Prospects for development of water resource projects in Nepal through Sino-Nepal co-operation

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Abstract. The enormous amount of water resources is a boon of nature for Nepal to escalate its global status and realize the golden era of development in every possible aspect if properly utilized. However, the incompetence of Nepal in current circumstances to arrange basic requisites for harnessing its resources left the Himalayan country behind, in crisis. Meanwhile, the northern neighbouring country China has potential to render the necessary requirements through the platform of Sino Nepal co-operation which certainly yields favourable benefits for both countries and eventually transforms friendship between Kathmandu and Beijing to new horizon. This paper describes water resources of Nepal in the context of hydropower, irrigation and water supply incorporating status of Nepal and necessary technology for development. It also discusses scope, challenges and opportunities for China in Nepalese water resources, all under the platform of Sino-Nepal relationship which ultimately cultivates the co-operation.

1. Introduction
Nepal [1] is one of the smallest South Asian country of total area 147,181 km² with the population of 28.98 million. Nepal is sandwiched between two rising superpower and populous countries, China and India. Nepal is affluent in water resources with many rivers, lakes, stream, etc., the most of the major rivers originated from the base of Himalaya. Despite, abundant resources, Nepal is still deprived from major hydropower, irrigation, and water supply projects due to absence of modern technology, proper management, allocation of budget and unstable political situation. On the other hand, China [2] is about 65 times bigger than Nepal with 18.42% of world’s total population resides inside its territory. China has already explored much of its water resources which is evident with successful running of many prolific hydropower stations including the world’s largest, three gorge hydropower station producing 22,500 Megawatt (MW) and contributing more than 10 Gigawatt (GW) of hydroelectricity in aggregate, distributed around the country through advance transmission and distribution system. Recently, China has slowed its development pace for water resources, changed its interest from its own country to “Going Out” policy and decided to explore the oversees projects, sharing its technology and expertise with necessary investment under road and belt initiatives. Eventually, China is establishing better cooperation, enhancing the friendly diplomacy and flourishing prosperity amid countries.

This paper mostly focuses and renders the importance, firstly, on hydropower, secondly irrigation and thirdly water supply sectors of Nepal along with Sino-Nepal co-operation. The reason behind this
arrangement is currently, the hydropower development is the major focus of Government of Nepal to raise country’s economy, if feasible, multi-purpose project consisting hydropower generation as primary, irrigation or water supply within as secondary sides.

Nepal [3] is rich in hydropower with 83,000 MW of theoretical potential while 66 technoeconomically feasible projects can be executed generating nearly 44,000 MW power to meet regional and national demands. However stymied project progress is creating a bottleneck in hydrodevelopment, with the country even endured painful load shedding (power cut) in past years and somehow resolved recently for household by importing electricity from India but industrial power outage issue still exist. This shows that hydropower sector has a long way to go in development of Nepal with handsome scope for investors.

Nepal [4] is an agricultural country with more than 70% of population is engaged in agriculture. Irrigation plays a vital role in cultivation of agricultural products. The large quantity of water available in the country and its potentiality to irrigate significant percentage of the total agricultural land, provide opportunities to surmount the barriers of economic development in this beautiful Himalayan country. Most of the irrigation system in Nepal is traditional and should be upgraded according to modern technology. Nepal is in need of efficient and modern irrigation system for agriculture growth.

Although several rivers originated from Himalaya of Nepal flow through mountains, hills towards plain in south, while serious issues of pure drinking water scarcity in this country present till now. Water treatment process [5] of water supply system in Nepal does not meet the standard criteria at some urban and many rural areas. The rural places of Nepal till date lacks the mandatory pure drinking water facilities. This condition gets worse by pollution which sometimes ignite the serious problem of epidemic. Many Non-Governmental Organizations (NGO) and International Non-Governmental Organizations (INGO) are constantly contributing in remote places of Nepal making drinkable water easily reachable for the local people.

These are three major fields of water resources in which Nepal requires essential progress in coming days. Nepal has a tremendous amount of resources available in the form of flowing water (water resources). On the contrary, Nepal is lagged behind in technology and equipment manufacturing which consequently push Nepal back even harnessing self-satisfactory advantages. This leads Nepal being lenient towards various foreign technology, equipment, and investment to receive the utmost benefit of its resources. Nepal being a nation landlocked by China and India geographically, relies mostly on these two huge nations, in the utilization of its water resources. This paper concentrates on the evolution of Sino-Nepal cooperation and subsequent cordial future for Nepal’s water resources also transcending the scope for China.

2. Current scenario of water resources, projects and development

Nepal’s rivers [6] possesses annual discharge of about 7,124 cubic meter per second, storage capacity of 202,000 million cubic meter and annual runoff up to 170 billion cubic meter that is evidently tremendous amount of water resources enclosed within such a small territory. There are about 6,000 rivers comprising rivulets and tributaries covering the length of about 45,000 kilometres and area of 395,000 hectares providing multi-dimensional application. However, Nepal is way behind in modernizing water resources plant with breakthrough technologies. Besides, the multipurpose projects incorporating hydropower, irrigation and water supply in one mega project as well as secondary and tertiary benefits such as flood control, navigation, recreation, aquaculture etc. have not been yet realized from the development of its rivers. Nepal has water bodies allocated as three major river basins namely Koshi, Gandaki and Karnali including some southern rivers, and two border rivers, Mechi and Mahakali as shown in figure 1.
Figure 1. Water resource map of Nepal with major river system [7].

