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Geothermal Energy Update of Nepal

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ABSTRACT

Thirteen new hot springs have been identified in different parts of Nepal in the update period. Of these, 7 lies in Myadgi district alone, 3 in Dhading district, one each in Dolpa, Humla and Gorkha districts. The new locations in Myagdi district of Western Nepal are: Dhirchyang (Ratopani), Nyarchang Tatopani (Shikha Village Development Committee, VDC), Dagnam, , Dowa, Darbang, Histan and Mudi Tatopani. Those found in Dhading District are Jharlang (Ruby Valley), Hindung Tatopani and TiplingTatopani. In Gorkha district, one hot springs has been identified at Machha Khola.

Geothermal energy still remained the lowest priority renewable energy resource in the update period. However, much work has progressed at local and private level for its direct use, mainly for balneotherapy and tourism development. Infrastructure is extending satisfactorily in a number of existing thermal locations where people use it mainly for bathing. Many positive factors have evolved indirectly for its development through the government. Construction of roads in the remote areas has progressed rapidly linking more geothermal locations. Tourism, which has been a backbone for the development and use of hot springs, has flourished. Effective programs for internal and external tourism are in place. These developments have led to the extensive use of the existing hot springs and possibility for scientific exploration. A number of organizations have started to participate in the infrastructure development of geothermal locations, particularly at Singa Tatopani, by community and the local military unit. Local promotion committees funded by Nepalese diaspora are also taking part in the campaign. The existing spring areas have been made user- friendly for the disabled people and created extended facilities for women as well.

INTRODUCTION

Rich in spectacular scenery, Nepal is a quiet cousin of neighboring powerhouses China on the north and India on the east, west and south. Nepal witnessed a major political change in this update period with the promulgation of new constitution in late 2015 which opened the door for legislative election. Accordingly, all the three elections to the Federal, Provincial and Local government have been conducted in 2017. A majority government is in place breaking a 16 years long political instability. While the development plans in all sectors used to be controlled by the central government until 2018, it is now decentralized to provincial and local level. It will have definite impact on the development of renewable energy including geothermal. This decentralized effort is particularly important since a majority of thermal springs are located in the remote mountainous and hilly areas where the central government had no interest and knowledge about direct use of geothermal energy.

2. GOVERNMENT SETTING

Nepal has two tier of government to look after energy development. At the Federal level, the Ministry of Energy, Water Resources and Irrigation is responsible for managing traditional, commercial and renewable energy. At the Provincial level, all the 7 provinces have their ministries to look after energy sector. Since the transfer of power from Federal to Provincial level is still in transition and taking place very slowly, the executive jurisdiction of provincial government is yet to be seen.

2.1 Lead Agencies Involved in Geothermal Energy

Alternate Energy Promotion Centre (AEPC), established in 1996, is the only institution under the government focused on developing and promoting renewable/alternative energy technologies in Nepal. It also acts as the focal point for renewable energy development in Nepal. Currently under the Ministry of Energy, Water Resources and Irrigation, it functions independently and has an eleven member board with representatives from the government sector, industry sector and non-governmental organizations.

It aims to promote large-scale use of renewable energy, currently focusing on solar PV technology, solar thermal energy, biomass, wind energy, biofuel, biomass and mini/micro hydro technology. With the support of this institution, the Government of Nepal has enacted Rural Energy (RE) Policy 2006, Renewable Energy (RE) Subsidy Policy 2016 and Renewable Energy Subsidy Delivery Mechanism 2016, to contribute to the national objectives of access to clean and sustainable energy. The enabling measures, such as targeted grants (subsidies) and exemption of renewable energy projects from certain licensing requirements have been set up. With the implementation of the new Constitution, provincial and local governments are now empowered to design policies and support-programs, and deliver public goods and services in regard to decentralized RE. In this context, AEPC is transitioning from an implementing agency that provides services like subsidies directly, to a support agency that enables provincial and local governments to promote and implement RE technologies. It is thinking to embrace plans and programs for geothermal energy as well. .Hopefully, in the next update period, some concrete actions will be in place.

Some organizations like Research Centre for Applied Science and Technology (Tribhuvan University), Department of Mines and Geology (Ministry of Industry), Nepal Academy of Science and Technology are potential ones to conduct geothermal activities in

Nepal. However, these agencies are not active for the lack of financial resources, manpower and the lack of knowledge about the direct uses of geothermal energy.

3. GEOLOGY BACKGROUND

Nepal can be divided into five distinct morpho-geotectonic zones from south to the north (Fig. 1). The southernmost fault, the Main Frontal Thrust (MFT) separates the Sub-Himalayan (Siwalik) from Gangetic Plains. The Main Boundary Thrust (MBT) separates the Lesser Himalayan Zone from Siwalik whereas the Main Central Thrust (MCT) separates the Higher Himalayan Zone from the Lesser Himalayan Zone.

