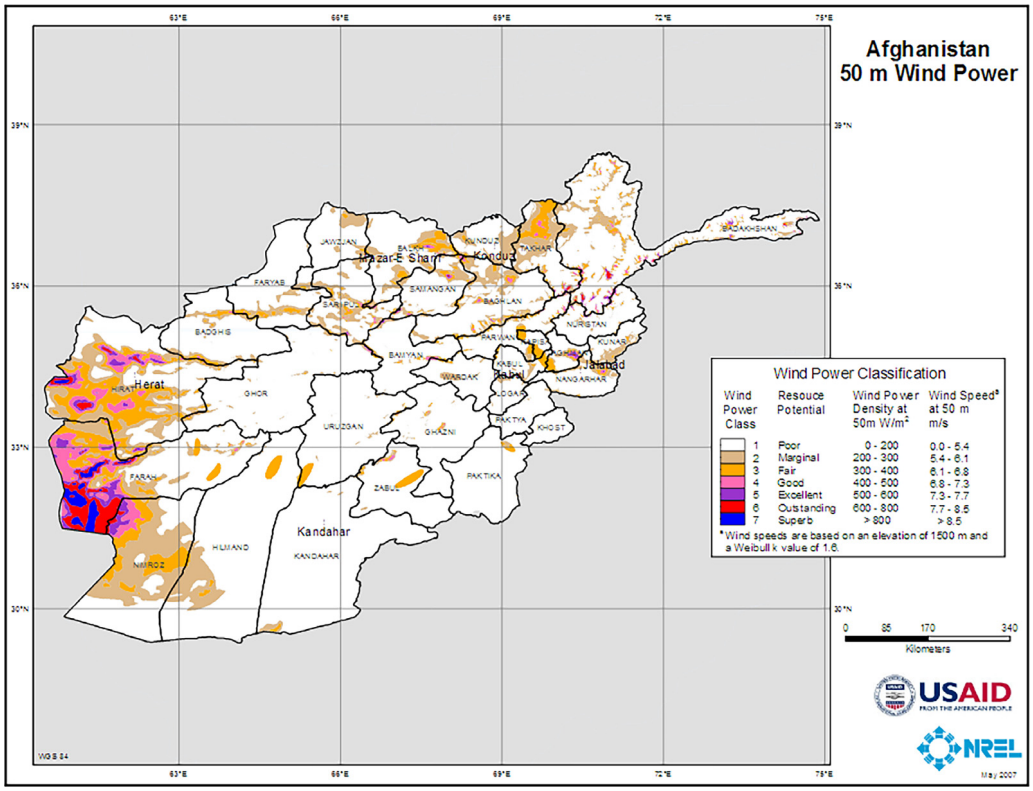


Fig. 12. Afghanistan potential wind sites map (NREL, 2007).

Table 8
Afghanistan electricity sources contribution (DABS, 2016b).

Existing Sources of Power		
No.	Source Name	MW share in (%)
1	Fossil Fuel (Diesel and Gas)	10%
2	Hydropower	8%
3	Renewable Energies	2%
4	Import Power	80%

Afghanistan economic growth and energy sector self-reliance. The value of these resources reaches up to 3 trillion USD (Byrd and Noorani, 2014). Almost 90–95% of hydrocarbons reserves remained untapped (ICES, n.d.-b). The risk of turning the country into the resource curse situation is also significant considering the already corrupt structure in place. This asks for proper resource governance and accountability measures to turn the hydrocarbon resources to profitable commodity particularly in the energy sector.

The hydrocarbon resources in Afghanistan are largely placed in north region of the country. The uncertainty is still exists on the

Fig. 13. Afghanistan Northern Amu and Afghan-Tajik Basins (Strand et al., 2010).

magnitude of these resources. A USA geological survey in 2011 estimated the Afghanistan north resources as 36.462 trillion cubic feet of natural gas, and 1596 million barrels of crude oil (Daly, 2012; Strand et al., 2010). The new studies are looking to find the more precise value of these resources. As shown in Fig. 13, Afghan-Tajik Basin and Amu Darya Basins are the major undiscovered crude oil and natural gas resources respectively. These resources to some extents are shared with Uzbekistan, Turkmenistan and Tajikistan and are presently without any mutual agreement. Some of these countries have already extensively used these resources and some are planning to do so.

Currently a 200 MW gas operated power plant construction is undergoing in Sheberghan province funded by USAID. Which is expected to become operational in 2018 this will boost the domestic power generation to an extent but much more is needed in this sector in order to minimize the import energy reliance. The hydrocarbon electricity generation will diversify Afghanistan capital Kabul energy sources and this intern will make the utility able to allocate the east located hydropower energy sources for much needed local eastern and southeastern population. This will also bridge the gap between the developed and underdeveloped capital and rural population respectively. As shown in Fig. 14, another 50 MW gas fired power plant in Mazar province is also on the plan.

Public and private investments are needed for the utilization of large number of fossil fuel and renewable energy available resources inside Afghanistan. In 2014 around 97% of Afghanistan domestic oil requirements were imported from outside. Gas production and transmission facilities are very limited. The lack of infrastructures restricted the expansion of 75 billion cubic meter identified gas reserves to 150 km area only (ADB, 2015).

China has shown investment interest in Afghanistan natural resources. Their interest reflects China's commitment to reduce its Middle East dependency and diversify its energy sources. This provides Afghanistan an additional opportunity to properly negotiate and utilize this prospect.

The future exploitation of Afghan gas and oil resources, if appropriately handled, will cooperate in local conflicts reduction and push Afghanistan toward self-reliance in energy sector and remove the dependency on current high cost energy imports from neighboring countries.

4.3.7. Import electricity

Afghanistan is in the near vicinity of energy rich countries of central Asia. After the removal of the Taliban government in 2001 the new Afghan government has given priority to import power as the fastest way to bring electricity to the capital Kabul and country as a whole. The south Asian countries at the neighborhoods of Afghanistan are energy rich countries and were ready for this opportunity. This brought extensive investment in Afghanistan energy import section, as shown in Table 8, currently 80% of the energy comprises from imports. Meanwhile, the continuous focus on import electricity has raised serious question of many experts for undermining the indigenous energy production available resources. (See Tables 9 and 11.)

The reliance on a few income resources usually dejects diversification, results the economy overheating, and adds to volatility of revenue and prices which is the case of Afghan energy in the import section. While the abundance of resources also often leads toward corruption and weak governance (USIP, 2007). Afghanistan economy is currently not ready to shoulder the burdens of import tariffs of energy and this caused many problems to the utility operation and increased tension between Afghans as the electricity prices keep increasing. The import power further implications has discussed with details in the energy sector problem Section 4.4.

As the Fig. 15 indicates, the import electricity amount and costs have increased, from 2009 onward and in 2016 it rose up to 385% in this period. In 2015 the import energy cost has reached $ 221 million and it is expected to rise to $ 267 million in 2016 (DABS, 2016b). This is in spite of fact that a recently constructed Salma hydropower dam in Herat province of Afghanistan cost around $ 275 million. This indicates that each year Afghanistan is paying the expenses of a hydropower plant construction to neighbors as the electricity tariff, while the internal hydropower resources remained untapped.

In addition the economic and financial aspects of the energy transit and import schemes require in depth analysis mainly in terms of equity assurance between participants. Considering the several uncertainties about bilateral energy transit and import projects, there are significant risks in pursuing decision of investments now that may result to be counter-productive in future. Afghan government must not be obliged to pursue substantial frontend power transmission infrastructures investment for energy transit setups unless supported by legally enforced long term energy purchase and contractual transit agreements.

Based on the above details the import energy availability is considered as an opportunity but at the mean time it has associated with some negative repercussions such as high cost, legality, and over dependency on others. The import choice will be more valuable if Afghanistan economy expansion requires more energy and the internal resources become insufficient or less cost effective. Currently, the energy transit to central Asia must become priority not import energy for the country's own demand as it has significantly sidelined the internal resources exploitation.

