Hydropower for sustainable water and energy development in Ethiopia

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Abstract Ethiopia is currently one of the fastest growing economies in Africa. Due to this rapid growth in economy the country is facing a huge challenge to meet the fast growing energy demand. The major demand comes from industrial, agricultural, service sectors and from the rising household consumption because of the rising standard of living. From among the many other sources of energy, the country identified hydropower to be the key to satisfy the current growing energy demand. When the government decided to develop huge hydropower projects on the country's major river basins, it not only considered the country's huge hydropower potential but also the additional social, economic and environmental benefits these multi-purpose hydropower projects bring. These hydropower projects also provide the opportunity to mitigate their minimal negative environmental impacts. This paper will explore the country's hydropower potential, energy consumption, and future energy demand. Then it discusses the role of hydropower in terms of satisfying the energy demand and the advantages it provides as compared to other alternative energy technologies. Finally, the part hydropower plays in leading the country into a more sustainable energy future is explored as well.

Keywords Hydropower · Sustainable energy · Multi-purpose

Introduction

Ethiopia is the second populous country in Africa with 90 million people (World Bank 2013). It is located in the Horn of Africa and plays a significant role in the socio-economic and geo-political situations of the region. In the past the country was known for the political instability and stagnant economic condition. But currently the country's economy is among the fastest growing economies in Africa (World Bank 2013).

The country devised The Growth and Transformation Plan and with it came rapid expansions in various sectors of the economy. With the economy growing very fast on an average every year, the energy demand of the economy is rising and the country is exploring the different possibilities to meet this growing energy demand that comes as the result of such prompt growth in economy.

To mitigate environmental degradation and pollution problems that could result due to such rapid economic growth. The country laid down the strategy known as the Climate Resilient Green Economy Strategy, which is expected to guide the country into a sustainable development path in various sectors, principally in the energy sector.

The Climate Resilient Green Economy strategy is the response to the country's ambition to build net emission-free economy by 2025, while bringing the positive impact of sustainable development needed in various sectors such as health, social justice, economic growth and natural resource conservation (Federal Democratic Republic of Ethiopia Climate Resilient Green Economy strategy, FDRE, CRGE 2011).

Ethiopia is known for its huge water resources. It is known as the Water Tower of Africa as the result of the abundant water resources in the country. Ethiopia has 12

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Table 1 Country profile of Ethiopia

Capital	Addis Ababa
Region	Africa
Coordinates	9.0167°N, 38.7500°E
Total area (km ²)	1,104,300
Population	90,000,000 (2014)
Rural population (% of total population)	81 (2013)
GDP (current US\$)	47,525,186,490.05 (2013)
GDP per capita (current US\$)	505.05 (2013)
Access to electricity (% of population)	23.00 (2014)
Energy imports net (% of energy use)	5.72 (2011)
Fossil fuel energy consumption (% of total)	5.7 (2011)

Source World Bank (2015a, b)

river basins, 22 lakes and the renewable ground water resource is approximately 2.6 billion cubic meters (Federal Democratic Republic of Ethiopia, Ministry of Water Resources, FDRE, MoWR 2002). Developing this abundant resource holds the key to fulfill the country's economy growing energy and water demand in various sectors such as agriculture, transportation, industries and service.

In terms of satisfying the growing energy demand the country clearly stated its vision in the Growth and Transformation Plan and Climate Resilient Green Economy strategy. The Climate Resilient Green Economy strategy aims to build zero net carbon emission economy and identifies hydroelectric power generation as the most viable option to make this vision a reality considering abundant water resources and the scheme's multi-purpose nature. Since hydropower can also offer a number of environmental and technical advantages, in terms of avoiding greenhouse gas generation due to consumption of fossil fuels (Bartle 2002). Table 1 presents the profile of the country.

Energy consumption in Ethiopia

According to the Ethiopian Electric Power Cooperation hydropower is the main source of power generating about 88 % of the electricity in the country. The country has enormous additional potential for extensive hydropower development. The national water resources are estimated to have the potential to generate as much as 30,000 MW of power from economically feasible hydropower projects (World Bank 2006).