Water resources available in Nepal is primarily utilized for generating hydroelectricity, providing irrigation facilities and supplying sufficient potable drinking water to its people. The utilization sectors for water resources in Nepal have been presented below:

2.1. Hydropower generation

In the present context, Nepal is mainly concentrated in hydroelectricity generation in order to mobilize its water resources and lift the poor economy. There is greater potential to generate hydro-electricity in Nepal but in the current Fiscal Year (FY) 2018, at the middle of Fourteenth plan (FY 2017-2019), the total installed capacity [8] of hydro-electricity reached about 1,045 MW which is only 2.375% of the total potential. About 87% of the total population has access to electricity facility in Nepal. The electricity transmission line of 66 Kilovolts (kV) has crossed the total length of 3,496 kilometres, so as to facilitate electricity energy around the country. The national initiatives, “Prosperous Nepal, Happy Nepali” has special attention paid towards sustainable development of water resource and energy. Also, the sustainable development agenda of Nepal [9] renders more priority to hydropower development.

The hydropower projects of Nepal are mostly dominated by runof river hydropower plant. Nepal seeks more storage type plant to mitigate the load shedding problem in dry season. Many hydropower projects are under construction and proposed to provide necessary electricity to the consumer. The major generating hydropower plants [10] are Kaligandaki (144 MW), Middle Marsyangdi (70 MW), Marsangdi (69 MW), Kulekhani (60 MW), Khimti I (60 MW), Upper Marsangdi A (50 MW), Upper Bhotekoshi (45 MW), Kulekhani II (32 MW), Chameliya (30 MW), Trishuli (24 MW) and Chilime (22 MW) hydropower stations. Also, there are many projects under construction among them prime projects are Upper Tamakoshi (456 MW), Rasuwagadi (111 MW), Middle Bhotekoshi (102 MW), Lower Solu (82 MW), Trishuli 3A (60 MW), Khani Khola (25 MW) and Kulekhani III (14 MW) hydropower plants. The possible future hydropower station proposed from various studies of major rivers and under planning phase are Karnali Chisapani (10, 800 MW) Panchewor (7,480 MW) Budhi Gandaki (1,200 MW), Arun III (900 MW), West Seti (750 MW), Upper Tamakoshi (456 MW), Dudhkoshi (300 MW), Upper Karnali (300 MW), Kabeli A (30 MW), Khimti II (27 MW), Upper Modi (14 MW) etc.

Now, it appears more transparent that there are extensive opportunities in hydropower sector and Nepal has already embarked in the quest of hydro-energy generation, yet, a lot to be exploited which needs latest cutting-edge technology to realize those envisaged projects in reality.
2.2. Irrigation facilities
Irrigation is another important sector where water resources can be used for the growth of agriculture production. Nepal [11] has 2.641 million hectares arable land, and 1.766 million hectares is irrigable land out of total 14.718 million hectares area of the country. Various efforts have been made for the development of irrigation since the first plan in the country. But about only 54.26% of total arable land is irrigated by the middle of Fourteenth plan [8]. Also, with the presently available surface and underground water irrigation facilities, only 66.87% of the total arable land can be reached which emphasize the vast improvement in irrigation technology. The most afflicted challenge of Nepalese irrigation system is to establish the networks that supply water to total arable land by using adequate technology so that irrigation facilities are available all year around. There is no other alternatives of river diversion canal and reservoir projects for this purpose. For those land having irrigation facilities are managed for water availability security to mitigate sudden water shortage due to climate change.

Surkhet valley irrigation project, Bagmati irrigation project, Mahakali irrigation projects, Rajpur Irrigation Project, Birgunj Irrigation project, Sunsari Morang irrigation project, and Praganna and Badhka irrigation project are some major irrigation systems running successfully. Currently operating projects is going through sustainable management, modification, and maintenance scheme from government and local community governing bodies. Also, different working projects such as Sunsari Morang and Bagmati project are at different phases of augmentation. Sikta irrigation projects and Daraudi Paluntr irrigation projects are under construction. Deep and shallow tube well irrigation projects are alternative irrigation projects which are implemented in southern part of Nepal. In the Fourteenth plan one of the main projects is to install, 22 districts of Terai region with 3000 wells, 20,000 tube wells to facilitate 63,100 hectares of land with ground irrigation.

2.3. Water supply utilities
The pure drinking water is the basic need for people of every country. Nepal is bestowed with water resources but still, there are people who do not get pure drinking water. By the mid of Fourteenth plan [8], about 90% of the population has received drinking water facility and 83% of the population has received sanitation facilities in Nepal. “Water and Sanitary for Everyone with Sustainable Management Initiatives” has taken by government of Nepal to maximize the mobilization of organizational structures for water supply and sanitation also add efforts in continuity for expansion of water network without compromise in water quality. The main obstacles for water supply system experienced along the development process are natural calamities at source of water, water source conflict, over exploitation of ground water and allocation of comparatively less budget for under construction projects resulting delay in completion.