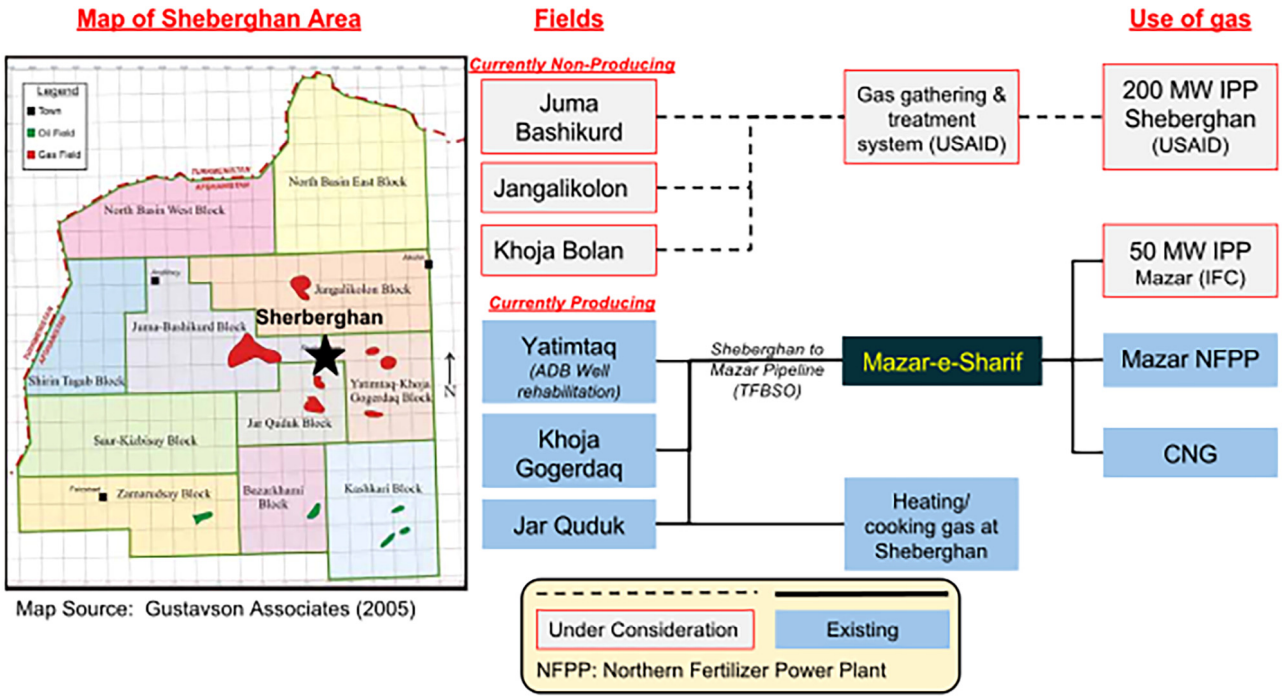


Fig. 14. Schematic view of likely sources and usage of Sheberghan Natural Gas (ICES, n.d.-b).

Table 9
Afghanistan and surrounding countries resources endowment evaluation (Vucetic and Krishnaswamy, 2007).

Country	Oil	Natural Gas	Coal	Hydro Power
Kazakhstan	Reserves: 29 billion bbl Production:1.3 million bbl/day	Reserves: 65 to 70 Trillion Cubic feet (TCF) Production: 0.570 TCF/yr	Reserves: 37.5 billion tons Production: 95 million tons (2004)	Potential: 20,000 MW Developed: 2000 MW
Turkmenistan	Reserves: 546 million bbl. Production: 260,000 bbl/day	Reserves: 71 TCF Production: 2.1 TCF/year	Modest or negligible	Potential: Modest
Uzbekistan	Reserves: 594 million bbl. Production: 150,000 bbl/day	Reserves: 66.2 TCF Production: 2.07 TCF/yea	Reserves: 4 billion tons Production: 2.8 million tons	Potential: Modest Developed: 1700 MW
Tajikistan	Modest or negligible Endowment	Modest or negligible endowment	Reserves: 3.6 billion tons Production: 32,000 tons (2002)	Potential: 40,000 MW Developed 4000 MW
Kyrgyz Republic	Modest or negligible Endowment	Modest or negligible endowment	Reserves: 0.8 billion tons Production: 400,000 tons (2003)	Potential: 26,000 MW Developed: 3000 MW
Iran	Reserves:132.5 billion bbl Production: 4.2million bbl Day	Reserves: 971 TCF Production: 3.5 TCF/year	Reserves: 461million tons Production: 1.1 mill. Tons	Potential: 42,000 MW Developed: 2000 MW
Pakistan	Reserves: 28.8 million bbl Production: 60,000 bbl/ Day	Reserves:26.83 TCF Production: 0.84 TCF/yea	Reserves: 185 billion Tons Production: 3.3 mill. Tons	Potential: Over 30,000 MW Developed: 6,500 MW
Afghanistan	Reserves: 100 million bbl Production: NA	Reserves: 5 TCF Production: NA	Reserves: 100 million Tons Production: NA	Potential: Modest[14] Developed : 262 MW

4.3.8. Regional cooperation: Afghanistan as energy transit hub

History and geography have either separated or linked central Asia to south Asia depending on the perspective and historical context. Impediments to integration recurrently proved challenging to overcome and division forces more often dominated than not especially in recent times. This is clearly visible from the absence of linkage infrastructures in the energy sector despite robust complementarities in abundant energy resources endowments and in the form of energy consumption and production, which stretch escalation to substantial but unexploited opportunities of integration and trading of energy across the regions.

Afghanistan is a major country in the region and its ability to become a bridge between south and central Asia is critical to any form of development and inter-regional collaboration particularly in the energy sector. Though, Afghanistan is a least developed country with poor governance and weak institutions. However,

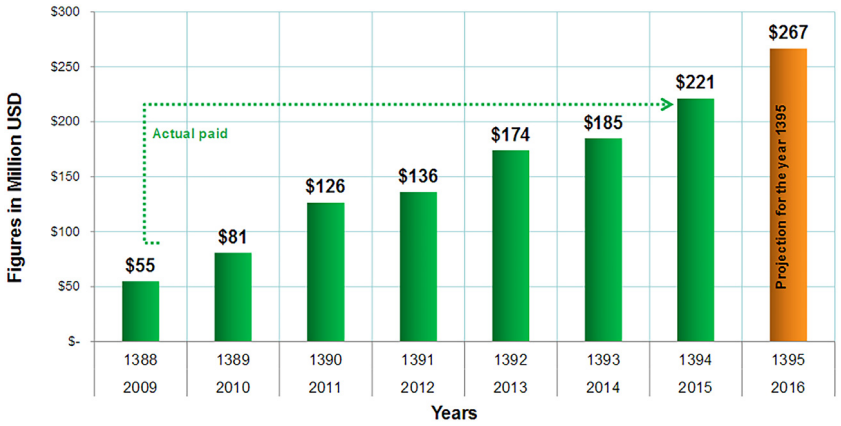


Fig. 15. Import energy cost per year (DABS, 2016b).

today there are opportunities to overcome the past legacy and seizure the vicious circle of economic regressions and political violence into hastened political stability and economic development. This will need determined efforts of Afghans, entrepreneurs, politicians, international community, donors and the neighbors of Afghanistan in particular (Vucetic and Krishnaswamy, 2007).

Afghanistan connects the energy surplus region (central Asian states) with energy deficit region (India and Pakistan). The win–win opportunities and regional interest's alignment for cooperation and trade in energy sector must be predominantly strong. Therefor Afghanistan is in a vital position to facilitate regional energy supply particularly electricity and gas. This will not only benefits Afghanistan economically from transit fees but will also encourage stability for mutual interests as most of the neighbors are in a manner involved in the conflicts of the country.

Pakistan and India are energy deficit countries while central Asia is energy surplus and Afghanistan is the most economical route for energy transit between these regions. With the emerging growth of Indian economy India's energy demand is growing fast and is looking for south Asian region energy resources. Figs. 16 and 17; highlight the overall picture of the energy flows scenario.

The global energy access competitions are becoming hugely interceptive. The strong economies compete directly and indirectly to block and prevent their rivals access to rich energy and market access. This is done through political influence and by offering other encouraging incentives as it is noticeable in Russia and USA case and etc. USA with its current political rivalry with Iran is discouraging the regional economies to have big economic deals with Iran. This on other hand has further strengthened Afghanistan cause to emerge as energy and economy transit hub by connecting the two contrasting energy regions of south and central Asia.