Ethiopia as mentioned above is a country with a large population that is increasing in Africa and the distribution of the grid power supply in the country is very limited;

70 % of the country is out of electricity reach particularly in the rural areas where the majority of the population lives (International Energy Agency, IEA 2014). Even in areas where there is grid coverage there are frequent blackouts and power shortages including the capital Addis Ababa, which is not only the country's political and economic capital but also the political capital of Africa. This has huge negative impact on the country's economy which is growing at a very fast rate. Studies indicate that the national demand will outstrip the supply capacity of the installed hydropower capacity in a few years, aside from impending demand for power export to neighboring countries which the country sees as a source of foreign currency (FDRE, MoWR, 2001). Figure 1 shows the increase in consumption of electricity and we can observe from the graph that the net electricity consumption of the country is increasing at a very rapid rate.

The rise in consumption can be explained by the increase in grid distribution, in population number, in living standard of the people, the rate of urbanization, industrialization and electricity demand of the service sector.

A decade ago the demand for electricity was very low due to the low level of development in the consumer sector mainly in the rural areas which covers large part of the country. It is not wise to transmit the main grid supply to this part of the country considering the high cost of power transmission and the benefits the country could secure if it made its plan to export electricity to the neighboring countries a reality. As a result the government has been making some effort to satisfy the electricity demand of the rural part of the country, mainly through stand-alone electricity supply facilities like micro-hydropower plants, wind turbines, and diesel generators.

Micro- and pico-hydropower plants are known for their ability to supply the rural areas in developing countries with environmentally sound, affordable and adequate energy, which will lead to the increase of employment opportunities, improvement of ecological environment, poverty alleviation, improvement of local living and cultural standards and economic development in remote areas (Goyal et al. 2014). Therefore, building such stand-alone electricity supply facilities for the rural areas looks to be a more sustainable way to address energy demand in remote areas.

In East Africa, Ethiopia has a reasonably high-installed capacity of 80 MW of standalone micro- and pico-hydropower plants (Water for Agriculture and Energy in Africa, WAEA 2008). This gives the opportunity to supply the base load electricity to the main industrial regions and cities like the capital Addis Ababa and export the remaining to the neighboring countries which can boost the country's earnings from foreign export.

Fig. 1 Ethiopia's electricity net consumption (1980–2012).

Source US Energy Information Administration (2015)

Table 2 The currently installed hydropower plants

	Power plant	Date of completion construction	Catchment area (Sq km)	Dam height	Installed capacity (MW)	Average energy (GWh)	Type of turbine	Dam length	Dam type
1	Beles	2010	14,200	35	460	1867	Francis turbine	125	Concrete gravity dam
2	Tekeze	2009	30,390	188	300	1393	Francis turbine	450	Arch gravity
3	Gibe II	2009	Weir	46.5	420	1635	Impulse vertical	171.13	Weir
4	Gibe I	2004	51	41	210	722	Vertical Francis	1700	Asphalt faced rock fill
5	Wakena	1988	5300	42		543	Francis vertical	2000	Earth and rock fill
6	Fincha	1972	170	22.2	134	760	Impulse vertical	340	Earth and rock fill
7	Finchaa Amerit Neshe	2011	29.5	38	97		Impulse vertical	1000	Earth dam
8	Tis Abay I	1953	15,300	Weir	12	33.7	Vertical Francis	Weir	Weir
9	Tis Abay II	2001	15,300	Weir	72	359	Vertical Francis	Weir	Weir
10	Koka	1960	200	23.8	42	110	Vertical Francis	458	Concrete gravity dam
11	Awash 2	1965	2.73 (weir)	10	32	182	Vertical Francis	88	Concrete gravity dam
12	Awash 3	1971	0.063 (weir)	20	32	182	Vertical Francis	125	Concrete gravity dam

Source The Ethiopian Electric Power Corporation (EEPCo 2015)

The other main reason that made the country to focus on developing the water potential and providing the grid supply is for the protection of the ecological environment, mainly its forest resources. The majority of the people live in the rural part of the country and due to low coverage of cheap electricity they are heavily dependent on burning biomass for their household energy consumption (World Bank 2001). This is putting a huge impact on the country's forest resources as the result of deforestation. Burning biomass is also associated with emission of greenhouse gases to the atmosphere which is also the cause of poor outdoor and indoor air quality (Gary and Deborah 2002). Therefore, trying to elevate the

dependence of the majority of the population dependence on burning biomass to fulfill their energy need is crucial for protection and sustainable management of the country's forest resources.