The Ministry of Water supply and sanitation is working on three major projects which are Melamchi Water supply project, Rural water supply and sanitation projects, and Third small town water supply and sanitation sector projects. Melamchi water supply project [12] with the primary objective to alleviate the shortage of potable water in Kathmandu valley is designed to divert about 170 million litres per day (MLD). Further, adding a supply of 170 MLD each from Yangri and Larki rivers which lie in the upstream of Melamchi as a future supply source. This project was started in 1998 and originally planned to be completed by 2007. Unfortunately, due to many problems and disputes amid Government of Nepal, Melamchi Development Board and Italian contractor Cooperaativa Muratori e Cementisti (CMC) di Ravenna regarding additional money this project, no wonder, once again has missed its deadline of delivering water before mid-October 2018. Rural Water Supply and Sanitation Projects [13] are implemented and financed by Government of Nepal to increase sustainable access to improved water services and promote improved sanitation and hygiene practices in rural areas as well as develop implementation in a long-term support mechanism to promote the sustainability of water supply schemes in selected district. This project was approved on May 29, 2014, and will be closed on June 30, 2020. The total cost of this project is US$90.00 million. The third Small Town Water Supply and Sanitation Sector Project includes the improvement or
construction of water supply system for up to 26 small towns, involving 1,450 kilometres of water supply pipeline; 78,000 household connection and 26 water treatment systems with an estimated capacity of 50,000 cubic meters per day.

3. Barrier of water resources development in Nepal

The water resource projects in Nepal are currently under developing phase, accompanied with many hurdles on its path forward. There are various problems in the development of water resources in Nepal.

The development of water resources demands a huge budget for constructing hydro-electricity, irrigation and drinking water projects but Nepal is an economically backward country. Majority of Nepalese people are under poverty they have no capacity to save and invest. Thus, there is lack of sufficient budget for the development of water resources in Nepal. Secondly, high-level technology and skilled manpower are necessary for plan, implement, and operation of water resource projects but there is lack of such high-level technologies and technicians in Nepal. Therefore, Nepal is compelled to import expensive technicians from abroad to operate different projects. The construction of projects requires advance technology exhibiting sophisticated machines, tools, and equipment. However, there is deficit of such leverage in Nepal. Nepal imports advance technology from foreign countries but insufficient capital for this purpose makes situation critical which is the third obstacle. The fourth is the geography of Nepal, which is covered mostly with mountains and hills, many of the water resource projects lie in the hilly region without transport facilities. The transport facilities are the prerequisite to be developed before launching any projects that impose substantial percent, yielding significant raise in the overall cost of the project. Nepal, indeed a tiny country with small number of population so domestic market is very limited which diminishes the scope for investors is Fifth huddle for water resource development. The purchasing power of the people is very low and only exportable market is India. But the Indian attitude is not favourable towards Nepal recently after promulgation of new federal constitution in 2015. Thus, limited market is another problem for the development of hydroelectricity in Nepal. The government policy is defective for the development of water resources because of political instability. There is a defect in formulation and desire for water resource projects. There is lack of adequate statistical data. Also, myopic political action has intensified the adverse impact on number of projects. Political decision makers, administrators, planners, technocrats, academia, and the media responsible to build properly managed system for development of water resources are all hampered by Nepal’s political instability is the sixth barricade.

4. Current technological status of Nepal

Hydropower sector of Nepal is prosperous among other two sectors comparatively. The present situation is that Nepal has developed only 1,045 MW of hydropower. Therefore, bulk of the economically feasible generation has not been realized yet. Most of the hydropower built in Nepal are run off river type, however, Nepal is looking forward for numerous peaking run off and storage type hydropower projects so it can meet the power demand in the dry season as well as mitigate currently existed load shedding problem. GIS [14] technology has been adopted for survey, planning, and management of various hydropower stations. There are many stations with aged monitoring system which are needed to be replaced. The surveillance system [10] for security purpose of the project is available recently. Transformer maintenance and testing plant are also available in Nepal. The hydropower plant is necessary to be rendered with recent technology. The most of the equipment in hydropower stations are not installed with advance control system but should be self-governing and automated with digital devices in days to come. Eg. the gate openings are manually operated.

Traditional irrigation system [15] built by farmers are gradually improving with advanced facilities and simultaneous construction of new projects thereby, upraising irrigation sector to another level. Recent technology of irrigation such as water lifting system, pumps, sprinklers, and drippers are implemented in some recently built major irrigation projects whereas several other projects operating and under construction still existed that seek for these kinds of utilities. Agricultural yield in any zone
can be raised with sophisticated efficient machinery and civil infrastructure in irrigation which propel the national economic growth. In this way, surface irrigation systems are developing in Hilly and Terai region of Nepal. On the other hand, certain region where surface irrigation is not available, in such situation underground irrigation is carried out which is also taking pace, including shallow and deep tube well, few equipped with mechanical pumps for pumping water from below earth surface. The productivity of water is also increased with water recycling and harvesting scheme rejuvenating irrigation in Nepal.

Nepal [9] possesses about 2.27% of the world’s fresh water resources which is definitely a gift from mother nature to a tiny country like this but still, 10% of Nepalese people is out of reach from basic water supply distribution system. Water supply system [12] in Nepal has been recently installed with GPS monitoring system. Currently, it is upgraded with latest computers for online billing and collection system. There are still many station and pipelines of water supply system in Nepal to be upgraded with smart technology for better management and more efficient operation.