The four central Asian states, Uzbekistan, Kazakhstan, Tajikistan and Kyrgyzstan have recently established an integrated central Asian Power System (CAPS). The CAPS jointly have about 38,000 MW generation capacity and in excess of 135 TWh annual generation. Turkmenistan and Iran which are not members of CAPS have 30,000 MW and 34,000 MW installed generation capacity respectively. In the CAPS region the electrification rate is 100% and has substantial surplus energy for exports especially in the summer and spring periods which reaches 11 TWh and the surplus is expected to further increase in next five years to over 30 TWh. This matches well with India and Pakistan energy peak demands which happen during summer period and hence providing an energy transit opportunity between central and south Asia through Afghanistan.

Central Asia possess divers energy resources, downstream countries like Uzbekistan, Turkmenistan and Kazakhstan have rich gas, oil and coal reserves and upstream countries of Amu and Syr-Darya rivers like Kyrgyz Republic and Tajikistan possess underdeveloped rich hydropower potentials. Such energy resources diversity creates opportunities to meet all region energy and electricity demand via environmentally friendly and cost effective manner seasonally. In the summer, by utilizing abundant less expensive hydropower and in winter season thermal resources when there is less water potential (World Bank, 2016).

Some major regionally important projects have been under pipeline and some have already been inaugurated. The Central Asia South Asia (CASA)-1000, Turkmenistan–Uzbekistan–Tajikistan–Afghanistan–Pakistan (TUTAP) power transmission projects and Turkmenistan, Afghanistan, Pakistan, and India (TAPI) a major gas pipeline projects are to name a few recently planned regional projects in energy sector. These projects have geopolitical significance and will help Afghanistan meet its energy demand and get revenue as transit fees.

These projects have regional interests and its application is inevitable. India dependency on energy as a fast growing economy is growing and will most likely to see a stable Afghanistan for their energy demand. Meanwhile, in contrast Pakistan itself is energy hungry but for the sake of India might not be that willing to cooperate in projects valuable to India. On the other hand China's interest in Afghan natural resources for diversification of its sources of energy in order to reduce its dependency on the Middle East will most likely influence Pakistan to take cooperative steps, considering the influence and strategic relation of China with Pakistan. The region convergence of interest in Afghanistan is increasing and the region is well placed to pursue common causes of cooperation in Afghanistan. Even though there are significant common interests and economic blossoming opportunities, still the cooperation steps have been modest thus far.

4.3.9. Afghanistan as transit corridor of energy

Afghanistan's central Asian neighbors (largely Turkmenistan) are looking to diversify their energy market and observe Afghanistan as the major energy transit corridor for their natural gas and electricity. The recent example is the inauguration of 1040 mile long, $10 billion TAPI natural gas pipeline project. This project was proposed long back in 1995 when Pakistan and Turkmenistan signed a memorandum of understanding regarding this project. But due to budget and security constraints remained disinterested. The project will carry 33 billion cubic meters (m^3) of natural gas from Turkmenistan Dauletabad gas reserves to Afghanistan Pakistan and India.

Projects like TAPI are geopolitically significant, and the major challenges are needed to be discussed widely. Afghanistan will benefit transit fees of around $400 million annually and 14 million cubic meters of natural gas per day from TAPI. This project is not

Fig. 16. A One billion worth proposed CASA-1000 electricity transmission project (CASA-100, 2011).

only gas transmission but TAPI's route is planned to be a comprehensive corridor through which Turkmenistan–Afghanistan–Pakistan 500-kV Line (TAP-500), railway and fiber optic projects will follow the same route. Other advantage of this corridor is that the land acquisition, resettlement and other social activities will be done at once for all the above future projects hence, making this corridor a vital option for fast project implementation.

In Addition, TAPI would become a major source of employment and energy security. Afghanistan would have the option to sell its surplus gas through it as well depending on its own reserves exploration (Maini and Vaid, 2013). Furthermore, Iran has also shown interest to extend an oil pipeline to China passing Afghanistan and Pakistan. The important concern remains as to whether Afghanistan is stable enough to grab these opportunities. (See Fig. 18.)

Based on 2015 British Petroleum (BP) statistical review Turkmenistan has the fourth largest natural gas reserves in the world exceeding 7.94 trillion cubic meters (TCM) (BP, 2015). Another estimation done by UK's Gaffney Cline & Associates shows from 4 to 14 TCM only for South Yolotan–Osman field of Turkmenistan. Disagreement exists on actual values of the resources but the clear fact is that, the Turkmen gas resources are enormous and the geopolitical incentives are great (Foster, 2010). Iran has 34 TCM the largest in the world natural gas proved reserves (BP, 2015).

Turkmenistan is located away from sea, so it is heavily relied on pipelines to supply its gas to the market. Furthermore, as shown

Fig. 17. Potential Gas and Electricity trades flows between central and south Asia (Vucetic and Krishnaswamy, 2007).

in Fig. 19 the country is looking to diversify its energy market as currently majority of Turkmen gas flows only through Russia. Turkmenistan is planning to export gas through multiple routes such as: North to Russia, south to India and Pakistan through Afghanistan, east to China and west via Caspian Ocean to Europe.

Since TAPI and most of the other energy transit projects pass through insecure zones both in Afghanistan and Pakistan i.e. tribal and independence pursuing areas, security is a clear challenge. Unless their benefits from the projects are clear and their cooperation is sought, transit projects security will remain a nightmare and expensive. These challenges require political solutions not military. Peace is an obvious necessity and all stakeholders and ethnic groups' participation is vital in this regards (Foster, 2010).

Afghanistan seeks and is well positioned to emerge as an energy transit hub and resource corridor. Afghanistan has a legacy of regional entrepreneurial culture inherited from the Silk Road. President Ghani expressed optimism that the war will end in near future and Afghanistan will emerge as a connecting hub for Asian economies (Office of the President, 2015). Though the obstacles seem formidable, there is still rare degree of interest alignment between the region states in forming an economically prosperous and politically firm Afghanistan, contributing to prosperity of the

Fig. 18. TAPI pipeline route (Coyle, 2012).

Fig. 19. Turkmenistan prospective Gas pipelines (Foster, 2010).

broader region. Afghanistan and the region should embrace this opportunity.

4.4. Electricity sector main challenges

The deteriorated security and law and order are the rout causes for the most of the existing problems. In addition, as illustrated in the energy sector problem tree in Fig. 22, the core problems of Afghanistan electrical energy system are considered the inadequate supply and network capacity to meet the demand. The analysis of electrical energy problems on broader perspectives highlights the following three main constraints associated with the mentioned core problems in Afghanistan energy sector:

1. Technical constraints
2. Financial constraints
3. Institutional constraints

These three broader problems are explained with complete details as below:

4.4.1. Technical constraints

The operational limitations in terms of insufficient distribution and transmission supply capacity are enormous. The electricity demand is rapidly rising and the gap between demand and supply has widened up. Laterally, with the increasingly growing demand the responsive steps taken are very modest and limited. The low off and on grid indigenous energy production especially renewable energies have extended the supply problems further. The below sub-causes represent the technical constraints:

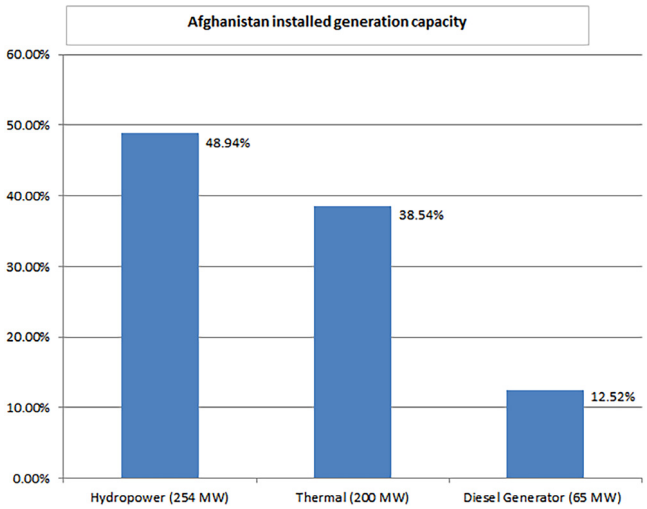


Fig. 20. Afghanistan energy generation profile (Author own work.)