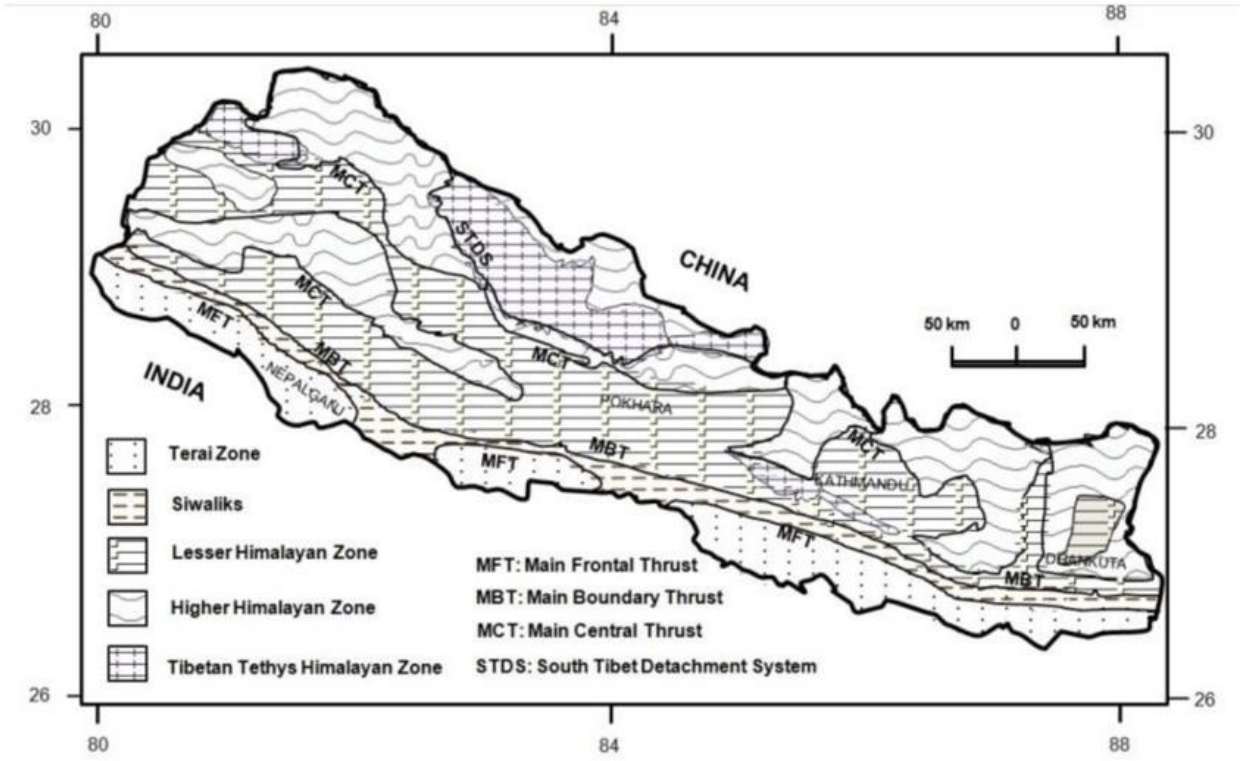


Figure 1: Geological map of Nepal

i. Gangetic Plain (Terai Zone): Considered as a bread basket, the Terai is a rich and fertile land in the southern part of Nepal. It is the Nepalese extension of the Indo-Gangetic Plains. The plain is less than 200 meters above sea level. This zone forms a nearly continuous belt from east to west. To the north, this zone is separated by an active thrust system called as the Main Frontal Thrust (MFT) with Siwalik. Northern Terai (Bhabar Zone) acts as a recharge zone for the groundwater of Terai. Middle Terai Zone is a narrow zone of about 10-12 km wide. Southern Terai Zone is the southernmost part of Terai up to Nepal-India border and also continues into India. This zone consists of main sediments of Gangetic Plain.

ii. Sub-Himalayan (Siwalik) Zone: This zone is delimited on the south by the Main Frontal Thrust (MFT) and on the north by the Main Boundary Thrust (MBT). It extends all along the Himalaya forming the southernmost hill range with width of 8 to 50 km. The Lesser Himalayan rocks thrust southward over the rocks of Siwalik along the MBT.

iii. Lesser Himalayan Zone (Mahabharat Range and Valleys): This zone is bounded to the north by the Main Central Thrust (MCT) and to the south by Main Boundary Thrust (MBT). MBT can be traced out in the entire Nepal Himalaya. From east to west, the Lesser Himalayan Zone of Nepal varies in rock type, age, structures, and igneous rock intrusion.