In Ethiopia, many natural sites are well suited to create storage reservoirs at relatively low costs and with relatively little environmental and social disruption (World Bank 2006). Bearing in mind the country's abundant hydropower potential and the suitability of the country's land escape for building multipurpose hydraulic infrastructures, developing this resource potential is a sustainable solution for the country's energy and power shortage problems (see Table 2).

Water resources of Ethiopia

Ethiopia is experiencing a major increase in demand for electricity, and considering this the country started to develop its river basins which have a huge hydropower potential. The plan also includes developing the Nile river basin where the Grand Ethiopians Renaissance Dam is being built on. It will be the largest in Africa when completed. There are nearly 200 identified economically feasible sites for hydropower development in the country (Bartle 2002).

Ethiopia is water-rich country with a number of rivers originating from the highlands of the country. In addition to this, the country also has a number of lakes especially in the Great East African Rift Valley part of the country. This huge potential gives the country a bright future not only in terms of hydroelectric power generation but also generating revenue from supplementary services such as tourism, drinking water supply, large scale irrigation and navigation in case of multipurpose hydraulic projects. Such multipurpose hydropower projects add sustainability factor for the river basin development schemes which make them more viable. Table 3 provides some basic information about the major river basins and its tributaries in Ethiopia.

Hydropower potential in Ethiopia

If the country fully developed its economically and technically feasible hydropower potential it will result in 4333 kWh increase in per capita figure (Bartle and Isambert 2001). Of this huge potential of the country only 5 % has been tapped so far (IEA 2014). Considering the efficient energy-generating potential and the environmentally friendly nature of hydropower as compared to the other renewable energy sources currently, the country considers its hydro-potential as one of the most valuable resources

and the backbone of the country's future social, environmental and economic sustainable development.

The country has initiated a number of hydroelectric projects and many are on the pipeline with the aim of satisfying the growing energy demand, as well as a plan to export electric power to neighboring countries and beyond. This includes the Grand Ethiopian Renaissance Dam being built on the Blue Nile River which is currently 22 % complete and will be the largest dam in Africa and the sixth largest in the world upon completion.

Hydropower can serve as a bridge into a transition to more sustainable sources of energy (Sternberg 2008). Considering this the country recognized hydropower as economically feasible and environmentally friendly option until the transition to a more sustainable energy generating technology is made (see Fig. 2).

Ethiopia's energy demand forecast

Ethiopia has a desire to build a sustainable economy which is based on clean and renewable energy source. The Growth and Transformation plan states the country's vision in the economic sector as "to build an economy which has a modern and productive agricultural sector with enhanced technology and an industrial sector that plays a leading role in the economy; to sustain economic development and secure social justice; and, increase per capita income of citizens so that it reaches at the level of those in middle-income countries". Considering this vision, power generation capacity of the country is expected to increase from 2000 to 8000 MW and the electricity coverage to 75 % (FDRE, Growth and Transformation plan, 2011). The prediction is considering the population growth, economic growth, living standard growth and technological growth. The country's energy generation is increasing continuously as the ongoing hydropower projects are being

Table 3 The major river and lake basins of Ethiopia

River basins	Source	Area coverage in Km ²	Annual runoff (Bm ³)
Wabi-shebelle	Bale Highland	202,220	4.6
Abbay	West, Southwest HL	199,912	52.6
Genale-Dawa	Bale Highland	172,259	5.8
Awash	Central Highland	110,000	4.6
Tekeze	North Wollo Highland	82,350	7.6
Denakil	North Wollo Highland	64,380	0.86
Ogaden	–	77,120	–
Omo-Ghibe	Central, Western HL	79,000	17.90
Baro-Akobo	Western Highland	75,912	23.6
Rift valley lakes	Arsi and Central HL	52,000	–
Mereb	Adigirat HL	5900	0.26
Aysha	NF	2223	–

Fig. 2 Ethiopia's installed capacity (GWe) (1980–2012). Source US Energy Information Administration (2015)

Fig. 3 Ethiopia's electricity net generation (1980–2012). Source US Energy Information Administration (2015)

commissioned. Figure 3 shows the increase in the electricity generation capacity of the country.

The population of Ethiopia is rapidly growing with the growth rate of 2.6 % according to a report published by the Department of Economic and Social Affairs of the United Nations Secretariat, UNDESA (2014). The country is in a state of prompt economic development and recorded double digit growth rate in the past few years. For instance the economy has experienced strong and broad-based growth over the past decade, averaging 10.9 % per year in 2004/05–2012/13 compared to the regional average of 5.3 % (World Bank 2015a, b).