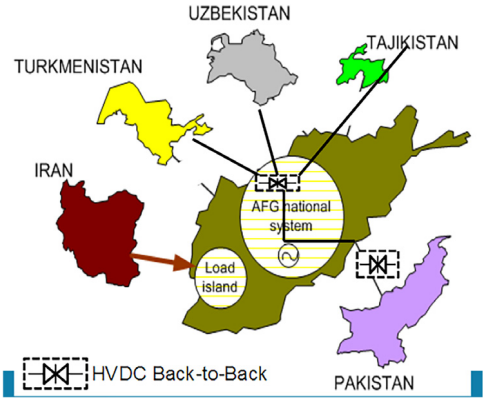


Fig. 21. Proposed regional synchronization solution (DABS, 2016b).

- *Insufficient generation capacity:* As shown in below Fig. 20, Afghanistan overall generation capacity is around 519 MW, hydropower resources contribute (49%) about 254 MW, thermal (gas and oil) contributes (39%) around 200 MW, and distributed generators count (12%) about 65 MW. This is very limited generation capacity considering the 2014 unsuppressed 2500 MW demand. Imports power contributes around 80% of the total electricity demand and import energy bill has augmented 14 times between 2007 till 2015 from $16 million to 224 million respectively (ADB, 2015). Import energy tariffs added huge burden on unstable economy of Afghanistan and its people. The lack of water usage treaty with neighbors (five from six rivers have trans-boundary water issues) and international investor participation hinder the indigenous hydropower and thermal power projects development.

- *Multi island networks and isolated transmission grids*: Isolated grids in southeast, north and no grid at all in south region are among big problems in this regard. In 2006 Afghanistan electricity system was operating as ten isolated electricity networks. Today it has been reduced to three networks islands named: North Eastern Power Grid (NEPS), South East Power Grid (SEPS), and Western Power Grid (WPG) (DABS, 2016b). Asynchronous isolated power networks need to change to an integrated national electricity network. The existing network configuration is extremely inflexible, unreliable and inefficient, as electricity produced in one network cannot be supplied to others which impedes proficient load dispatching as well.
- *The on grid distribution is restricted and localized:* Inadequate design of the distribution networks limited its capacity to accommodate all people. And in most dense areas the network equipment's i.e. cables and transformers are overloaded.
- *Synchronization difficulties with neighboring countries:* Currently all neighboring power grids operate asynchronously with Afghanistan this limited the prospect to expand and interconnect the power system rationally. Thus, it is important for Afghanistan to develop their networks based on an accepted Grid Code with importing countries to enable the synchronization of networks. As shown below in Fig. 21, the High Voltage Direct Current (HVDC) Back to Back Converters scheme has been proposed as a synchronization solution but is up to now at the planning stages which also needs further economic viability and technical compliance analysis.

The asynchronous operation of Afghanistan electricity systems resulted in six non-synchronous or separated networks. This limits Afghanistan opportunity to expand and interconnect regions and improve reliability (Irving and Meier, 2012).

- *Limited off-grid sustainable development:* Rural population electrification rate is less than 9% while, around 75% of population lives in rural areas and around 67% GDP comes from these areas. Afghanistan has not utilized the sustainable development potential thus far and limited attention has been given to the remote areas with huge renewable potential. Since last 15 years the sector was mainly focused on import power, which hugely damaged off-grid sustainable development plans. The utilization of rural renewable resources has been minimal up to now. Fostering these resources will improve the energy sector mix and security.
- *Seasonal hydropower availability* (mainly during summer): The seasonal water level changes are reducing the production capacity of hydropower plant in Afghanistan. Adding to that the water sediments has decreased the existing hydro reservoir capacity hugely which further limited the capability to store sufficient water for striving periods.
- *Trans-boundary water sharing agreements:* In order to attract donor investments funds and to utilize the shared rivers hydropower potential the water sheering treaties are necessary, specifically in the lack of self-funding capabilities as donors are less likely to invest on internationally disputed areas.

4.4.2. Financial constraints

Afghanistan is currently vastly dependent on donor funds some key names in this regards are World Banck, Asian Development Bank, USAID, Kreditanstalt für Wiederaufbau (KfW) and etc. These organizations are the main contributors to Afghanistan energy sector and are required to continue their financial support further. As the electrical energy sector of Afghanistan requires significant capital investments. Based on Afghanistan 2012–2032 energy sector master plan, USD 7330 to 10,096 million are estimated for generation and network integration development, USD 1727 million for main transmission networks, and 1040 million for internal provincial network development until 2032 (Fichtner, 2013). These figures seem far beyond the current government capability to finance.

The weak financial operation and inadequate income from electricity are also posing a huge challenge. Pricing reform and proper revenue collection procedures are important in this regards. To summarize the key financial constraints below sub-causes are highlighted:

Table 10
Investment by stages and types until 2032 (Fichtner, 2013).

Overview on Investment type	Optimized scenario investment [m$]				
	Subtotal by project	Stage A	Stage B	Stage C	Stage D
Generation development	7329.6	327.6	348.5	981.5	5671.9
Major transmission projects	1726.8	595.0	676.9	212.9	242.0
Transmission development within the provinces	1040.1	290.1	439.8	215.1	95.0
Total	10096.4	1212.7	1465.2	1409.5	6009.0

- *High commercial losses and low efficiency:* The existing electricity system has huge amount (30–40%) of technical and commercial (T&D) losses. The reduction of these losses is important for the sector economic benefits and its role in GHG emission reduction (Irving and Meier, 2012). These losses must be reduced in order to improve financial sustainability and connect more people with the network. To tackle this issue DABS is implementing bulk metering plan, asset maintenance plan, and computerized maintenance system.
- *Inadequate meter reading and billing system:* Currently the meter reading process is manual which is prone to misreading and corruption and the process is not transparent.
- *Inadequate tariff systems* (Unfair-cost tariffs): This discourages the private sector investments. The pricing of electricity is uneconomical considering the high costs it takes. The electricity average tariff is $ 0.12–0.8 per kWh, below what is required to cover the import power generation costs around $ 0.1–0.06 per kWh, and adding to that the transmission and distribution costs around $ 0.1–0.07 per kWh. Based on current energy mixture, to be cost reflective the tariff is calculated as $0.18–0.15 per kWh (ADB, 2015). The security concerns caused the costs of new investment, network operation, and maintenance to rise.
- *Weaker regulation:* The legal framework of energy sector and cooperation across government entities are weak. Lack of specific regulation and laws to energy sector has led to poor governance. The absence of market centric pricing policy damaged the full cost recovery. In order to attract the much wanted foreign investments these deficiencies need to be addressed.
- *Delayed consumption bills payments*: Some of the high consuming customers are not paying their electricity bills on time. This group includes some high level governmental officials and warlords.
- *Inadequate import power purchase agreements:* Afghan government must not be obliged to pursue substantial frontend power transmission infrastructures investment for energy transit setups unless supported by legally enforced long term energy purchase and contractual transit agreements. Furthermore, these agreements are on US dollars and it is sold on Afghani to consumers and the volatile exchange rate of Afghani pushed the utility company to increase the per unit price of electricity periodically in order to be able to pay back the import tariffs. This caused significant dissatisfaction of consumers both residential and industrial.

4.4.3. Institutional constraints

Because of the energy sector institutions inability to sustain proper economic and operational policies numerous development opportunities have been missed or failed in Afghanistan. It is essential to enhance the institutional environment and capacity of the energy sector. Based on World Bank (2013) a comprehensive financial and institutional atmosphere is a prerequisite in an organization for effective investments. Feeble institutional capability has been a major contributor to the slow progress of energy sector in Afghanistan. Obtaining reliable, sustainable and affordable energy supply relies heavily on addressing the essential concerns of governance in the financial, operational, and institutional domains.

Due to weak institutional capacity, the last decade has perceived wasted resources, efforts duplication, failure to adapt to changing environment, and weakness of strategic and political visions. Afghanistan energy sector institutional constraints main causes are summarized as below:

- Utility poor operational and financial performance.
- Inadequate investments strategy.
- Weak Human Resources (HR) capacity.
- Weak forecasting and planning in the sector.
- Deprived organizational structure.
- Corruption and poor governance

Without efficient operation and financial sustainability energy deficiencies in the country will linger, associated with increasing costs of energy to consumers. For strengthening the energy sector governance it is vital to address transparency, public participation, and accountability which are among the necessary elements for efficient operation and country's equitable social, economic, and environmental improvement (World Bank, 2013).