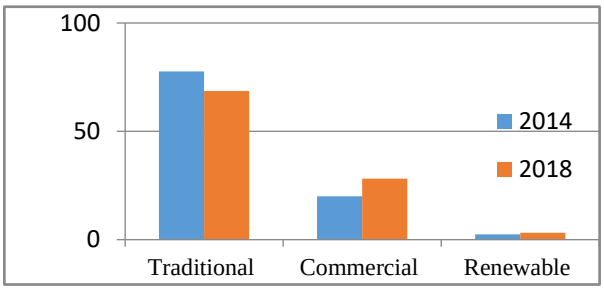
iv. The Higher Himalayan Zone: This Zone mainly consists of huge pile of strongly metamorphosed rocks. It includes the rocks lying north of the Main Central Thrust (MCT) and below the highly fossiliferous Tibetan-Tethys Zone. It consists of an approximately 10 km thick succession of strongly metamorphosed coarse grained rocks extending continuously along the entire length of the country. Granites are found in the upper part of the unit.

v. Inner Himalayas (Tibetan-Tethys) Zone: The Zone begins from the top of the South Tibetan Detachment System and extends to the north in Tibet. Most of the Great Himalayan peaks of Nepal such as Manaslu, Annapurna, and Dhaulagiri have rocks of Tibetan-Tethys Zone.

RENEWABLE ENERGY IN NEPAL

The traditional sources of energy continue to dominate energy demand and consumption in Nepal. Despite high potential for generating energy through abundant water resource and potential wealth in solar energy, production and use of these energy resources has not kept pace with development and population growth. In 2018, the proportion of traditional, commercial and renewable energy

consumption in the total energy consumption was 68.56 percent, 28.22 percent and 3.23 percent respectively. The figure for 2014 stood at 77.6 percent, 19.99 percent and 2.5 percent respectively. Traditional energy source include firewood, agricultural residue and animal residue. Commercial source of energy include coal, petroleum product and electricity. Evidently, there is a reduction of traditional energy consumption and increase in commercial energy. In the case of renewable energy, its share has slightly increased to 3.23 percent.



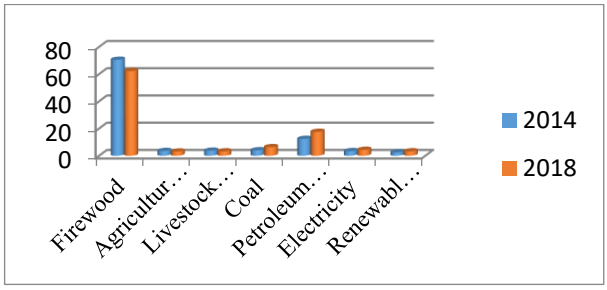


Figure 2: Renewable energy use (Economic Survey, 2019)

Figure 3: Renewable energy use breakdown

In the energy sector, hydroelectricity continues to assume highest priority. Nepal is making significant progress in harnessing hydropower potential since there is a large flow of international, national government fund along with private participation.

By mid-March 2019, 1142 MW of electricity was generated compared to 847.68 MW in 2015. Out of the total electricity production in 2018, 1029.58 MW came from hydro power, 53.4 MW from thermal plant, 27 MW from solar plant and 32 MW from mini and small hydro plants. More hydropower projects are near completion and a number of such mini and macro level projects are underway. The country expects to harness additional 710 MW by 2023. This may not seem huge exploitation but for a small country like Nepal, it has significant impact. While the country was struggling to meet domestic electricity demand until 2018, it is encouraging people to consume as much electricity as possible by replacing gas for domestic use. Electric vehicles for public transport are being operated increasingly. In view of the abundant potential and government's plan to harness hydroelectricity, Nepal is poised to export it to neighboring countries within a few years.

Use of solar energy is gaining momentum in different parts of the country with the support of Asian Development Bank and some other countries. The continuing fall in the price of photovoltaic solar can result in rapid change. During this period, 16,572 solar power plants, 10,018 improved stove and 203 improved water mills have been installed.

5. GEOTHERMAL ENERGY IN NEPAL

Figure 3 depicts the districts where thermal springs are located. Out of 77 districts of Nepal, 17 districts have geothermal potential. Table 1 shows their location in each district. Table 2 is focused mainly for Myagdi district where a number of new geothermal areas have been identified.