5. Essential new technologies
Modern technology is crucial for the efficient development of water resource project. New technology can act as a backbone to solve the water resources challenges in Nepal. New technology is gradually making inroads into Nepal’s water resource projects but the speed is too slow. Some new technologies Nepal at present situation, seeking to boost the speed of development are Advance Geographic Information System (GIS) Technology, Remote sensing technology, Automation Technology, Smart Grid Technology, Online payment system, Tunnelling technology, Water treatment and purification technology, Electromechanical equipment and technology, Ground water technology and Solid Waste and waste water management technology.

Nepal is presently using the outdated technology which should be replaced with advanced GIS tools for robust development of water supply, irrigation and hydropower projects. Nepal needs latest remote sensing technology like Light Detection and Ranging (LIDAR) for effective implementation of water resources project. Automation has been achieved by various means including mechanical, hydraulic, pneumatic, electrical, electronic devices and computers, usually in combination which has significant importance in Nepal. Nepal Electricity Authority is planning to upgrade the system to support a power load up to 2,000 MW and for the expansion of grid, smart grid technology is necessary for hydropower sector of Nepal. The online payment services provide convenience to customers using water resource facilities such as electricity, water supply, and irrigation to pay their bills. Nepal requires some numbers of Tunnel Boring Machines (TBM) which is effective in loose soil tunnelling for developing water resource projects. Water supply system of Nepal should be improved with newly available technology. Nepal needs to build its own hydro equipment manufacturing company for that latest electro-mechanical technology is essential. The enhancement of hydrological forecasting is obtained with Hydrological telemetry terminal system which should be employed in water resource projects in Nepal. Ground water modelling software, appropriate ground water extraction, and recharge technology is necessary for optimized utilization of ground water in organized manner to improve the quality of life. Nepal has only few solid waste and sewage treatment plants. Nepal is exploring for better technology to obtain adequate management of solid waste and sewage.

6. Overview of Sino-Nepal co-operation in water projects
Nepal and China [16] initiated bilateral ties in April 28, 1960 after Sino-Nepal treaty of peace and friendship was inked, since then the relation between both countries have been amiable and cordial. Sino-Nepal friendship has been substantially enhanced day after day along with experience of the sincere brotherhood and conducive environment both respectful towards the sovereignty of one another, is an apparent evidence. In year 2015, the devastating Himalayan earthquakes [17] struck Nepal after which the massive humanitarian aid deployed promptly from Chinese side was an earnest effort, Nepal is always indebted to. In the same year few months later, unofficial blockade, imposed from India [18] to reveal the agitation against Nepalese new constitution, shook the land beneath
Nepalese people once again when it was trying to restore from consequences of earthquakes. Nepal was at the most vulnerable state however the various sort of support from China sustain Nepal to hold the grip and stabilize the situation. This economic and humanitarian crisis generating policy of India for Nepal deteriorated the Indo-Nepal relationship and surged Anti-India sentiments among vast majority of Nepalese. Afterward, Nepal tilted more toward China signing further bilateral agreements with Beijing to intensify the relationship. Nepal [19] signed a memorandum of understanding on cooperation under one belt one road initiatives on May 12, 2017. This has built an amiable platform for Kathmandu and Beijing to exchange resources and technology in days to come. Consequently, evolving China as the large source of Foreign Direct Investment (FDI) in Nepal leaving southern neighbour, India behind with great margin recently. Relatively open economy strategy of Nepal has rendered the wide range of opportunities for foreign investor specially China to raise their investment tremendously and topped the FDI chart [20] of Nepal in years 2015, 2016 and 2017, three consecutive years. This is one of the crucial outcomes of trustworthy and congenial friendship established between Nepal and China. Nepal’s policy is generally business friendly but still some room to improve to accelerate the scenario. Several investments from China arrived in Nepal with their involvement in many water resource projects contributing prime efforts to build development infrastructures. In this way, China’s involvement as a developer in several hydropower, irrigation, and water supply projects has invigorated the new space between Nepal and China to produce prosperous opportunities and pragmatic co-operation for today and tomorrow.

The successful completion of Upper Marshyangdi ‘A’ (50 MW) [21] and Upper Madi hydro power plant(25 MW) [22] without much delay by Chinese State-Owned companies, Sino Hydro Resources Limited and China International Water and Electric Co. in year 2016 and 2017 respectively explains the sincerity and capability of Chinese company that they are on their way to accompany Nepal to realize the spectacular hydraulic engineering projects, further ameliorate it’s the wilting economy. In the year 2018, then prime minister of Nepal, KP Sharma Oli officially visited China [23] which lead to signing of agreement between the government of Nepal and private companies of China to develop hydropower, cement factories and highland food parks in Nepal. Chongqing Water Turbine Works Co Ltd has bagged Khimti II hydropower project (48.8 MW) under Engineering Procurement, Construction and Financing (EPCF) modality with the investment of US$88 million which is expected to be completed by July 2021. Recently another Chinese company, Zhejiang Hydropower Construction and Installation Co. has awarded contracts of worth US$39.5 million which comprise civil structures, electro and hydro mechanical components to build Nyadi Hydropower project (30 MW). The same Chinese firm has obtained civil and hydro works contract worth US$51 million for Kabeli ‘A’ hydropower project (37.6 MW). Meanwhile Siddhakali Power Limited (Nepalese private company) and Dongfang Electric International Corporation (DEC International) has signed memorandum of understanding to build Trishuli Galchhi hydroelectric project (75 MW) under EPCF modality. EPCF modality is a new concept in Nepal which is favourable to both sides and can be novel solution for developing hydropower within stipulated time. Sino hydro corporation received the contract for hydro mechanical and electromechanical works for Tanahu hydropower project that is planned to start production in the next five years which is reservoir type plant located in central Nepal. Kulekhani III (14 MW) cascaded project, for which two Chinese companies are involved in its construction, Sino hydro responsible for civil work and Jhei Jian Jia Lin is supplying electromechanical and hydro mechanical work, will be completed by January 2019. The contract for civil and hydro mechanical work of Rasuwagadi hydropower project is taken by China International Water and Electric Corporation and the project is supposed to be completed in mid of 2019.