It is important for energy institutions to manage the mentioned policies in order to better absorb the internal and external resources in the form of technical expertise and financial flows. Afghanistan energy sector capacity building and institutional reform is a major requirement in order to tackle the mentioned obstacles. As currently the weak governance and abrasive corruption is hurting the progress badly.

As shown in Table 10, the Afghanistan energy master plan suggests more than $ 10 billion investment opportunities until 2032. So the rectification of the above mentioned three constraints are important in order to better utilize these opportunities.

Fig. 22 flow chart summarize the energy sectors main opportunities and constraints.

4.5. The major negative impacts of these problems on energy sector

The mentioned challenges have affected overall Afghanistan social and economic development badly. As mentioned in the literature review Section 2.2 electricity has direct link with the country GDP, and the region social and economic development. The issues in the energy sector have not only damaged Afghanistan economy but it also had negative impacts on the region as well. The major impacts are summarized as below:

- *Low electrification rate:* This impact is very clear, as only 30%–38% of the households currently have access to the electricity in Afghanistan (ADB, 2013).
- *Reduced economic growth and less development opportunities:* The absence of reliable energy source has discouraged the industrial investments which led to the unemployment growth and instability of the country.
- *Limited electrical energy security:* The energy security is turning to be a serious issue as currently Afghanistan is importing around 80% of its electrical energy from importing countries which are selling their surplus energy and in case

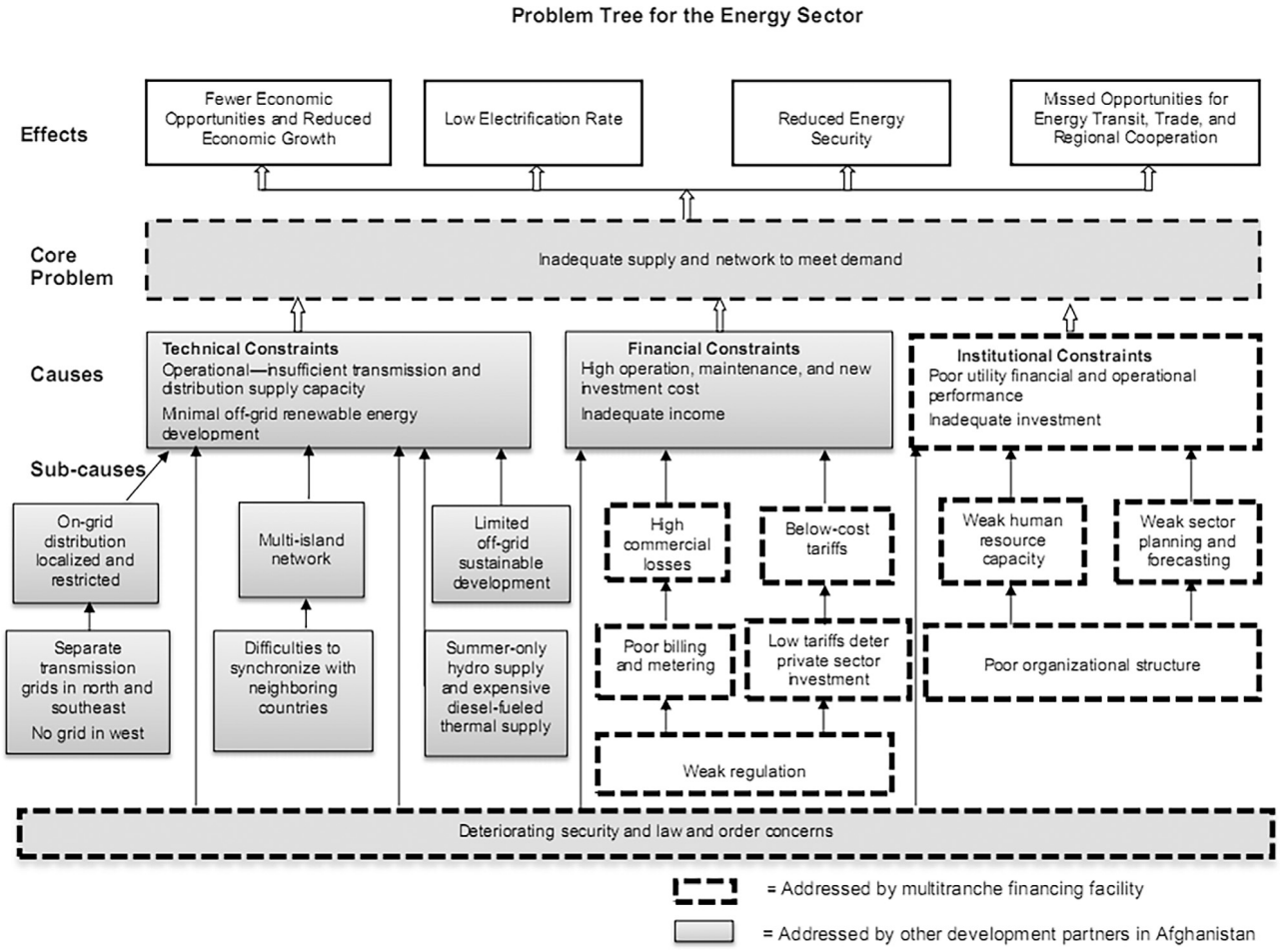


Fig. 22. Afghanistan energy sector problem hierarchy (ADB, 2015).

of their own demand growth Afghanistan will come second priority, unless there are some strict legal obligations existed in the contracts. Furthermore, the radial network structure reduced the reliability of the overall electrical networks system of the country and with the unstable security situation this issue has become more significant as insurgents are using electricity cables disconnection act as a tool for their influence.

- *Wasted regional cooperation opportunities for energy trade and transit:* Afghanistan is located between the energy hungry and energy rich countries and this gives Afghanistan a chance to become a potential energy transit hub in the future but due to lack of proper infrastructures and stability this opportunity remained unutilized. In addition, Afghanistan energy resources exploitation will make the country an energy importer country itself.

4.6. Afghanistan trans-boundary water and its importance for Afghanistan

Afghanistan has four main internationally shared river basins. Both the energy (hydropower) and agriculture aspects of these rivers are vital for Afghanistan economy and prosperity. As mentioned in the literature review Section 2.4 Helmand River is the only river of Afghanistan which has a bilateral water management agreement signed with Iran in 1973. Based on the agreement Afghanistan has agreed to allocate 26 cubic meters per second water flow to Iranian side (Habib, 2014). Apart from that there is no water sharing agreement exist for other Afghanistan rivers. Though, these rivers are immensely vital for Afghanistan energy and agriculture sectors.

The four major basins are the Amu Darya and Panj, the Helmand, the Hari-Rud and the Kabul. The Panj River is shred with Tajikistan and is a tributary of Amu River which is than shared downstream with Turkmenistan and Uzbekistan. The Kabul River is shared with Pakistan and is a tributary of Indus River. The Helmand River is shared with Iran and the Hari-Rud flows toward Iran and Turkmenistan (Vick, 2013). Hence, these rivers water usage possess regional measures (FAO, 2012).

The Panj River average flow is 33.4 km^3/year and during the Soviet Union era 9 km^3/year of water have been allocated to Afghanistan through an agreement signed in 1946. But due to lack of infrastructures Afghanistan was not able to utilize its share of water. This is in spite of fact that the Amu River and Syr Derya downstream countries agriculture basins have become doubled since 1960 to 1980 and Iran has developed irrigation infrastructure and storages for the Helmand Rivers with the transfer capacity in excess of what is allowed based on the treaty (Hearns, 2015). This added more complexity to the issue as the dependency of downstream countries on the river has exceeded (Ahmad and Wasiq, 2004).

The previously built water infrastructures have been damaged or destroyed very badly during last three decades wars. Currently only 30–35% of Afghanistan waters have been utilized in the country due to lack of infrastructures. Based on Oxfam, scarcity of water caused around 43% of conflicts in the local communities of Afghanistan (Hydratelife, 2012). Due to temperature rise the snow

melting period has become shorter which caused further shortages of water in the most demanded summer period. Construction of hydropower plant will not only generate sufficient electricity but will also regulate and control the flow of water.

Given the scale of Afghan shared water issue the construction of multipurpose dams are inevitable. Benefits sharing can encourage cooperation and avoid conflicts by concentrating on the mutual benefits rather than mere share of water itself. Trans-boundary benefits sharing methods for dam site selection can facilitate the exploitation of optimal location such as fields with high altitudes, high water potential (slope), low evaporation and etc. This can be applied in significant proportion on Panj and Kabul Rivers.