Fig. 4: Location of hot springs in Nepal

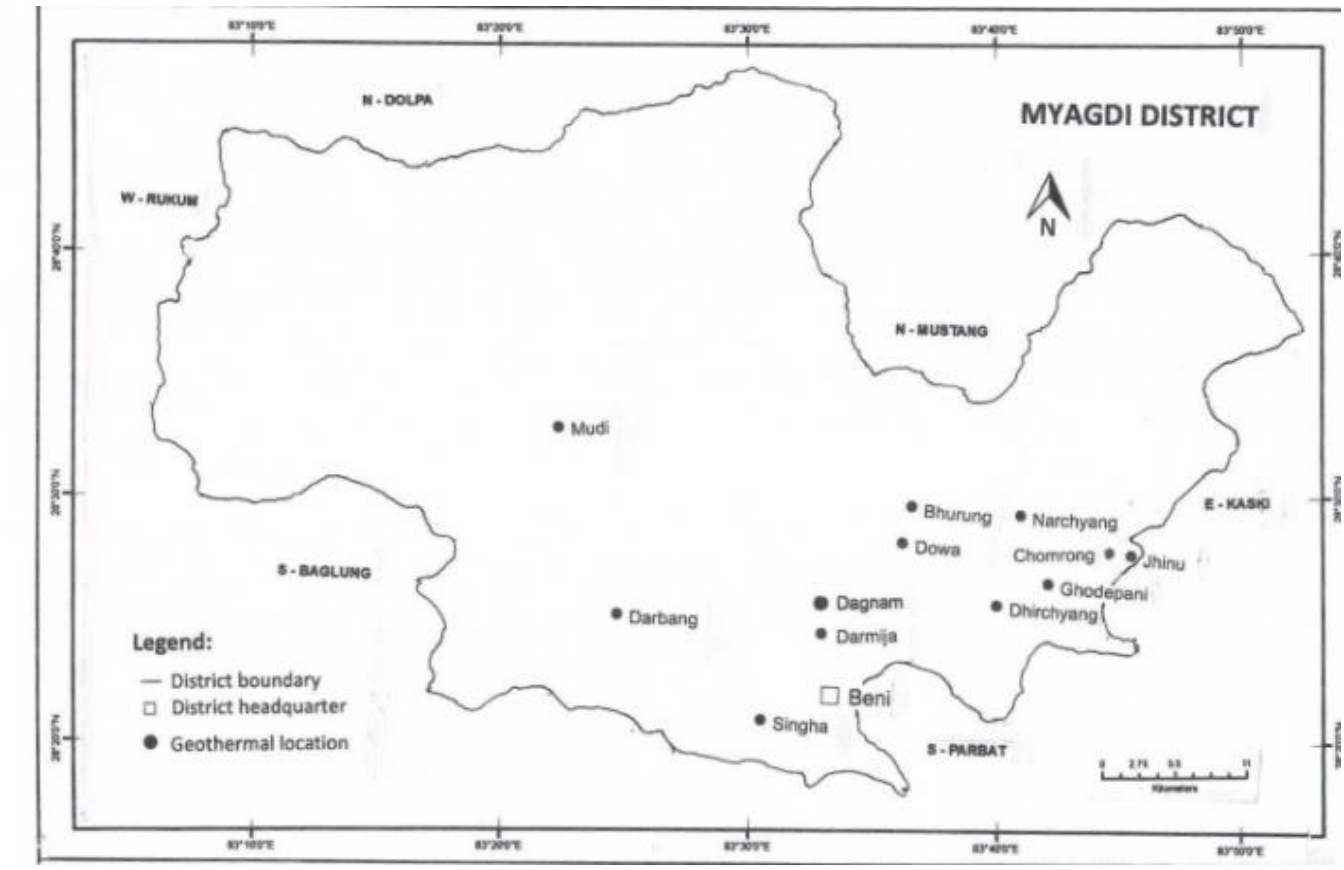


Fig 5: Location of thermal springs in Myagdi district

Table 1: General information about localities and temperature

Locality	Flow Rate (l/s)	Surface temp ° C	Discharge Enthalpy (kJ/Kg)
Darchula district			
Sribagar	0.9	73	380
Sina Tatopani	0.8	30	225
Chamaliya	0.3	30	158
Bajhang district			
Tapoban	0.3	31	126
Jumla district			
Dhanchauri–Luma	0.8	24	448
Tilanadi	1.3	42	464
Dang district			
Riar	1.5	33	227
Rupandehi district			
Surai Khola	1.7	36	210
Mustang district			
Muktinath	3	22	211
Jomsom	0.07	16.5	380
Dhima	n.a.	n.a	n.a
Sadhu Khola	1.39	69	460
Kaski district			
Jamile	0.05	30.6	n.a.

Kharpani	0.4	49	n.a.
Machhapuchhre base camp	2.2	64	1020
Mayangdi	2	40	376
Down Batase	0.1	44.3	420
Up Batase	0.2	21.5	n.a.
Tanahun district			
Bhulbhulekhar	1.2	34	n.a.
Rasuwa district			
Chilime	0.9	48	386
Syabri Besi	0.4	34	365
Pargang	3.8	49	390
Dhading District			
Hindung	1.5	29	n.a.
Jharlang	2.2	53	n.a.
Tipling	1.2	32	n.a.
Sindhupalchowk district			
Kodari	5.5	42	17
Sankhuwasabha district			
Hatiya	n.a.	n.a.	n.a.

Table 2 lists the hot springs located in Myagdi districts with the latitude and longitude of the village development committees they belong to.