In the irrigation sector, Chinese investment is comparatively less than lucrative hydro power sector. The one of nation pride project named Bheri-Babai [24] diversion multipurpose project was put into construction to mitigate the water problem in Babai river which is draught in dry and floods in rainy season. This issue is solved with inter-basin water transfer project. China Overseas Engineering Group (COVEC), has commenced this project in June 2015 with total value of US$107 million and a construction period of 58 months. The length of tunnel 12.2 kilometres will be constructed to divert 40
cubic meter per second to irrigate about 51,000 hectares of farmland. The advantage of 152 metres difference in water levels between Bheri and Babai rivers are utilized to construct 48 MW hydro power plant as multi-purpose project. This inter basin water transfer project involves huge budget, manpower, and sophisticated technologies. The paperwork of this project has finished and construction work has already commenced in 2018. Bheri and Babai project is the first project in history of Nepal that has used tunnel boring machine to excavate tunnel through fragile rocks. Tunnel boring machine has diverse application in mountainous country like Nepal. After completion of the project, Nepal will achieve additional US$29 million irrigation income and US$42 million from power generation annually. The project progress is unprecedented, completed 70 percent of tunnel work within ten months of time period from commencement and on the way to set another example of success for Chinese companies in Nepalese water projects.

Unlike Hydropower and Irrigation, recently as seen in Nepal there is no investment in water supply project from Chinese investor. In 2008 February 19, China Railway 15 bureau Group corporation [25] and CMIIC Joint Venture (CRCC) received the contract to construct tunnel for Melamchi water supply project because of which many disputes between both parties, ultimately ended the contract without any achievements. Either, this may be the reason that dragged less interest of investor or hydro sector has overshadowed water supply sector. Also, government has acknowledged water supply as non-profitable sector.

Indeed, there are uncountable ups and downs as to realize any envisaged project is a complex process from commencement till the first operation. Sometimes sever disputes and difficulties put the projects in hold and if not resolved immediately with reasonable means, can end the co-operation leaving both parties in loss. However, the risk of certain percent is always there in every investment, in spite of the risk, there are several ways to solve the conflict and issues under mutual trust and understanding between involved parties.

7. Challenges in co-operation and solutions
Nepal has not been an easy piece of cake for any foreign investors to deal with and China is also not an exception which can be noticed from the track records of Chinese firms. The existence of various factors impeded the hydro economic cooperation between Nepal and China. Chinese investor has found many difficulties establishing congenial trade cooperation with Nepal. It is common to discover the failure of Chinese companies along the project implementation process after they are awarded the project in Nepal and resulted abandon of project in process from either side. Amid the unfavourable circumstances, attempt to build stable and strengthen co-operation through successful project completion has not ended the hope from Nepal and China. This hope is kept alive with success of couple of middle range project such as Modi and Marsangdi build in synergy. But, lack of diplomacy and understanding in major projects such as Budhi Gandaki and West Seti left both sides struggled without any advancement eventually terminating the contract from both sides. The unsuccessful narrative of Chinese companies for Melamchi water supply project in which contract for tunnel construction was awarded to China Railway 15 Bureau Group Corporation and CMIIC JV(CRCC). This Chinese firm fails to reach the required achievement level in the stipulated time according to Nepalese side and similarly, Chinese firm blamed Nepalese side for not providing amiable environment which up surged the disputes and later both parties abolishing contract completely without any remarkable achievement in the construction. Budhi Gandaki and West Seti projects are major hydro power projects of Nepal both are also included in National pride project list. The inadequacy of Nepal and China to get along in these major projects explains how the cooperation of Nepal and China has fallen apart in distrust and eventually strained the future cooperation.

Budhi Gandaki hydropower project (1,200 MW) [26] is located in Dhading and Gorkha districts is storage reservoir type plant with estimated project cost of US$2.6 billion (approximately Nepali Rupees 270 billion) which was expected to be completed in 8 years. The MoU was signed between Government of Nepal led by Puspa Kamal Dahal as the Prime Minister and China Gezhouba Group Corporation in June 2016 amid controversial outcry of public procurement act violation adding
another challenge after technical, economic and social aspects for this project implementation under Engineering, Procurement, Construction (EPC) model. The unstable political situation of Nepal turns down the Puspa Kamal Dahal led Maoist party government and brought Nepali Congress government led by Sushil Koirala into power. This government reasoned overlooking on public procurement act by prior government as faulty provision and made an unexpected decision against Gezhouba that scraped the project deal. Eventually, project saga languished in uncertainty.