With growth of the economy the living standard of the majority the population increases which will obviously increase the per capital energy demand. All these factors will sum up to and expected to raise the energy demand of the country immensely. Considering this the government is exploring all options for generating energy which fulfills the energy demand which will be expected to result from the growing economy. The government considered renewable energy sources to meet this demand considering their marginal social and environmental detrimental effects while proving to be a reliable energy source. Hydropower is the main renewable energy resource being considered in

the country, currently there are hydropower plants under construction and many other are on the pipeline.

Hydropower as a green and sustainable energy source

The need for the sustainable energy source which has the capacity to support the global energy demand is a big challenge. Renewable energy sources are considered as solution for this challenge since they are characterized by most of the principles of sustainable development.

Hydropower is currently the largest renewable power generation source, with a global installed capacity of around 1025 GW at the end of 2013. It provides also the cheapest electricity compared to any other power generation technology and in a very suitable construction sites it is possible to incorporate the three pillars of sustainable development into hydropower schemes (International Renewable Energy Agency, IRENA 2015).

Currently there is a greater plea for a transition from fossil fuel sources of energy which are currently having devastating effect on the global climate to clean sources of energy with less environmental impact and more economic feasibility (Intergovernmental Panel on Climate Change, IPCC 2014). This stresses the importance of the renewables since they have lower levels of greenhouse gas emissions. Especially hydroelectric power generation is being given much more attention considering the big role it can play as sustainable energy source since it is the largest source of energy among the renewables.

The renewable energy resources are usually assessed using sustainability indicators such as carbon di oxide emission, land requirement, social impact cost of electricity generation, efficiency of energy consumption, water consumption, the availability of renewable resources and the technology availability (Evans et al. 2009). Such an assessment will indicate the social, environmental and economic footprints of these projects.

Hydropower has a huge role in contributing to the sustainable development since it can be used as a sustainable energy source, which can provide a more significant portion of the world's energy need in contrast to the other renewable energy sources (Gurbuz 2006).

Hydropower projects, in addition to power generation, often support other essential water services such as irrigation, flood control, fisheries, drinking water, recreation, slow sedimentation downstream, tourism and navigation. These make hydropower projects more feasible, beneficial and sustainable (Engelbertus 2002).

There was a big debate whether to categorize hydropower as renewable and clean energy supply because some argue that hydropower has visible impact on

quality of water as well as on biodiversity not to mention its negative social impacts, but this is related to sustainability not renewability and it is the obligation of the government to incorporate factors of sustainability into hydropower projects (Gary and Deborah 2002). Besides contemporary hydropower projects include environmentally sensitive technical improvements (Sternberg 2008).

Hence at the world summit on sustainable development in Johannesburg, and at the 3rd World Water Forum in Kyoto representatives from most countries have proclaimed hydropower to be renewable source of energy (Yuksel 2010a, b; Gary and Deborah 2002).

Hydropower has a lot of additional advantages compared to the other renewable energy sources. First it is very economical because it provides the cheapest electricity of compared to any power generation technology, it is also very flexible according to the demand for power, hence it provides grid stability (IREA 2012). Hydropower has the lowest level cost of electricity when compared by considering installed capital cost, capacity factor, economic life, operating and maintenance costs, and the cost of capital to other energy generating technologies (IEA 2010; IPCC 2014; IRENA 2015).

When large reservoirs are available, hydropower can store energy for weeks, months, seasons or even years. Hydropower can therefore provide the full range of ancillary services required to achieve high penetration of variable renewable energy sources, such as wind and solar (IRENA 2012).

Hydropower shows the highest energy payback ratio, it is resource efficient, has the highest electricity efficiency rate (85–95 %) and provides the most efficient storage technology compared to other renewable source of energy such as solar, wind and geothermal (Eurelectric 2013).

All energy systems emit greenhouse gases (Weisser 2007). But greenhouse gas emissions of hydropower power plants are among the lowest which make it viable option when compared to most of the other sources of power, especially fossil fuels plants (WNA 2011; Gagnon 1997). Studies have also shown that development of even half of the world's economically feasible hydropower potential could reduce GHG emissions by about 13 %, and the contribution in minimizing sulphur dioxide (SO₂) and nitrous oxide (NO) which are the causes of acid precipitation is also huge (International Hydropower Association, IHA, International Commission on Large Dams, ICLD, Implementing Agreement on Hydropower, IAH, Canadian Hydropower Association, CHA 2000). Bearing in mind all the above reasons hydropower can be used as an energy bridge for the transition from fossil fuels to more clean and sustainable energy sources in the future. Hydroelectric power generating plants have the lowest greenhouse gas

emission compared to other alternative energy sources from (World Nuclear Association, WNA 2011).