Table 2: Geothermal information about Myagdi district

Locality	Latitude (E)	Longitude (N)	Flow rate (l/s)	Surface temp ° C	Discharge enthalpy (kJ/Kg)
Myagdi district					
Bhurung (Dana)	28° 29'	83° 36'	1.8	71	484
Chhomrong	28° 37.7'	83° 80.7'	0.9	48	n.a.
Dagnam	28° 44'	83° 54'	n.a.	n.a.	n.a.
Darbang	28° 42'	83° 41'	n.a.	n.a.	n.a.
Darmija	28° 25'	83° 33'	n.a.	n.a.	n.a.
Dhirchyang (Ghara VDC)	28° 45.7'	83° 65.6'	n.a.	n.a.	n.a.
Dowa (Bega)	28° 47'	83° 61'	n.a.	n.a.	n.a.
Ghodepani	28 29.335’	83° 39.5’	n.a.	n.a.	n.a.
Histan	28° 42'	83° 63'	n.a.	n.a.	n.a.
Mudi	28° 66'	83° 38'	n.a.	n.a.	n.a.
Narchyang (Shikha VDC)	28° 58'	83° 74	n.a.	n.a.	n.a.
Singa Tatopani	28° 36'	83° 52'	6	54	452

n.a. not available

The situation of a few important thermal springs including the newly reported ones in the update period are described below.

5.1 Myagdi district hot springs

Myagdi district is gifted with quite a few soaks. Located west from the district capital of Beni, Singa Tatopani is the most popular and used hot spring of Nepal even though for most people the Kodari hot spring is equally known due to its location closer to Kathmandu, the capital city. These are the “must-visit **hot springs in Nepal”**. The Singa Tatopani, located at 2,743 m.a.s.l. is about 390 km west of Kathmandu and 150 km from Pokhara. The spring pool has a of dimension 11.0 m X 5.8 m X 0.62 m and can hold up to 100 people at a time. More than 60,000 people from various parts of the country visit this spring every year mainly to cure for rheumatic and gastric diseases.

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On the way to Dhaulagiri Base Camp, this spring area is often overlooked by foreigners but Nepali patients have been coming here for centuries believing in the healing property of the spring. With the popularization of this spring by national TV and leading daily newspapers, this spring has become the most popular one. Like other spring areas in the hilly region, this location also suffered the crackdown of the walls from the massive earthquake in 2015 which led to upgrade the structures with new facilities. Following the earthquake, two more sources of thermal water have appeared along the Tatopani market on the bank of Myagdi river. The source temperature is a bit lower than that of Singa spring which issues 52°C water. Physical infrastructure has been added after 2015 to accommodate and provide facility to increased number of visitors from distant place. The Myagdi Relief Committee, the Nepali diaspora based in Bahrain, is also contributing financial support to the development of the thermal area. With nominal entrance fee it collects from the visitors, the management committee has been able to add user-friendly structures to old and disabled people with wheel chair accessibility to the pond, separate rest rooms and dress change rooms for male and female. Local military unit has added one building as well. Income from the spring is used to operate the local secondary school with over 300 students. The location serves about 20,000 people for bath and treatment. (https://www.youtube.com/watch?v=1u25pQhITkQ)

There has been a rapid growth of local hotels, restaurants and lodges in and around thermal area supporting local business. Local people have been employed by the Committee to operate the pool. The old temple has been replaced by the new one where people pray for Hindu Goddess and sacrifice animals to cure for diseases.

Popularity of this spring has developed to the extent that the high political leaders have visited last year to treat the family member through balneotherapy. This has drawn government attention towards the importance of hot springs. The management committee plans to build another pond and bath rooms in the vicinity to manage the overcrowd visitors in the peak season. The Singa Tatopani Management Committee has also established a Singa Tatopani Natural Therapy Centre where people get information about what diseases are treated by taking bath in the pool, the limitations for patients with tuberculosis and high blood pressure, the need to use a mandatory mask to avoid contamination of respiratory diseases etc.

With increased flow of information and popularization of other hot spring areas through newspapers and 'YouTube', more competition is taking place in the adjoining and distant spring areas for their increased utilization and better management of geothermal water. For instance, in Darmija hot spring of Myagdi district is improving the shelter constructed recently which accommodates more than 200 visitors. While the government is expanding the tourist destination areas, the committee vows to develop the thermal pond to be included in the list. The local village development committee has protected the pond from the river by repairing the existing wall which is damaged by the 2015 earthquake.

Bhurung thermal spring, also known as Dana Tatopani, is another area which lies in the Annapurna trekking route. It has surface temperature as high as 60°C. A pond measuring 35' ×25' offers unique opportunity for the tourist to relax their body on their trekking in the Annapurna Circuit. Two small ponds are also constructed in the area.

Photo 1: People entering pool at Singa Tatopani

Photo 2: Bhurung Tatopani

Photo 3: Kodari Tatopani

Photo 4: Kharpani, Kaski district

Chhomrung lies at a height of 2,170 m in the center of Ghandruk Village Development Committee. To the north of Chhomrong lies the Annapurna mountain, to the east the Machhapuchhre while the Modi Khola flows at the base of the village which makes the surroundings truly heavenly. No geothermal data is available for this site.

Ghorepani Tatopani, located in the famous Annapurna trekking circuit in the Western Nepal, is one of the area which has benefitted much through tourist visit. Despite the increased flow of tourist, physical infrastructure in the thermal spring has not developed in this area.