Another setback for Chinese firm [27] was West Seti hydropower (750 MW) project formally handed over to China Three Gorges Corporation and envisaged to be developed under public private partnership. However, the MoU signed between Nepal Electricity Corporation and China Three Gores Corporation was ended with Chinese firm steeping back stating Financial non-viability as a significant issue. This back to back failure of two multi-billion projects indicates acute failure in governance of Nepalese side and lack of diplomacy with proper homework in advance from the other side. There is much to be done from both sides mainly focused on amendment policies and concretized framework. The fiasco of these project implies that there are many influential factors that has impeded the Nepal - China cooperation which are essentially needed to be acknowledged from both sides to prevent similar adverse consequences. It is also utmost necessary to figure out reasonable factors and causes, beforehand any blames from one to another, making superficial arguments without considering the damage that might be levied on both sides. So, the cooperation should be focused to achieve more benefits from the bilateral relationship. It should be interest of both China and Nepal to encourage dialogue opportunities on any dispute and issues involved in any collaboration of projects before it gets out of one’s hand.

Lately, the environment is a major concern for all countries around the globe. The construction of high dams for diversion and storage purpose for water resources project has serious environmental consequences. These built dams alter the chemical, physical and biological process of river ecosystem also trapped mineral rich nutrients. This is the major reason that makes many mega projects unfeasible. Before commencement of any project, it is utmost necessary to conduct Environment Impact Assessment (EIA) to study the implication of project on environment. There are many projects in Nepal got stalled in its initial phase considering the EIA reports. Nevertheless, any project implementation should not breach the International Environmental Protection Code of Conduct otherwise devastating event is inevitable which can be costly to humanity. However, the development progress should not be totally ceased so, a new framework of sustainable development based on balance and compensation of negative effect due to development in accordance to environmental constraints with least adverse impact of project on the ecology is necessary. The meticulous decision making from both Nepal and China is necessary to ensure the sustainable development without any compromise.

Last but not least, also equally important is, influence of India in Nepal is very intense. Nepal will always seek for the safest ground in between, neither completely aligned with China nor India and restrain the polarization. Polarization of Nepal is destructive for itself and vulnerable for its neighbouring countries in every aspect but instead Nepal as bridge between two huge countries is a better concept. Not Landlocked but Land that Links can establish development of Nepal and prosperous economy without any doubt, side by side Nepal to participate and contribute its eminent role to both China and India in their further growth impartially to be future super powers. These Nepal-China, Nepal-India or China-India bilateral relationship should be aggregated and extended in trilateral relationship among China-Nepal-India as a whole. Nepal is adhered with the policy of neutrality and nonalignment. In present context, it is very essential to commence trilateral cooperation to harvest more mutual benefit than ever.

Nor is the cooperation perfect, no cooperation ever is. Regardless of several hurdles, the bilateral ties between Nepal and China is growing in full fledge. Re-negotiation has kicked off for Buddha Gandaki hydel project [28] from Nepalese side recently and hope for China coping with circumstances is still alive to break the stalemate of the project through dialogue. China is also interested to invest in many projects with new approach, necessary homework, and favourable strategy. It can be seen in
recent interest of Sichuan ANH hydraulic and hydro-electric engineering company limited, subside company of Shang Dong Water development groups as this group sent a letter to Nepal Investment Board describing their willingness to seize the Tamor Hydropower project (762 MW). Actually, this project is half cheaper than Budhi Gandaki so can be taken as a sensible step promoted by Chinese side. Nepal on the other side is working on to render a conducive ambience for investor with concrete policies and framework. The lesson learned from above unsuccessful projects should be carefully contemplated and implemented in days to come.

8. Scope for Sino-Nepal co-operation in water sector

Although, Nepal is a landlocked country however its opportunities are not bounded in any way at all along side with prosperous water resources. Nepal shares its border with only two countries India at the eastern, western and southern side, and China at the Northern side. Nepal does not have any access to the sea that imposed Himalayan country to import technology and equipment by land way via only these two countries. Even though Nepal has a good diplomatic relationship with India in past but recently there were some disputes after promulgation of Nepalese new constitution whereas after memorandum of understanding for Belt and Road initiatives between Nepal and China was signed, the ties of Nepal with China have grown deepen and reached to the same level as that of India in the past. Nepal is also firmly committed to ‘One China Policy’ and never allows its soil to be used for any inimical activities against China. Nepal-China relations have always remained friendly and cordial from many decades ago.

Nepal is rich in water resources but lack in advance technology and budget have constricted the way of water resource development projects. Currently, Nepal cannot afford mega hydro projects without relying on foreign nations, so the government of Nepal has warmly welcomed foreign nations for investment and sharing their technology. China being Nepal’s one of the closest neighbouring country, should take opportunity on its favour which is prudential approach for both countries. Many major water resource projects are under survey and under construction, most of them are hydropower projects. Also, currently operating projects are required to be upgraded with new technology. China has advanced technology and vast experience in the field of hydropower. China can utilize it to assist Nepal to exploit water resources. Addition to this, excess electricity is targeted to transmitted to India and via India to another energy hungry nation, Bangladesh. In this way, China can take indirect advantage of South Asian market by investing and allocation of technologies to projects in Nepal.