The hydropower dam's construction projects are amongst the most time consuming and controversial infrastructures because of their high level social and environmental impacts. Dams in most cases interrupt the river natural flows; riparian system, change water quality, change river courses, and effect river sediment regime are some of the impact associated with it. If such concerns are not addressed properly some vulnerable inhabitants are probably to be further disadvantaged which will challenge the objectives of the development. So the sooner the process starts the better for Afghanistan and region as a whole.

Regional cooperation is required in this regards with the support of internationals community. They need to find out mutually beneficial water sharing mechanisms and offer incentives which could encourage collaboration and benefits sharing. The initial step required is to develop a conceptual framework for hydropower dams' projects benefits sharing and analysis of all externalities and negative impacts compensations.

Hensengerth et al. (2012) suggested the following benefit-sharing mechanisms:

- Costs can be shared in proportion to gained benefits in case of joint ownership of the dam.
- Losses are compensated by sharing the net benefits.
- The downstream state build a dam in the upstream state, cover the costs and shares the benefits

Institutional and political cooperation and willingness are necessary in order to make the agreements happen. Water benefits sharing agreements can be attain by observing the usage of water from economic perspectives rather than attracting it in quantitative means. Countries must conceive rivers as productive resources and attempt to maximize the economic benefits linked with it. The Panj River between Tajikistan and Afghanistan can apply this scenario to much success as this reviver creates share border between these countries and have enormous hydropower potential and so are Kabul River and others.

There are four categories of advantages which will benefit involved states:

- Advantages for the river: Enhanced management of the river ecological system and sustainability.
- Advantages from the river: Water linked economic improvement through irrigation development, power generation, flood control, increase food and navigation enhancement.
- Advantages due to reduced costs: Reducing political conflicts and the costs associated with it, and cooperative policy development between countries.
- Advantages beyond the river: Improved trade, markets, and regional infrastructure. International rivers can act as catalytic agents and can facilitate the environment to a much larger cooperation among countries, even economic integration (Sadoff and Grey, 2002).

Statistics indicate that on average Afghanistan produces 58 billion cubic meters water every year but merely 30% of the water is used inside the country and the remaining flows into neighboring countries (Iran and Pakistan) due to lack of adequate infrastructures and facilities (Office of the President, 2016). This is in spite of the fact that these waters do not only have agricultural benefits but can produce sufficient hydropower for people and industries. (See Fig. 23.)

Since 2001, after the fall of Taliban the solicitation of trans-boundary water resources topic has increasingly became relevant to Afghanistan reconstruction process (Thomas and Warner, 2015). This is clearly evident in president Dr. Ghani speeches to the nation on numerous occasions, where he pleaded more focus on Afghanistan water resources management, which will provide access to electricity, food, water, and jobs creation. The president mentioned in his speech that "We also want our waters to reach the heart of our draught-hit deserts, which for years carried the autumnal pain of barrenness" (Office of the President, 2016).

Shared water resources control interactions have been more sensitive between Afghanistan and its neighbors since 2004 after the re-inauguration of Salma Dam on Harirud river basin shared between Iran, Turkmenistan and Afghanistan. International community is promoting negotiation and cooperation in accordance to the "United Nation 1997 Convention on the Law of the Non-navigational Uses of International Watercourses". However, trans-boundary water communications during the Hamid Karzai government (2001–2014) have mostly been pigeonholed by unilateral resource seizure on the Afghanistan side, whereas no agreements exist in the basin (Thomas and Warner, 2015).

The current administration has both the potential to progress in the direction of further tensions and competition or further cooperation. The achievement of current and forthcoming programs for easing a reciprocally satisfactory water management will mostly depend on the degree to which ongoing and past strategies, constraints and tactics of different riparian's for water governance are better understood.

The situation of hydro-politics between Iran and Afghanistan in the Harirud Basin narrates to the wider question: by what means do countries attain, maintain and control over trans-boundary water resources. The Basin of Harirud designates a particular case about how a basically weaker upstream government (Afghanistan) might attain water control as Afghan side has lack of expertise, political influence and infrastructure to manage its water properly (Thomas and Warner, 2015).

Recently some promising cooperation steps have been taken between Afghanistan and Pakistan toward management of shared rivers. In 2013 a higher level delegation from both sides agreed on construction of 1500 MW hydropower dam on Kunar River, a river which currently contributes 16.03 billion cubic meter (m^3) annually to Pakistan. Both sides have agreed on Kabul River Basin Management Commission (KRBMC) as well (Kiani, 2013). But the practical steps yet to be taken as the political tensions increased between the two countries due to Pakistan's progressive support to the terrorist groups involved in Afghanistan. Sartaj Aziz, Pakistan Prime Minister adviser on Foreign Affairs and ex-president Pervez Musharraf widely confessed this fact (Boone, 2015; Siddique, 2016).

Afghanistan and Pakistan share nine rivers with approximately 22.6 billion cubic meter water flows annually. During Indus River flow reduction in winter, Pakistan currently receives around 17% of its water supply from Kabul River (Kiani, 2013). Water sharing issue between these states have become more complicated as due to lack of political stability in Afghan side the Pakistani side has presumably misused the opportunity and widens its reliance on Afghanistan water, which upstream control might have deeper consequences on downstream (Pakistan) and hence subsequently, will lag Pakistan agreement on the issue.

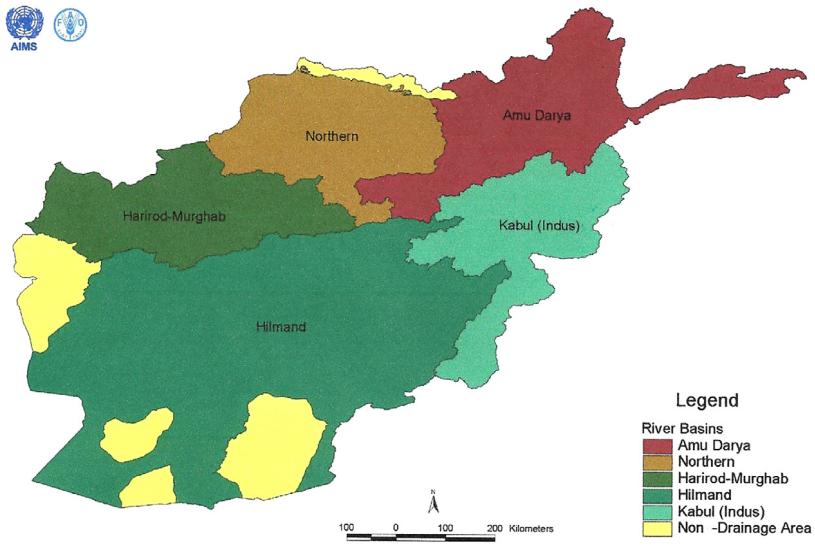


Fig. 23. Afghanistan rivers basins (FAO, 2012).

Pakistan has raised its concerns on Afghanistan plans to build hydropower dams and water storages on the help of India. Pakistan formerly showed its intentions to divert Chatral River from interring Afghanistan (Kiani, 2013). Chatral River originates from Pakistan and inters Afghanistan where it combines with Kunar River and then inters back jointly with Kabul River to Pakistan. Chatral River case adds another complicated dimension to this issue as both countries are downstream and upstream from each other. Both countries should negotiate through international brokers such as UN or World Bank. WB solved the complicated water treaty of Indus River between Pak–India in 1960 and that experience application might be helpful to reach a beneficial water sharing agreement.

Chatral and Kunar Rivers scenario make upstream and downstream countries equally worried about their interests. As both states (Afghanistan and Pakistan) have upstream and downstream interests. This often offers incentives to reach agreements. Otherwise, a violating upstream country (Pakistan in Chatral River part) might face problem in another water source where it has downstream interest (such as Kunar and Kabul Rivers cases). Similarly both Afghanistan and Pakistan require better measures for flood control and Afghanistan in particular is interested in the hydropower potential and domestic water supplies of the rivers. Water management talks among the two riparian's however, have traditionally been secondary to the cross border strains existed between these two countries (Vick, 2013).