The Narchyang thermal spring (also called Paudwar tatopani) lies in the Sikha village development committee below Nilgiri Himal. Surface water at 52°C temperature gushes out with flow rate of 4.1 litres/sec. Local people have constructed a pond of 35' ×25' which is used mostly by local people because of its location off the trekking route and the poor infrastructure.

Dhirchyang (also called Ratopani) thermal spring lies on the other side of Narchyang separated by the river. The pond is at the extension phase and is visited by the local people and from Dowa.

The Dowa (also called Bega) Tatopani has surface temperature of 28° C with a minimum flow rate 2.5 l/s.

Dagnam hot spring lies 3-4 hours' drive west of Beni, the headquarter of Myagdi district, past Darmija thermal spring.

Dhadkharka hot spring of Myadgi district is visited by local people and little is known about this spring.

5.2 Dhading district hot springs

In the area to the northwest of Kathmandu, south of the Ganesh Himal and Manaslu, a few less well-known hot springs can be found in Dhading district. Jharlang hot spring which is a day and a half walk from Dhading Besi is located below the Jharlang village development committee, at the confluence of Dundure river and Ankhu river. It is within 28° 10' latitude North and 83° 07' East. Apart from the water at surface temperature 53° C, some gas can also be noted emerging from the surface. The location is within Ruby valley.

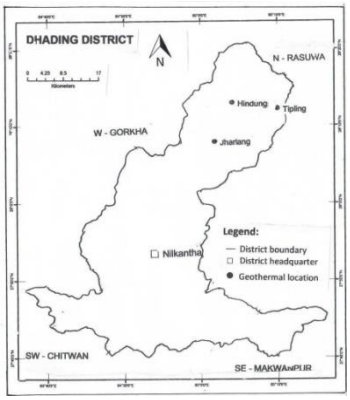

Fig. 6: Thermal springs in Dhading district

Photo 5: Sardi Khola, Kaski district

Lying between 28° 20' latitude North and 83° 16' East, .Tipling (also called Chalise) hot spring is located one and a half hours walk from Chalise village. Three naturally hot spring ponds have been constructed. Only local people visit these springs as it is neither in the trekking route nor is easily accessible by vehicle. Another hot spring known as Hindung is located between 28° 13' latitude North and 83° 05' East below Napier village between Lapa and Sertung village development committees.

5.3 Gorkha, Dolpa, Humla and Sankhuwasabha hot springs

In Gorkha district, two hot springs has been identified at Machha Khola village (at 3,300ft), half an hour from Khola Besi, along Budhi Gandaki river.

Kermi Hot Springs in Humla district are more of a river than anything else. Steaming water courses down the mountainside, slowing slightly in small pools built by the locals, and leaving a vivid coloring on all rock it touches.

Dolpa district has one hot spring called Shahartara. Little is known about it.

One of the most popular thermal area of Nepal is the Kodari Tatopani located on the bank of Bhotekoshi River at Kodari in Sindhupalchowk district near the border between Nepal and China. It is about 114 km away from Kathmandu valley. It stands at latitude of 27.9°N and longitude of 83.9°E. Thousands of people from Kathmandu and surrounding area visit this place for bath and recreation. Kodari Tatopani premises include a common area which has a shower. Recently, a low concrete partition is made for male and female with a roof cover as well. The showers are in the shape of a colorful lion head sprouting the water between their teeth. Apart from the basic shower, the hot spring also houses a swimming pool populated by little children who take turns to do back flips into the murky waters, soaking in bathtubs, or a relaxing recline in the sauna rooms. The entire market area around the thermal spring faced massive devastation from the April 2015 earthquake including areas in the north. As a result, the trade route to China had to be closed for 3 years. Recent opening has created hope for the use the spring water again.

6. PROBLEMS AND PROSPECTS OF GEOTHERMAL ENERGY IN NEPAL

6.1 Problems

Compared to many other nations with low temperature field, the exploitation of geothermal energy in Nepal still remains minimal. The main problems facing the country have not changed over the past five years. Nepal has not initiated any drilling activity for its use or exploratory purpose. No investment has been made in the research and development (R&D) activities. Investment is limited to improving and extending physical facilities at the geothermal pools funded by local people and development committees. Limited number of manpower who was trained in the geothermal area is outdated and no effort seems to be taken to train new manpower. Some students at the Institute of Engineering, Tribhuvan University, are attempting on the design, fabrication and performance testing of geothermal cooling system in the southern Terai region where the underground temperature remains relatively constant at 15°C - 20 °C year round against the atmospheric temperature between 40°C and 46°C.

Table 3 (below) indicates that Nepal uses this energy resource solely for balneotherapy and tourism purposes. Currently, Nepal has an installed capacity of 3.55 MWt, and around 96 TJ of geothermal fluids are utilized of which more than 90% are for balneotherapy (Table 4 below).

Many thermal locations including some important ones also became the target to lose their fairly good infrastructures or spring source from the devastating earthquake of 7.8 magnitudes that took place in 2015 and their recovery works are in place.

