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SPATIAL ANALYSIS OF PHYSIO-CLIMATIC CHANGES AND IT'S IMPACT ON HUMAN ADAPTATION IN TAWANG VALLEY: A CASE STUDY OF MONPA TRIBE, EASTERN HIMALAYA

Abstract

Land of Monpa Tribe (Tawang-Chu River Basin) is an amalgamation of a diverse and complex deterministic mountain-ecosystem. Changing pattern of temperature in the mountain ecosystem is altering ecological processes and inter-ecological nexus. Understanding of adaptation to survive with all present values against physio-climate changes in the adverse mountainous river basin is very difficult. It may alter their entire ethnic and cultural values as well as lifestyle. Monpa Tribe of the Tawang-Chu valley has been undoubtedly experiencing adverse climate variability challenges at present as it has been found that annual temperature pattern is fluctuating and altering vegetation index. The key problems are; increased rainfall uncertainties, intensifying droughts, rising temperatures and seasonal uncertainties. Only the effort of diagnosis of it can provide stability to humanity. By using Landsat Satellite Images on five years interval Land Surface Temperature (LST) and Normalized Difference Vegetation Index (NDVI) changing trend and its correlation has been analysed in this paper. This paper outlines some essential initiatives that can help in policy making for climate change related plans.

Keywords: *Monpa Tribe, Mountain Ecology, Tawang-Chu River, NDVI, Human Adaptation, LST.*

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Introduction

Mountain ecosystem is unique and distinct from other ecosystems (Beniston et al. 1997). An amalgamation of various factors like rugged

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topography, harsh climatic conditions, inaccessibility and remoteness reduced livelihood options and level of sustainability in the local's lifestyle (Ranjan et al 2016). Tawang valley is a surpassing example of it (GOI 2003). This hidden valley, situated in the lap of the Eastern Himalaya mountains, is the mysterious land of the *Monpa Tribe* known as the celestial paradise in a serene night. *Monpa* people are bounded from their soul with the valley from ancient time. Their longevity, natural flair, lifestyle, culture, religion is deeply intertwined with the place where they live therefore, they cannot adopt changing ecology effortlessly. Hence, physio-climatic changes are degrading their adaptability.

Maintaining livelihood sustainability is one of the major challenges in this valley (Pandey et al 2004). Today, it's a fact that climatic parameters and features are changing and physiographic features are also taking place accordingly in Eastern Himalaya (IPCC 2001). Characteristics of the ecosystem are transforming with the food chain/web. It means the nature genre is making a new home of the Monpa Tribe (Pandey and Prasad 2018). So now a prominent question is raising that "how a *Monpa Tribe* can adopt the present natural changes to be an assurance of his existence?". Variability in climate, leads to changes in geographic features and its explicit impact is bringing a lot of obstacles against sustainability in mountainous livelihood (Mishra and Pandey 2019). Mapping the degree of adaptation requires multiples measurement of fluctuation in climatic indicators (Singh 2015). Altered physio-climatic features have reconstructed the ecological services and dependent consumers have to adopt changed ecology to maintain self-existence (Ranjan et al 2017). This self-existence maintaining process is a human adaptation initiative because it helps to maintain smoothness of ecological services for human survival (Singh 2002). However, mountainous climate and its physiographical features are altering or not; if it is! then what is the rate of alteration (in terms of changing) like queries have not uniform perceptions (Pandey et al 2016). Is there any impact of changing physio-climate changes on livelihood, lifestyle and their health of *Monpa* and its adaptability to face socio-cultural identity crises?

Every person has individuals' thought about climate change that is why perception on it varies from person to person in mountain communities but scientifically retrieve data through remote sensing and geographic information system shows static values to explain climate change mechanism (O'Riordan 2002). The paper makes an attempt to perform (i) spatial analysis in temporal form and (ii) it's impact on nature. The study measures the situation of major active climatic indicators like temperature, vegetations and snow cover. It has been also analysed the driving forces responsible for changes and recognising adaptive measures to sustain positively.