Hitherto, trans-boundary water governance has hindered by deficient state, local and national government capability, legitimacy and accountability. Afghanistan in most cases as an upstream country has surrender huge losses and yet not being able to utilize its share of water effectively. The neighboring countries currently are enjoying as sole beneficiaries of the majority of Afghan water and hence will not be willing to bring the issue on table easily. Therefore, it is the national interest responsibility of the Afghan government to take the initiatives, overcome the barriers and develop its institution to negotiate the issue holistically. The Afghan government has shown intentions to bring the trans-boundary water resources management onto the national political agenda. Therefore, the international technical assistance communities and donors have a crucial role to play in regard to Afghanistan shared water resources management, protection and regional stability concerns.

There is lack of institutional and human resource ability to communicate the issues appropriately. Development of institutions ability must be considered as a top priority. Building an atmosphere of mutual confidence and trust among involved countries and to cover the gap in the expertise of negotiating and management capacity at the national level characterize the two main challenges.

The analysis of diverse regional trans-boundary water management (such as Lake Victoria, Nile, Danube, southern Africa and North America) cases Appelgren and Klohn (1997) suggested the following implementable and practical options for trans-boundary water management which can be cooperative for Afghanistan shared water issues resolution:

- Strengthening or establishment of management institutions integrated and housed under available regional collaboration framework.
- Adaptation to and recognition of political directions with ability to put up variations in political arena.
- National policies recognition with the objective of harmonizing the policy between countries.
- Legal capacity and management establishment to carry the parties toward parity for international and wide basin negotiations.
- Identification and execution of priority objectives that encourage national decision makers to focus on national and regional energy, water and food security.

Ganoulis et al., 2011; 2013 emphasized on political commitment and developed a seven step trans-boundary water resource management model which can be adopted along with Rahaman (2009) five internationally recognized shared water resources management principles mentioned in literature review part (2.3) for better utilization of Afghanistan water resources utilization: (See Fig. 24.)

1. Consultation of stakeholders and cooperation on social concerns, institutional and legal agreements.
2. Defining the problem: Trans-boundary diagnostic analysis.
3. Agreement on common monitoring, data collection and data sharing.
4. Common strategic action plan and vision development
5. Modeling and assessment of physical and environment issues.

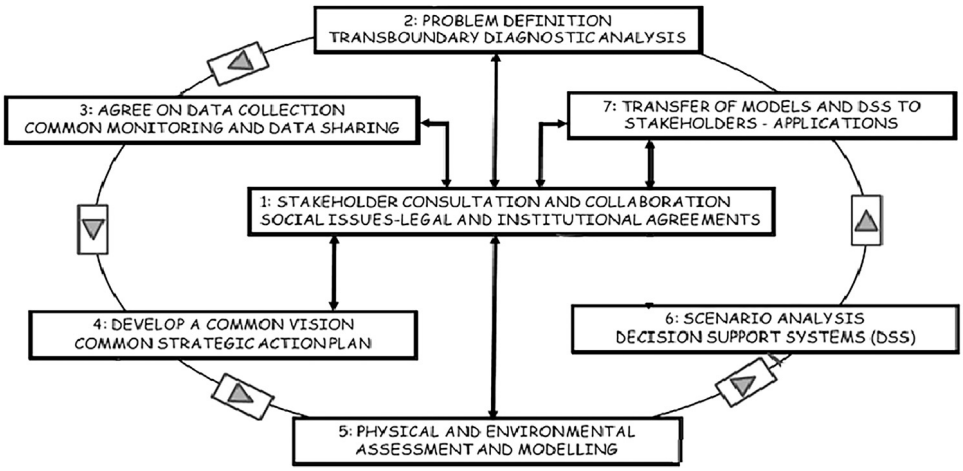


Fig. 24. Seven steps trans-boundary water resource management model (Ganoulis et al., 2011; 2013).

6. Decision support system and scenario analysis procedures.
7. Recommended models and decisions transfer to applications

Trans-boundary water agreements need commitment and time. The Afghan administration should decide the utilization principles of the limited capacity the country has. Currently it seems that the government is in dilemma of which arises first: dams infrastructures or water treaty, as the commitment and plans of dam's construction exist without the trans-boundary water treaty. Until, the donors and government step-up to fund the negotiation and construction neither might not happen.

As mentioned in the literature review Section 2.4. the below globally accepted principles are necessary to consider for all types of trans-boundary water management and Afghanistan needs to assess all these principles and its impacts in order to be able to effectively utilize its shared water part.

All the region countries and Afghanistan in particular are in demand of water for domestic needs, hydropower, irrigation, and flood control. The situation is pretty much ripe for the negotiation and agreement. However, in this unstable region with conflicts, absence of trust and cross border intrusions the needs and condition might not be enough to settle on a water sharing agreement. To date the political will of the states has not been sufficient. The reliable and foreseeable means are needed to reach an agreement on this vital issue.

The below PESTLE analyzes framework identified the main factors which have impacts on Afghanistan trans-boundary water management. It identifies the political, economic, social, technological, legal, and environmental factors of the trans-boundary water management issues. It provides an overview of the whole background from several angles. (See Fig. 25.)

5. Chapter five: Conclusion and recommendation

5.1. Chapter introduction

This chapter provides the conclusion and recommendation based on the evidence provided in this study. It also includes the study limitation and further research areas information.

5.2. Conclusion

Based on the discussed evidence Afghanistan has sufficient energy resources to meet its electricity demand. Only the renewable energy resources utilization is sufficient to fulfill the current and midterm future demand. The expected demand in 2032 is approximately 318 GW based on Afghanistan energy sector master plan whereas, based on MEW there is 318 GW of renewable energy production capacity in Afghanistan. Though, to date the utilization of these resources are minimal and only around 30% of the population has access to electricity. The developments of these resources are vital for Afghanistan energy sector and economic development.

Along with renewable energies there are ample fossil energy resources such as hydrocarbons carbon and coal which can play a significant role in Afghanistan economic growth and energy sector self-reliance. The natural gas resources are estimated around 36.462 trillion cubic feet. The utilization of these resources will further strengthen Afghanistan energy sector self-reliance.

Based on this study the key challenges to the energy sector are the deteriorated security and lack of law and order implementation which are the root causes of most of the existing problems. In addition, the core problems of Afghanistan electrical energy system are considered the insufficient supply and network capacity to meet the demand. On broader perspectives the following three main reasons associated with the core problems have been identified:

- Technical Constraints
- Financial Constraints
- Institutional constraints

The absence of Trans-boundary water sharing agreement has remained a huge obstacle for Afghanistan hydropower potential utilization, as basins of four main rivers are shared with other countries and the development of any kind of energy or water infrastructures possesses regional measures. Furthermore, substantial financial funds are required in order to utilize the huge hydropower potential existed in these rivers. Considering the current shaky economic condition of Afghan government it seems beyond their ability to fund these projects hence, in order to attract donor's investments the existence of water sharing treaties based on common interests of the involved countries are necessary, as donors are less likely to invest on internationally disputed projects.

The opportunities for the energy sector are summarized in the following key four categories:

- **Sufficient Renewable Energies:** There is significant renewable energy production potential in Afghanistan such as hydropower, solar, and wind energies.
- **Non-Renewable Energies:** Fossil fuel such as natural gas, oil and coal resources.
- **Regional Cooperation:** Afghanistan could emerge as a major energy transit hub.