Even though a few popularization activities for its direct utilization (in agricultural drying, fish farming, greenhouse heating, snow-melting, bio-digestion etc.) are in place, it has not been effective due to the lack of demonstration.

Geothermal energy is still viewed in terms of generating electricity. Due to abundant hydroelectricity potential, its increased generation and low temperature field, geothermal energy has not received government attention. Besides, only a few geothermal fields have discharges exceeding 3 l/s and the subsurface temperature of most of them is not yet known due to the absence of necessary chemical data. Potential organization in Nepal like APEC and the Department of Mines and Geology do not realize about obtaining such data.

There is still a lack of access to many geothermal areas for public use. Most thermal springs are located in the remote mountainous or hilly areas. Many of them are also situated on the bank of rivers where only local people can enjoy the benefit.

6.2 Prospect

Despite the problems mentioned above, the prospect for the use of geothermal energy development is becoming eminent in the country for a number of reasons:

1. Awareness has risen among the local people to mobilize local financial and physical resources for development

2. ii. With the adoption of Provincial administration system in 2017, there is a high opportunity to involve the provincial government to invest more in the utilization of this energy in the near future. Local entrepreneurs are now in a position to consider geothermal energy as a viable option if they have knowledge about the direct uses of it.

3. iii. Growth of tourism industry and road development is significantly contributing towards the utilization of geothermal energy in the short- and long term period.

The country's tourism sector is recovering gradually from the deadly earthquake in 2015. Tourism entrepreneurs and associations have geared up to attract more foreign tourists including Annapurna region in central Nepal. In 2018, Nepal government has recognized 100 new tourist destinations throughout the nation. It has announced the year 2020 as ‘Visit Nepal Year’ and aims to welcome 2 million foreign tourists.

Jhinu Tatopani, Bhurung (Dana) Tatopani, Chhomrong Tatopani, Ghorepani Tatopani hot springs are located in the Annapurna trekking circuit, the second most popular trekking destination in Nepal which in turn lies in the foothills of world's 10th tallest mountains including Mount Annapurna.

Annapurna trekking circuit covers various districts of Nepal including Kaski, Lamjung, Manang and Mustang. There is a manifestation of hot springs in all these districts. The influx of domestic as well as foreign tourists has increased with the beginning of the tourist season along the Annapurna Trekking Circuit. With the growing number of trekkers, locals have also considered opening up more lodges and provided good facilities to the tourists. Among the springs located in the Annapurna Circuit, Jhinu and Bhurung Tatopani is benefitting internal and foreign tourists. The local hot spring committees have expanded the physical facilities to extend the tourists’ stay. In a number of adjoining geothermal localities, people have started to exert pressure to the local village committees to expand facilities and build separate pools for the females. Tourists are enjoying the swimming pools in this area and tourism entrepreneurs are demanding a policy to divert the hot water for managed swimming pools so that increased number of lodges and restaurants can be opened.

All the seven provincial governments are placing road construction and improvement as the top priority which ultimately helps to have easy access to many hot spring areas in the high mountain and hilly areas. North-South Highway of Nepal has a meaningful contribution to the development of geothermal industry in Nepal as with the East – West Highway since the former has linked many hot spring areas in remote places. These highways open possibilities to use available low temperature geothermal water for snow melting and greenhouse farming at higher altitude. Even though these corridors are currently known as ‘death traps’ due to increased number of vehicle accidents arising poor quality of road, efforts are under way to improve them.

Table 3 : Geothermal localities and geothermal information

Locality	Type *	Maximum Utilization			Capacity (MWt)	Annual Utilization		
		Flow Rate (kg/s)	Temperature °C			Average Flow	Energy	Capacity
			Inlet	Outlet		(kg/s)	(TJ/yr)	Factor
Sribagar	B	1.1	71	36	0.161	0.7	3.232	0.636
Sina Tatopani	B	0.8	30	25	0.017	0.6	0.396	0.750
Chamaliya	B	0.35	30	25	0.007	0.3	0.198	0.857
Tapoban	B	0.4	31	24	0.012	0.3	0.277	0.750
Dhanchauri–Luma	B	0.8	24	18	0.020	0.6	0.475	0.750
Tilanadi	B	1.3	42	34	0.044	1.1	1.161	0.846
Riar	B	1.5	33	25	0.050	1.2	1.266	0.800
Surai Khola	B	1.7	36	26	0.071	1.4	1.847	0.823
Muktinath	B	3	22	15	0.088	2.5	2.308	0.833
Jomsom	B	0.07	16.5	12	0.001	0.05	0.030	0.714
Bhurung Tatopani	B	1.8	72	30	0.316	1.3	7.202	0.722
Narchyang	B	4.1	52	35	0.292	3.5	7.848	0.853
Dowa	B	2.5	40	28	0.126	2	3.166	0.800
Jharlang	B	3	53	32	0.264	2.5	6.925	0.833
Hindung	B	2.5	45	30	0.157	1.8	3.561	0.720
Sadhu Khola	B	1.5	70	30	0.251	1	5.276	0.666
Jamile	B	0.05	30.6		0.006	0.04	0.161	0.800
Kharpani	B	0.4	49	30	0.032	0.3	0.752	0.750
Machhapuchhre base camp	B	2.2	64	31	0.304	1	4.353	0.454
Mayangdi	B	2	40	30	0.084	1.7	2.242	0.850
Down Batase	B	0.15	44.3	26	0.011	0.1	0.241	0.666
Up Batase	B	0.2	21.5	15	0.005	0.15	0.129	0.750
Singha Tatopani	B	6	54	35	0.477	5	12.531	0.833
Bhulbhulekhar	B	1.2	34	27	0.035	0.8	0.739	0.666
Chilime	B	0.9	48	35	0.049	0.7	1.200	0.778
Syabri Besi	B	0.4	34	28	0.010	0.3	0.237	0.750
Pargang	B	3.8	49	30	0.302	3	7.518	0.789
Kodari	B	5.5	42	35	0.161	4.8	4.432	0.872
TOTAL					3.555		96.113	0.761