Besides, South Asian Association for Regional Co-operation (SAARC) and The Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC) [29] are working to increase the cooperation to build transboundary gird for Cross Border Electricity (CBG), energy transfer amid partner nations. India is a largest power system in South Asian countries who’s bullying to show its dominance over this region is evident in CBG which has somehow deterred the scheme progress, however, the momentum has been gained after the Third BIMSTEC Energy Minister Meeting 2018 in Nepal. Nepal-India transboundary gird known as Dhalkebar-Muzaffarpur [30] cross-border transmission line is erected and has already started operating enabling Nepal to import electricity during its deficit and export during its surplus seasons. Currently, this cross-border gird line is envisaged to increase its capacity and under expansion. In addition, Nepal and Bangladesh signed power co-operation agreement to build regional level power gird connectivity, also surprisingly succeeded to convince India be on board by both countries because use of Indian territory is necessary to regulate electricity trade. In fact, Bangladesh is an energy affinity nation with handsome electricity price rate compare to Nepal, China, and India. Bangladesh has strategy to purchase 9,000 megawatts electricity from Nepal until 2040. Bangladesh signed agreement with India’s NTPC Vidyut Vyapar Nigam (NVVN) [31] to buy 300 MW to 400 MW electricity from Upper Karnali hydropower project going to be built with Indian investment in Nepal. The generated electricity will be transmitted from Nepal to Bangladesh through Indian territory. The plan for cross border transmission among these three countries is shown in table 1.

10
Table 1. Possible future cross border transmission amid Nepal India and Bangladesh [29].

| By Year  | Nepal-India (MW) | India -Bangladesh (MW) |
|----------|------------------|------------------------|
| 2021-22  | 200              | 500                    |
| 2026-32  | 6100             | 1500                   |
| 2031-32  | 12500            | 2000                   |
| 2035-36  | 15800            | 2000                   |

This shows the huge amount of electricity energy will be generated and transferred within these three countries. In the present context, these countries need adequate investment and advance technologies to realize the cross-border transmission projects in near future.

On the northern frontier, China has already established a high voltage transmission line up to Shigaste and showed keen interest to extend it to Kerung of Nepal with the adequate commitment and agreement from Nepalese government. In early 2017, State Grid Corporation of China, (SGCC) officially visited Nepal to hold table talks with the Ministry of Energy, Water Resources and Irrigation and the Nepal Electricity Authority to set up transmission line linking Rasuwagadi and Kerung. For the construction of first trans-himalayan electricity line between Nepal and China [32] both sides are seeking for eligible consultant to prepare detailed project report as for now and later the scheme is expected to gain momentum. This transmission line is also vital for providing electricity to Chinese railway service which is incorporated in belt and road initiative and planned to linked up to capital city of Nepal, Kathmandu. Also, China appetite for electricity around dry area near border with transmission line from Nepal can be fulfilled economically.

These circumstances make hydropower projects of Nepal financially viable and fruitful to investor minimizing the risk of return. Meanwhile, concerning the risk due to currency exchange rate fluctuation in any infrastructure project constructed deploying foreign direct investment, the government of Nepal has established hedging fund [33] services with appropriate guidelines. The risk management scheme deployed to undermine the negative consequences of asset price fluctuation is known as Hedging Fund Service. Hedging fund compensates any liabilities produced to any party, either investor or government because of exchange rate fluctuation with insurance like system. This fund mitigates any exchange rate risk while making the remuneration in American dollar (US$) establishing the minimum vulnerable situation for both parties. This is the most important step taken by Nepalese government to deepen the ties with China through passage of investment.

Moreover, the promulgation of a new constitution and elected government with majority seat had dawned the stable era in Nepal with favourable climate for investment and technology deployment. Kathmandu and Beijing should work together to achieve better tangible targets in the field of water resources, benefiting both.

9. Conclusion

Undoubtedly, water resource is the primary wealth of Nepal. Nepal has substantial potential of inland water resources. The economic growth of Nepal depends on mobilization and progress of water resource projects. There is no other means to improve Nepal’s wilting economy, as for now except mobilization of its water resources. On the other hand, lack of advanced technology, Nepal is unable to tap those resources for nation benefit. In the present situation, Nepal, cannot do it on its own without getting assistance from neighbouring country, China. China has many opportunities in Nepalese water sector. China can be source of technology in development of Nepalese water resources as it is meriting both nations for future prospect as well. In a nutshell development of water resource projects in Nepal has win-win reciprocity for Nepal and China under the common umbrella of Sino-Nepal co-operation.

In addition, training, seminar, academic exchange and workshop is equally necessary for effective implementation of policies and new technology in water resources development. There are few workshops held every year in Nepal in the water resources sector. Nepal warmly welcomes such training and workshop programs from foreign countries which is cultivating its water resources.
technical manpower. This aspect can also be promoted through Sino-Nepal co-operation.