Scope

The basin of the Tawang-Chu River belongs to the *Monpa Tribe*, whose livelihood is mainly dependent on agricultural activities and it is strongly tied

with their culturally. Landscape feature in this high-altitude valley leads assurance of livelihood which is unique in nature since it possesses some inherent character which distinguishes it from other factors. Human adaptation, with nature that has existed since ancient times, is deeply intertwined with biological identity. If there is a change in it, then it not only has an impact on livelihood but also on health. This is the kind of crisis on human existence and can be eliminated by increasing human adaptability against changes in nature. Changing pattern of temperature in the mountain ecosystem is altering ecological processes and inter-ecological nexus. Natural resources and its services are also taking shape according to the degree of climate change. Human adaptation cannot be better measured without assessing this dangerous change. Remote sensing and (GIS) generated data has been used to analysed the physio-climatic features and its temporal changes. By using Landsat Satellite Images on five years interval Land Surface Temperature (LST) and Normalized Difference Vegetation Index (NDVI) changing trend and its correlation and degree of impact on human adaptation has been analysed in this paper. This research identifies the causes of the physical-climatic constraints in the adaptation of the *Monpa Tribe* lifestyle in the valley.

Location of the Celestial Paradise: Tawang- Chu Valley:

The political boundary of the Tawang-Chu river basin was set as a district in Arunachal Pradesh on 6 October 1984. So, the Tawang-Chu river and its tributaries' basin lies in this political periphery. Tawang district is situated in far western part of the state and covered about 2172 Sq Km area. The total area located between 27°27'48.0"N to 27°53'17.3"N Latitude and 92°14'40.3"E to 91°58'43.7"E longitudes. The taken study area, as a district of Arunachal Pradesh adjoins two international boundaries.

From Northsides, with China in Tibetan Plateau and from West and Southwest Side with Bhutan. The rest of the border lies with Kameng district. To fulfil the objectives of the study, physiographic morphology has been premeditated using the survey of India toposheet numbers 78M/9,10,13,14,15; 83A/1,2,3. *Tawang* means (*"TA"- Horse and "WANG"- Chosen*) choose land by the Horse. As legend has it, it is believed that the land of Monpa chosen by the horse of *Mera Lama Lodre Gyatso*, a spiritual monk for establish a Monastery (Hamlet 2001). And as we know that, it is the birthplace of sixth holy Dalai Lama as well as the second biggest Buddhist Monastery in the world. *Mera Lama Lodre Gyatso* was a disciple of an Indian Buddhist *saint Guru Padmasambhava* who made this uncanny holy Monastery (Dutta 1919).

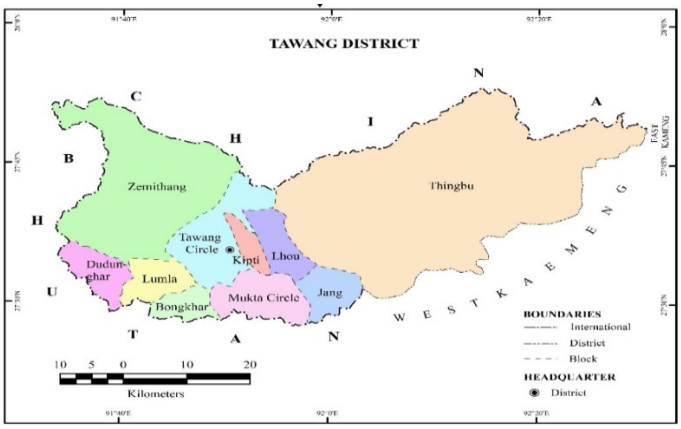
The Monpa: Spiritual Mien of Buddhism:

About 50000; suave, amiable and prodigious *Mahayana sect* Buddhist gentle souls live in this high-altitude impassable valley (Census of India 2011). In which, about 29000 are male and remaining are females(Census of India,

2011). Most people are cultivator in these adventures and beautiful land (Dutta 1919). Each moment of his life is directed by religious ritual and mountainous nature (Biswal 2006). They enjoy every act of their life by keeping pace with nature, whether it is the festival of *Dungur*, Torgoya, Losar or agricultural activities. The meanings of *Monpa* is "from *the land of Mon* (southern part of Tibet Plateau) in local language and traditionally word Monyul belongs to their tribal identity which is also the clan name of the Monpa's dynasty (Hamlet 2001).

They live in this valley from 4th Century AD. which is the beginning time of human civilisation in this place (Dutta 1919). It shows that how much they are connected with this land. Almost 90 per cent people's economy depend on cultivation and animal husbandry (Figure 2). They are generally practicing traditional and organic agriculture therefore, they more vulnerable to physio-climatic changes (Dutta 1919). Their adaptivity capacity is continuously going down in terms of durability. Hence, their cultural acuity is slowly falling apart. The effect of which can also be seen on festivals like *GandenGgamchoe, Drukpa Tse-ze, ZhepaSaka Dawa, Choekor, Torgya* and *Losar (*Norbu, 2008).