* B = Bathing and swimming (including balneology)

Table 4: Geothermal direct heat uses as of 2019

Use	Installed Capacity (MWt)	Annual Energy Use (TJ/)	Capacity Factor
Individual Space Heating District Heating Air Conditioning Green House Heating			

Fish Farming Animal Farming Agricultural Drying Industrial Process Heating Snow Melting Bathing and Swimming Other Uses	3.555	96.113	0.761
Sub Total	3.555	96.113	0.761
Geothermal Heat Pump			
Total	3.555	96.113	0.761

Table 5: Present and planned production of electricity

	Fossil Fuels *		Hydro		Other Renewables **		Total	
	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr
In operation in December 2019	53.40	0.04	1029.58	0.77	59.00	0.04	1141.98	0.86
Under construction in December 2019	unknown		640.70	0.48	15.00	0.01	655.70	0.49
Funds committed in 2019	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown
Estimated total projected use by 2020	62.00	0.05	1780.28	1.34	74.00	0.06	1916.28	1.44

* 53.4 MW from thermal plant ** 32 MW from micro and small hydropower plants and 27 MW from solar and wind

Table 6: Total investment in geothermal in 2018

Period	Research & Development Incl. Surface Explor. & Exploration Drilling	Field Development Including Production Drilling & Surface Equipment	Utilization		Funding Type	
			Direct	Electrical	Private	Public
	Million US$	Million US$	Million US$	Million US$	%	%
1995-1999	0	0	0.01	0	100	100
2000-2004	0	0	0.03	0	100	0
2005-2009	0	0	0.05	0	100	0
2010-2014	0	0	0.06	0	100	0
2015-2019	0	0	1.4	0	100	0

Road access has opened yet another possibility to explore the use of granites available in the northern central and western area. Hopes for High Density Rock technology has increased to tap it for small scale electricity generation in the northern areas.

7. DISCUSSION AND CONCLUSION

Nepal's energy situation has not changed over last five years, traditional source still having dominance. Drastic change in the scenario can be expected within next few years through increased use of commercial sector with hydroelectricity replacing it. However, in terms of renewable energy, its use has remained minimal (3.23 %). Contribution from geothermal energy is negligible. Despite the problems discussed above, Nepal still shows high prospect for its development due to increased road infrastructure and tourism industry.

Myagdi district seems to be the most potential area to be explored. A number of them are in the trekking route. The scope of hot spring tourism is vast and if properly developed, can be a lucrative addition to the tourism market. With the current infrastructure tourists may visit hot springs for the quaintness of it, but to attract international tourists it needs to be scaled up. Combining thermal springs with yoga, Ayurveda and even shamanism can make it a viable product. Apart from just catering to the domestic market, it should be expanded to attract foreign tourists with additional services like spas and hotels.

Since the springs are on public land, the private sector is not able to develop them to suit upmarket customers. Local communities lack the expertise and market reach to attract international tourists. Tourism entrepreneurs and local committees who are already running hot springs say that if the government provides the roads and tax breaks to invest in upgrading hot springs, the private sector would jump in.

Given proper knowledge and exposure to people in Myagdi district about the direct use of geothermal energy, they are now in a position to invest in the geothermal field. Crucial part lies in executing pilot/demonstrative program, particularly in the utilization of geo-heat pump, agricultural products drying, fish farming and greenhouse farming,. This is where APEC's strength lies.. Electricity generation does not seem economically viable at this stage in Nepal for various reasons.

As with other renewable energy resources, geothermal energy policy in Nepal is dictated by the availability of fund than by its need. So far, solar and wind energy uses are gaining momentum due to moderate external funding as pilot projects.. In case of geothermal energy also, such financing and technological support can show a promising result. Existing chemical data should be updated and expanded to new thermal springs through national survey so that the subsurface temperature can be known for various uses. Quantitative estimation of geothermal reservoir in Western Nepal should be made for further utilization.

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