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References
[1] Central Intelligence Agency 2018 The World Fact Book (Nepal) accessed on November 7 available at: https://www.cia.gov/library/publications/resources/the-world-factbook/geos/np.html
[2] Central Intelligence Agency 2018 The World Fact Book (China) accessed on November 7 available at: https://www.cia.gov/library/publications/resources/the-world-factbook/geos/ch.html
[3] Pradhan G 1998 Exploiting Nepal’s hydropower potential: Some prospects Asian Persp. 22 171-85
[4] Dahal A R 2013 Impact of irrigation in the command area of Bagmati irrigation project Econ. J. Dev. 15 1-14
[5] WHO and Government of Nepal Department of Water Supply and Sewerage 2005 National drinking water quality standards 2005 Implementation Directives for National Drinking Water Quality Standards
[6] Government of Nepal National Planning Commission Secretariat Centeral Beuere of Statistics (CBS) 2017 Statistical Year Book of Nepal
[7] Shrestha N B 2012 Rivers of Nepal Border Nepal available at: https://bordernepal.wordpress.com/tag/mahakali/
[8] Government of Nepal National Planning Commision 2073 Fourteenth Plan (FY 2017-2019) (2073/74-2075/76)
[9] Asian Development Bank (ADB) 2013 Country Partnership Strategy: Nepal 2013-2017 Country Environment Note Nepal pp 1-9
[10] Nepal Electricity Authority (NEA) 2018 Annual report 2017
[11] Government of Nepal Ministry of Irrigation 2015 Annual Irrigation Book 2015
[12] Mandal C K 2018 Melamchi water will be delayed The Kathmandu Post available at: http://kathmandupost.ekantipur.com/news/2018-08-25/melamchi-water-will-be-delayed.html
[13] The World Bank Group 2017 Nepal second rural water supply and sanitation project: Project performance assessment report Report No. 114286 Loan/Credit No. C3911; CH369 Jun 16 2017
[14] Prajapati R N 2015 Delineation of runoff river hydropower potential of Karnali basin-Nepal using GIS and HEC-HMS Eur. J. Adv. Eng. Technol. 2 50-4
[15] Howarth S E and Lal N K 2002 Irrigation and participation: Rehabilitation of the rajpur project in Nepal Irrig. Drain. Syst. 16 111-38
[16] Wikipedia available at: https://en.wikipedia.org/wiki/China%E2%80%93Nepal_relations
[17] Murton G 2016 A Himalayan border trilogy: The political economics of transport infrastructure and disaster Relief between China and Nepal Cros. -Cur.: Eas. Asia. Hist. Cult. Rev. 18 96-108
[18] Ramachandran S 2015 Sino-Nepalese relations: Handshake across the Himalayan China Brief XV 15-20
[19] Shrestha M B Cooperation on finance between China and Nepal: Belt and road initiatives and investment opportunities in Nepal J. Finan. Dat. Sci. 3 31-7
[20] Cheng C 2018 Chinese tops FDI pledges to Nepal three years in a row Xinhuanet available at: http://www.xinhuanet.com/english/2018-08/01/c_137360898.htm
[21] Hua X 2016 China invested plant goes into service in Nepal Xinhuanet available at: http://www.xinhuanet.com/english/2016-09/27/c_135717229.htm published on Sept 09
[22] Pondexter G B 2017 25-Mw upper Madi hydropower project begins generation in Nepal Hydro world 01 available at: https://www.hydroworld.com/articles/2017/01/25-mw-upper-madi-hydropower-project-begins-generation-in-nepal.html

[23] PTI 2018 KP Oli China visit: Beijing, Nepal ink 8 pacts in major infrastructure projects Financial Express available at: https://www.financialexpress.com/world-news/kp-oli-china-visit-nepal-beijing-sign-8-deals-worth-2-24-billion/1213051/1

[24] Post Report 2018 Bheri-babai diversion tunnel: Project completes 70 percent works The Kathmandu Post available at: http://kathmandupost.ekantipur.com/news/2018-10-14/project-completes-70-percent-works.html

[25] Post Report 2012 Melamchi water supply project The Kathmandu Post available at: http://kathmandupost.ekantipur.com/printedinition/news/2012-10-31/melamchi-water-supply-project.html

[26] PTI 2017 Nepal signs mega hydro project deal with Chinese firm The Hindu available at: https://www.thehindu.com/news/international/nepal-signs-mega-hydro-project-deal-with-chinese-firm/article18721870.ece

[27] Post Report 2018 The west seti fiasco The Kathmandu Post available at: https://kathmandupost.ekantipur.com/news/2018-09-21/the-west-seti-fiasco.html

[28] Poindexter G B 2018 Nepal prime minister to “revive” 1,200-Mw Budhi Gandaki project Hydro World available at: https://www.hydroworld.com/articles/2018/02/nepal-prime-minister-to-revive-1-200-mw-budhi-gandaki-project.html

[29] Kharbanda V K and Panda R R 2018 Regional energy cooperation for accelerating cross border electricity trade & investment Urja Khabar available at: http://www.english.urjakhabar.com/regional-energy-cooperation-for-accelerating-cross-border-electricity-trade-investment-in-south-asia/

[30] Pangeni R 2017 Dhalkebar-muzaffarpur transmission line to come into use from May My Republica available at: https://myrepublica.nagariknetwork.com/news/dhalkebar-muzaffarpur-transmission-line-to-be-charged-in-220-kva-by-may/

[31] RSS 2018 Bangladesh to purchase power from upper Karnali hydropower project My Republica available at: https://myrepublica.nagariknetwork.com/news/bangladesh-to-purchase-power-from-upper-karnali-hydropower-project/

[32] RSS 2018 China visit successful: PM Oli The Himalayan Times available at: https://thehimalayantimes.com/kathmandu/china-visit-successful-pm-oli/

[33] Subedi B 2018 NRB initiates ‘hedging’ fund exercise The Kathmandu Post available at: http://kathmandupost.ekantipur.com/news/2018-05-20/nrb-initiates-hedging-fund-exercise.html