Hydropower can be regarded as clean energy since it emits lower greenhouse gas emissions compared to the most of the other sources of energy. This makes these energy generating schemes more favorable compared to other sources of energy in terms reducing the environmental consequences that could result due to emissions of greenhouse gasses.

Generally all energy generating technologies have their own advantages and disadvantages. But selecting the more suitable energy generating technology varies from country to country depending up on their socio economic and environmental conditions. Hydroelectric power generation projects can serve as sustainable source of energy as long as long as the necessary measures are taken to mitigate their environmental and social negative impacts as well as to exploit the additional benefit this multi-purpose projects can provide.

Hydropower for socio-economic and environmental development in Ethiopia

Hydropower development has become the focus of attention in recent years in Ethiopia. This is because the government has identified this sector as the primary source to satisfy the energy demand and achieve the country's sustainable development goals which are stated in the major development plans of the country. The following section discusses the economic, environmental and social positive impacts that can be exploited from the hydroelectric power development projects in the country.

Social benefits

Hydropower projects are mainly criticized because their reservoirs covers large amount of space and this is responsible for the displacement of communities from their original dwelling place. This issue could be more severe in developing countries like Ethiopia because of the lack of enough financial resources to equitably resettle people displaced due to these projects. But Since Ethiopia has many projects sites that are well suited to create storage reservoirs at relatively with relatively little social disruption (World Bank 2006), if these projects are placed in this areas where their social impacts are minimal, nonexistent or in areas where the damage can be completely compensated this problem can be avoided.

In addition to these multi-purpose hydroelectric power schemes provide various services such as recreational uses, navigation, and flood control. Most importantly since Ethiopia's majority population's main source of income is

agricultural products, these multipurpose reservoirs built for the hydroelectric services can serve a great deal by serving as a constant supply of water for irrigation. This can increase the number of growing seasons for the local farmers.

According to the International Energy Agency, IEA (2014), 70 % of the country is out of the reach of electricity, particularly in the rural areas where the majority of the population lives. It is easy to imagine the positive, social benefits this cheap electric power will bring to the majority of the people by serving as a resource for new alternative sources of livelihoods, which might not exist without the electric power supply. This creates alternative earning opportunities for the people thus contributing towards solving the unemployment problem in the country. The social benefits resulting from these multi-purpose hydroelectric power plants will have a positive impact nationwide by improving the social status of the majority of the people directly or indirectly. If these projects are assessed properly and planned by taking the principles of sustainable development into account there is no way they cannot provide more social benefits than their adverse impacts.

Environmental benefits

African countries generally are endowed with abundant renewable energy potential, which they can harness so that, by 2040, renewables provide more than 40 % of all power generation capacity in the continent, varying in scale from large hydropower dams to mini- and off-grid solutions in more remote areas (IEA 2014).

Ethiopia, it is a country which depends mainly on burning biomass as energy source and this has led to years of deforestation and environmental degradation; 70 % of the population is not covered by electricity (IEA 2014).

Considering that 85 % of the country's population lives in the rural part of the country where the electricity coverage and energy source is at the lowest level, it is easy to picture the huge impact of using burning biomass as a source of energy on the environment as well as on indoor air quality (World Bank 2006). More than 80 % the remaining demand for electricity is fulfilled by the few installed hydropower plants (Bartle 2002).

The country also imports a huge amount of fossil fuel from abroad to satisfy the energy demand. This has a huge impact on the country's economy since the country spends most of its hard-earned foreign currency on the import of fossil fuels (see Fig. 4).

In addition to contributing to loss of foreign currency, fossil fuel consumption is associated with greenhouse gas emissions. This is against the country's desire to accomplish a zero net greenhouse gas emission economy. The

Fig. 4 Ethiopia's oil consumption (1980–2013). Source US Energy Information Administration (2015), Ethiopia oil consumption (1980–2013)

Fig. 5 Ethiopia's CO₂ emission (metric tons per capita). Source World Bank

country is a signatory to many international agreements on reducing greenhouse gas emissions and has the intention to keep its commitments.