Figure 1: Study Area



Source: Computed on ArcGIS, 2019

Figure 2: Tawang District and its Nature

Primary Survey, 2018

Dataset and Methodology

These toposheet numbers also has been considered during using remote sensing technique to retrieve data and using ArcGIS. Landsat Satellite Images L7ETM+ (1999), L 4 - 5 TM (2010), L8 OLI/TIRS (2018) of 15m, 30m and 100m resolution has been used to retrieve spatio-temporal data (Table 1,) Digital Elevation Map (DEM)/CartoDEM of the study area has been retrieve using Cartoset-1 (Figure 2). Remote sensing and Geographic Information System (GIS) generated data have been used to analyse the physio- climatic features and its temporal changes.

Table 1: Acquisition of Landsat Satellite Images L7ETM+ (1999), L 4 - 5 TM (2010), L8 OLI/TIRS (2018)

	Dates	Path/Row	Satellite	Resolution
1.	09-12-199016-01-1990	136/41137/41	Landsat 4 - 5TM	30m
2.	04-12-199413-12-1994	136/41137/41	Landsat 4 – 5 TM	30m
3.	14/12/199918/12/1999	136/41137/41	Landsat 4 - 5TM	30m
4.	22-11-200419-11-2004	136/41137/41	Landsat 4 - 5TM	30m
5.	16-12-201010-01-2010	136/41137/41	Landsat 4 - 5TM	30m
6.	19-12-201728-12-2017	137/41136/41	Landsat - 8OLI/TIRS	30m

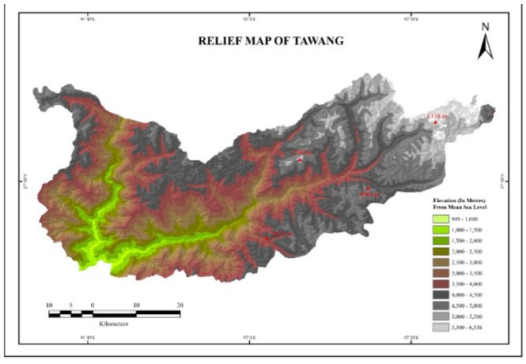
Source: Landsat Satellite Images retrieve portal of USGS, 2019

Physio-Climatic Features of Tawang-Chu River Basin:

The landscape of the district is entirely mountainous, lying between about 949m to 6338m and most of inhabitants are living in lower altitude, where they enjoy a cool temperate climate (Figure 3). The area is characterized by

rugged topography, high mountain ridges with steep slopes and deep incised valleys carved by the Tawang-Chu River. Tawang-Chu River basin can be echeloned on the basis of elevation in twelve parts in which, four bands have 4000m to 5600m elevation range (Choudhury, 1996). It covers almost 90 per cent of the Tawang river basin (Figure 3). Mount Gori Chen is the highest mountain peak in Tawang District with a height of about 6338 meters. Kameng river originate from Gori Chen glacier and flowing through Tawang District towards Kameng District (Rana et al. 1996). Confluence Zone of Tawang–Chu and Nyamjang-Chu near Lumla has been considered lowest point of the Tawang-chu river basin (Figure 3). This high-altitude region has binate drainage pattern-Tawang-Chu river and Nyamjang-Chu river. Although Tawang-chu is the Prime river, comes into existence when Mago-Chu and Nyukcharong-Chu make the confluence point on 2240m elevation near Kyelatongbo. Hereafter, Tawang-Chu River flow towards almost southwest direction and meet Nyamjang-Chu river near Lumla around Indo-Bhutan Border and goes into Bhutan making a steep V-shape narrow valley (Singh, 1988). Tawang-Chu River has dendritic and parallel drainage pattern in the study area. According to the previous years 2018 and 1019, minimum temperature is -5.0^0 c during winter season in January month and maximum temperature is 24^0 c during summer season in July month. During winter season average temperature of the basin has been recorded about 2.0^0 c and summer season it shows around 17.0^0 c while 15^0 c is yearly average temperature. The River Basin get maximum rainfall in July and minimum rainfall in December month. Snowfall usually occurs in December to February.