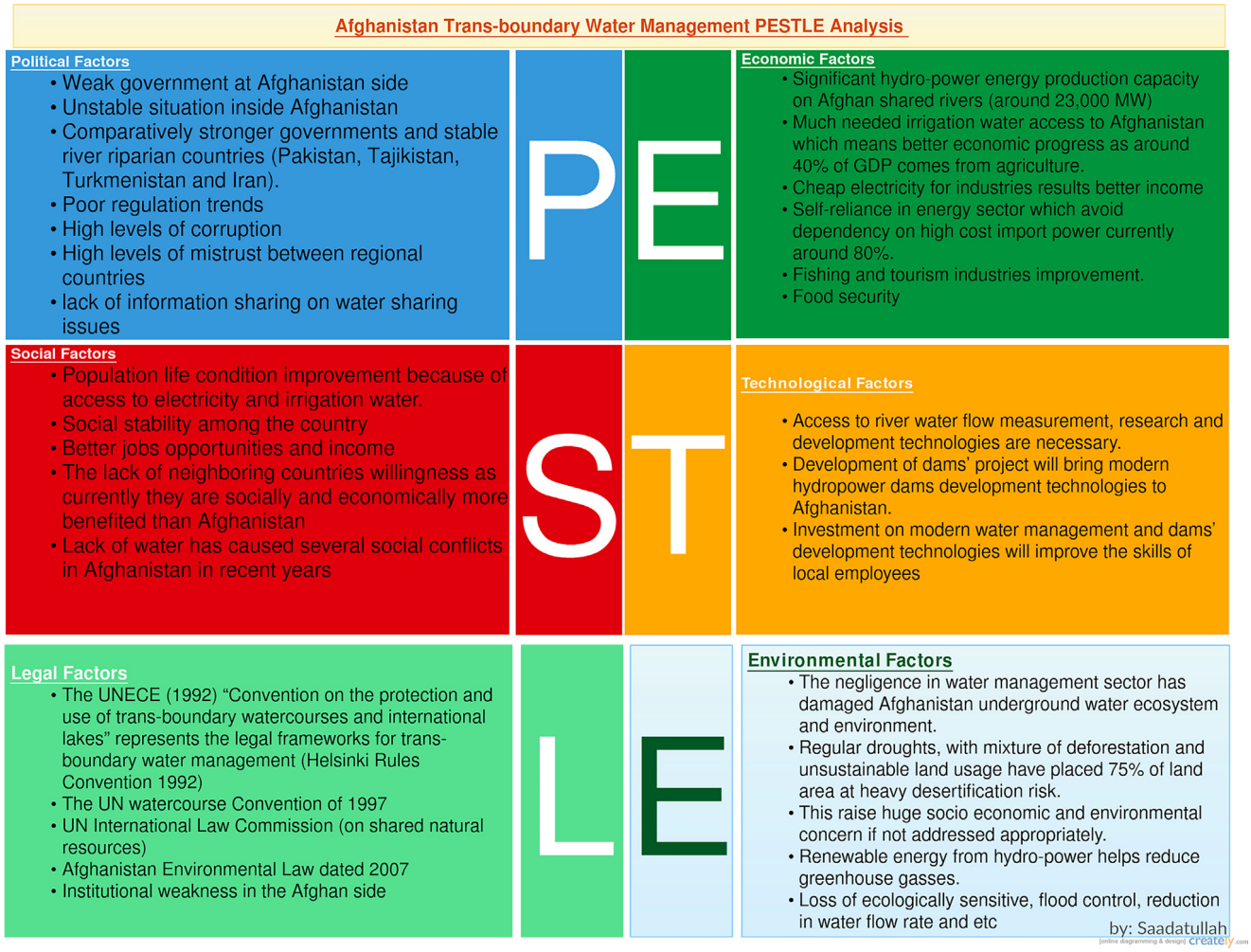


Fig. 25. PESTLE analysis of Afghanistan trans-boundary water (Author own work).

- **Import Power:** Easily accessible energy resources from central Asian countries.

Based on this research analysis it has highlighted that at the moment Afghanistan is investing far too much on import energy from neighboring countries and far too less on utilization and development of its own energy natural resources such as renewables, gas and hydropower energy generation. The import power has made the country energy supply vastly reliant on neighbors and donors. Furthermore the import power is less cost effective and has slackened the economic growth of the country.

Afghanistan can be transformed as energy transit hub as it connects the energy surplus region (central Asian states) with energy deficit region (India, China and Pakistan). The win–win opportunities and regional interest's alignment for cooperation and trade in energy sector is predominantly strong. Afghanistan provides economically best route options for energy trades. Therefor Afghanistan is in a vital position to facilitate regional energy supply particularly electricity and gas. This will not only benefits Afghanistan economically from transit fees but will also improve stability for mutual interests as most of the neighbors are in a manner involved in the conflicts of the country.

5.3. Recommendations

- Afghanistan must invest in its indigenous electricity generation resources in order to reduce the dependency on import power; improve the electrification rate and economy of the country.
- The technical, financial and institutional reforms are needed in the energy sector to deal with the existing challenges. A viable and robust framework is required to resolve the sector complex and diverse problems.
- Afghanistan must improve energy supply, transmission and distribution networks infrastructures both domestically and regionally and take steps to evolve from a nonsynchronous energy system to an integrated synchronized system.
- Trans-boundary water management agreements are vital for Afghanistan electricity and irrigation systems. The country must initiate the water agreements treaties process with the help of international water conventions at the nearest possible future. The development of a multi-shareholder process for the formation of a common vision and sustainable water management of all the rivers are vital for the region and Afghanistan in particular.
- The human capacity development in both energy and trans-boundary water management is necessary. Afghanistan must invest on the development of technical expertise in both fields in order to address the associated issues at national and international levels in case the trans-boundary water issue resolution reaches the international level.
- Afghanistan geographical location and regional and global politics are well aliened for the country to become an energy transit hub between energy surplus and deficit regions.

Table 11
Trans-boundary water management globally accepted principles (Rahaman, 2009).

Principles	Details
Equitable and reasonable utilization	This principle enables each basin state to use an equitable and reasonable share of water resources within its own territory. Reasonable and equitable utilization is the foundation of shared sovereignty and rights equality, however, it does not necessarily translate to the allocation of an equal share of waters. There are several factors which need to be considered in determining a reasonable and equitable share such as the basin geography, hydrology, population dependency, socio-economics, the present utilization of waters, potential future needs, climate and ecological and availability of other resources, etc.
Not to cause significant harm	Based on this principle, no state in an international shared basin is allowed to use the water resources in their territory in a way that would result in significant harm to other basin states and the environment.
Information exchange and cooperation	Under this principle, it is the responsibility of all riparian states of an international waterway to collaborate and exchange information regarding the watercourse and the current and future planned usage of water resources.
Consultation, negotiation, and notification	Every state in a trans-boundary watercourse is eligible to prior notice, negotiation, and consultation in cases where the planned use by another riparian of a trans-boundary watercourse might cause serious harm to its interest or rights.
Peaceful resolution of disputes	This principle supports that every state in a trans-boundary-watercourse must settle the disputes peacefully in case a concerned state cannot reach an agreement via negotiation.

Afghanistan must realize this opportunity sooner than later by taking realistic steps toward peace in the country as without stability the realization of all these opportunities remain highly uncertain.

5.4. Research limitations and further development

There is very limited credible data available for both sectors analysis. Most of the resources surveys data done by Afghan government have archived as hard copies and are not available online and access to it requires travel to the relevant ministries offices. Considering the time frame and financial limitation for this research it was decided to focus on existing available credible data sources.

Future researches about the energy production fields which are identified in this paper such as locations for renewable energies, need further feasibility studies in terms of distance from local communities, implementation and location physical suitability. In addition the environmental impacts analysis of trans-boundary rivers management on Afghanistan and neighbors sides will be helpful.

Appendix

A.1. Afghanistan uncertain future

The essential incentive for all the discussed opportunities is peace. Natural gas, oil and pipeline construction relies on stability and the involvement of all the stakeholders in the projects. This is challenging task especially in a country with such magnitude of tribal communities.

While Afghanistan has the potential to emerge as energy transit hub and is vital regional economic development the security of the country remained a key obstacle for the realization of these opportunities. Though the major regional countries interest alignment in stable Afghanistan is significant still there are very limited steps have been taken to make that happen, even some countries are still playing damaging role toward these incentives. Afghanistan has featured in both China and India economic strategies but neither country sees it as a critical ingredient. China on its part might see its economic belt of Silk Road happen excluding Afghanistan as the pipelines can be laid around Afghanistan and resource could be found elsewhere.

India has been blocked geographically by Pakistan for several decades on overland trade connections with central Asia. This caused the development of Chabahar port in Iran through India's investment which provided them a new logistic and trade link with central Asia and Afghanistan (Schwarck, 2014). The inauguration of these multiple trade connections will revive the country's natural and historical place once again in the region. Despite the clear security threats the TAPI pipeline project has inaugurated recently which will go through Afghanistan. The USA provides support to the project in order to isolate Iran from regional integration (Daly, 2012).

The international community assistance is decreasing gradually. The USA and NATO military presence in Afghanistan has caused increasing tension and back clashes. The instability is continuously growing and the Taliban controlled territory is spreading. The corrupt and weak government has further made the political situation extremely fragile. The USA presence has seen suspicious by many regional powers such as Russia and China. All these facts suggest an uncertain future ahead.

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