Graph depicts that the carbon dioxide emission of the country increases even though the greenhouse gas emission is low compared to other countries, for now it is possible to expect a huge rise in emission in the near future due to the increasing consumption of fossil fuel as energy source. The country acknowledged this possibility and identified the hydropower development as a more viable option (see Fig. 5).

Therefore hydropower can be a good source of energy both in terms of satisfying the stern need of the economy for energy and protecting the integrity of the environment

as well as keeping the countries emission level very low which will help the country keep its international commitment in terms of keeping greenhouse gas emission level low.

Economic benefits

Ethiopia is one of the African countries whose economies rely heavily on agriculture. The majority of the population depends on this sector to earn their income. The agriculture in the country is based on the seasonal rain, which is highly variable and uncertain, especially nowadays because of the impact of climate change. Therefore, the planned as well as the existing multipurpose hydroelectric projects will serve

as a reliable source of water, thus avoiding the uncertainty associated with water availability and variability due to climatic change. This in turn would help the country to avoid the droughts which might result due to water scarcity.

In addition to the significant economic contribution they provide by making the agricultural-based economy proof from the impacts of climate change, these schemes can be a source of foreign currency, since the country has plans for trading electric power to neighboring countries which can also have political benefits by serving as a source of regional cooperation.

Perspectives on Ethiopia's development plans and strategies

Ethiopia is a country with a big ambition to become a middle income country by 2025 and the country wants to achieve its developmental goals by changing the concept of sustainable development into reality. The country's economy is currently growing very fast; it is among the fastest growing economies in world and will continue to be so (CRGE 2011). This is in line with the country's ambition to become a middle income country by 2025.

To achieve these goals the country has devised various development plans, and the most recent one is the Growth and Transformation Plan, which aims to achieve major development goals by fast track implementation of various developmental projects.

The implementation of the growth and transformation plan is expected to increase the energy demand of the economy significantly and the country recognized the detrimental effects this could have on the environment. The Ethiopian Federal Democratic Republic Growth and Transformation Plan, FEDRE GTP (2010) states that it is crucial that building a 'Green Economy' is the sustainable away to achieve the country's developmental goals. Therefore the country devised a strategy to gear the country's development plan into a sustainable path devised the Climate Resilient Green Economy Strategy which aims to protect the country from the effects of climate change and environmental damage that comes due to the implementation of rapid developmental projects which boosts agricultural productivity, strengthen the industrial sector and increase foreign export.

The Climate Resilient Green Economy Strategy outlines the importance of clean energy resource to support both the growing need for power and ensure the integrity of the environment. The strategy recognizes the country's potential for hydropower generation and that hydropower

development could serve as one of the country's main energy source. Hence the country's major development plans puts the hydropower as the major source of energy to support the growing energy demand but more importantly it is very crucial for the country's plans to build a green economy.

Conclusion

Hydroelectric power is the leading renewable energy source in the world and the case is no different in Ethiopia. This is considering its many benefits and the distribution of the economically feasible hydropower resource. It provides the low cost in generation, maintenance and flexibility in supply according to the demand. Hydropower is the best renewable energy in terms of satisfying the energy need in a larger scale and in terms of the opportunity it provides for implementing adequate mitigation measures for its negative effectiveness.

Ethiopia has entered into a period of rapid economic growth in recent years. The country has prepared plan and strategy to guide this development into a sustainable path. These plans address the various development sectors which are key for the country's sustainable development and among them is the energy sector since it is the main sector that is of due importance to make sure the continuing growth of the economy.

Ethiopia is a country with large water resources. As a result the country plans to develop its water resources as an energy source. The government believes that if this resource tapped it can provide not only hydroelectric power but could also be a source of social, economic and environmental development by providing various additional services such as navigation, tourism, irrigation in case of multipurpose hydropower projects.

Exploiting this resource brings various social and economic advantages to the country which might not be possible without it. This helps to compensate any detrimental effects these projects might have most importantly hydropower holds the key to making the country's dreams in terms of satisfying the energy demand along with building a zero net emission economy, where the social and economic development targets stated on the development plans are a reality.

Compliance with ethical standards

This paper has not been submitted elsewhere in identical or similar form.

Conflict of interest The authors declare that they have no conflict of interest.

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