Figure 3: Digital Elevation Map (DEM)/CartoDEM of study area.



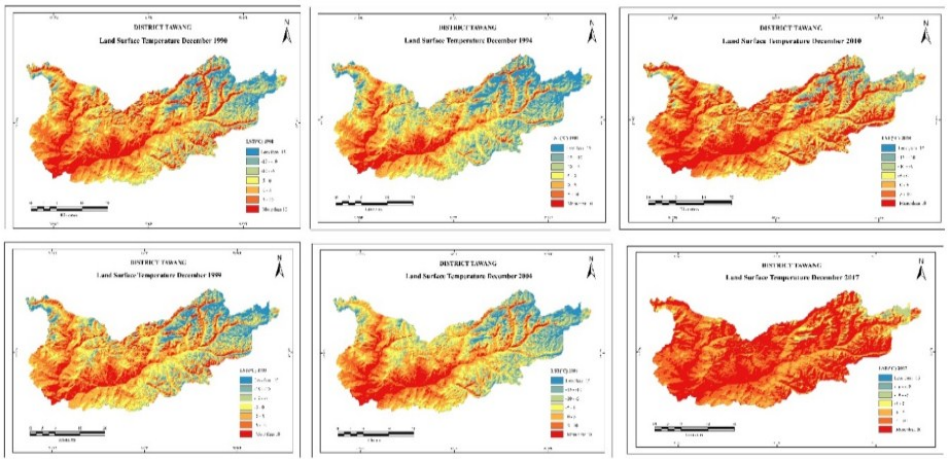
Source: Cartset-I Satellite, 2019

Hydrometeorology of high-altitude river basin determined by physio-climatic features. such as temperature, precipitation pattern local wind pattern, water cycle, land use -land cover features, slope, watershed and drainage system Study area has three clear seasons (i) Mild Summer Season (during March to Mid- June), (ii) Copious Rainy Season during (Mid-June to September) and (iii) Hard Winter season (October to February).

Result and Discussion

Changing temperature in positive terms leads to climate change means global warming. Ground temperature of Tawang-Chu River basin in changing and its impact on ecology can be seen on the valley (Figure 4).

Figure 4: Temporal estimation of Land surface temperature of Tawang-Chu River basin (in ^{0}c).



Source: Computed by Authors Landsat Satellite L7, L 4, L 5, and L8 through USGS portal, 2019

Land Surface Temperature (LST)

To know about the temperature trend; Seven time periods (in years – 1990, 1994, 1999, 2004, 2010, 2017) has been taken to analysis the temperature of the valley. Taken years interval of temperature analysis is not equal due to unavailability of the clear sky during retrieve data from Landsat satellites (Figure 4). The radiative temperature of the valley surface has been calculated using the LST technique through images obtained from Landsat satellite (Figure 4). The rising trend of surface temperature can be easily seen in this satellite images (Figure 4 and Table 2). It has been observed that the minimum temperature has increased by about 20^{0}C in the last 27 years. Similarly, the average maximum temperature has also increased in the last 27 years by 3^{0} C. Yes! It is not that much big amount as minimum temperature showing the trend, but the rising trend of average maximum-temperature is a comparatively more significant sign about changing ecological services because it can alter the entire ecological footprint. Enormous Changes in the annual mean-value of temperature from a negative (-0.73) into positive digit (8.54) in taken years can be seen (Table 2). Beside this, the value of standard deviation describes; how the interval between minimum and maximum temperature is shrinking with increasing temperature trend in the River Basin (Table 2).

Table 2: Temporal data extraction of Land surface temperature of Tawang-Chu River basin (in ^{0} c).

	Min	Max	Mean	S. D
1990	-37.52	29.59	-0.73	20.00
1994	-34.25	27.52	-2.61	17.24
1999	-28.83	27.48	-0.23	17.77
2004	-29.61	28.95	0.50	17.62
2010	-26.67	32.05	4.3	17.62
2017	-17.69	32.33	8.54	14.96

Source: Generated by Author using Landsat Satellite L7, L 4, L 5, and L8 through USGS portal, 2019 Normalized Difference Vegetation Index (NDVI) of Tawang-Chu River Basin:

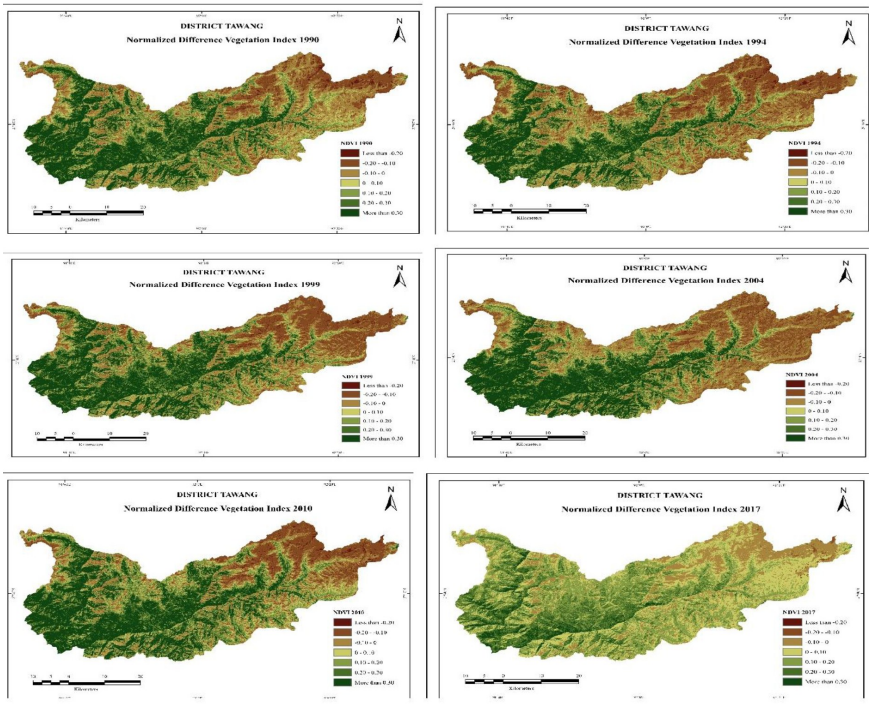
Vegetation and Fauna

Tawang-Chu River Basin has about 56.45 percent forest cover of total geographical area which is limited to an altitude of about 3500 m. In which, 366 km^2 has Very Tropical Wet and Dense Rainforest Cover, 486 km^2 has moderate dense (Tropical Semi Green and Moist Deciduous Forest) while 374 km^2 is open Alpine Forest Cover (IUCN 2004). The valley has rich biodiversity and ecological services as about 420 types of plants species has been recorded according to forest survey of India, 2011. Fluctuations and changes in physical-climate indicators have profound effects on the service chain of ecology, of which temperature is one of the most important climate-indicator (Street et. Al. 1990).

Normalized Difference Vegetation Index (NDVI) is an effective green vegetation quantification method to analysed vegetation availability with density using remote sensing technique. The same year interval has been taken in this analysis so that the comparative study of both can be done (Figure 5).

Basically, this index based on the chlorophyll detection method is retrieved from the satellite sensing process. For the calculation, following formula has been used-

Figure 5: Normalized Difference Vegetation Index (NDVI) of Tawang-Chu River Basin



Source: Computed by Authors using Landsat Satellite L7, L 4, L 5, and L8 through USGS portal, 2019

$$NDVI = NIR - RED \div NIR + RED$$

Where, **NIR = Refection in *NEAR INFRARED Spectrum***

RED = Refection in *RED Spectrum*

Output index value of the formula lies between (-1.0) to (1.0) in which, extreme negative value interprets water properties, near about zero or almost zero (-0.1 to 0.1) shows snows or barren land/ rock.

Table 3: Statistical Data of NDVI from 1990 to 2017

Year	Min	Max	Mean	S. D
1990	-0.89	0.89	0.12	0.51
1994	-0.77	0.74	0.09	0.45
1999	-0.86	0.86	0.12	0.50
2004	-0.85	0.76	0.10	0.47
2010	-0.66	0.75	0.12	0.42
2017	-0.26	0.51	0.12	0.23

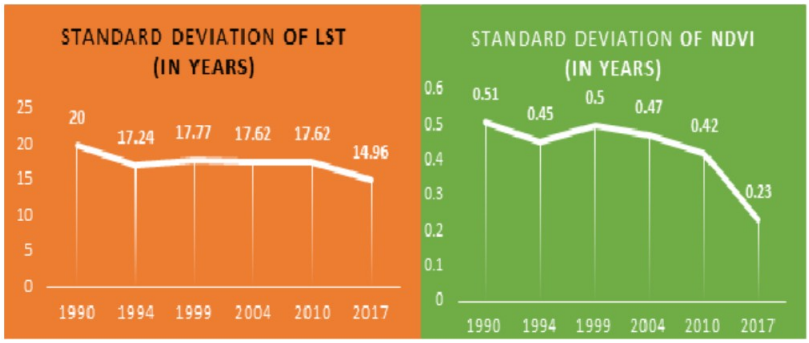
Source: Generated by Author using Landsat Satellite L7, L 4, L 5, and L8 through USGS portal, 2019

Further positiveness of value shows the degree of density of vegetation. As an example, 0.89 is almost near to 1 and it has higher values; indicates dense rain/temperate forest of the study area (Table 3).

Besides this, low positive values between 0.1 to 0.3; represents short-length vegetation like grassland or shrubs. NDVI shows that dense vegetation at Tawang-Chu river basin gradually declining while the area of vegetation is increasing. As we can say by looking at the table, that in 1990, the amount of dense evergreen forest is in much better situation (as NDVI value is 0.89) but green less area is decreasing gradually than subsequent years (Table 3). Retrieved Data interpret that, dense scaling of vegetation is shrinking although water surface and snow area also show a shrinking tendency in subsequent years. It means, increasing vegetation area on the snow surface and water surface interpret significant sign that tree line of the river basin going upward (Table 3).

Retrieved data also show that the decline rate of vegetation is rapidly increasing. In 2017, NDVI Index 0.51 which's interpret the shrub or grassland; is the evidence of the declining rate of vegetation density (Table 3). According to the output of data, the study has been reached at the point where it can be stated that average temperature is gradually rising, although the minimum temperature changing rate is very fast during the last 27 years. Gradually and rapidly declining trend of LST and NDVI shows strong positive relation between land surface temperature and Normalized Difference Vegetation Index (Figure 6). It means, NDVI has directly proportional to Land surface Temperature of the river basin. As temperature increases, the area and nature of vegetation are also taking place accordingly (Figure 6).

Figure 6: Standard Deviation trend between LST and NDVI of Tawang River Basin



Source: Generated by Author using Landsat Satellite L7, L 4, L 5, and L8 through USGS portal, 2019

Positive changes in temperature casting negative effect on precipitation. The positive change in temperature is having a negative effect on the rainfall as both the amount and duration of snowfall is decreasing and the amount of rainfall is also decreasing while the time period of rainfall is increasing. Because the period of snowfall is partly modified into the period of rainfall.

Changing Nature and Monpa Tribe

Understanding of adaptation to survive with all present values against physio-climate changes in the adverse mountainous river basin is a very hard job. It may alter their entire ethnic and cultural values as well as lifestyle.

The above findings indicate that Tawang district has been undoubtedly experiencing adverse climate variability challenges at present as it has been found that annual temperature pattern is fluctuating and altering vegetation index. The key problems increased rainfall uncertainties, intensifying droughts, rising temperatures, seasonal uncertainties. These scenarios have largely affected crop and livestock performances in the valley, with corresponding negative effects on Monpa's food security and income positions. Their food habits, cultural values, livelihood, health and psychological temperament closely influenced by the nature of the land. If changing in nature physically identified then its impact on their lifestyle cannot be denied (Figure 7).The tribal community are mainly depending on the cultivation need to manage their livelihood system. Management of resources by considering the identified changes in nature is the only way to survive and it is extremely necessary in present scenario. Due to this changing physio-climate, no one can tell what may change and when. It can also invite many calamities as a disaster or pandemic disease which cannot be controlled by human beings. One of these types of pandemic is *Novel Corona Virus*/COVID-19. This epidemic is raging in the world nowadays and also knocking the passage to get in the land of Monpa. Not entirely, but the role of changing temperature pattern and the vegetational feature cannot be denied to explain the impact of this timebomb pandemic because When it has been identified the contamination and spreading rate of this disease then it has been found that all severe affected places have same temperature during high spreading rate of COVID-19 (Table 4).

Figure 7: Culture of Monpa Tribe

Primary Survey, 2018

Table 4: Temperature pattern Temperature (Minimum to Maximum in) During exacerbation time of COVID-19 in most effected places.

Place	Temperature (Minimum to Maximum in) During exacerbation time of COVID-19	Remark
Wuhan, China	1^0c to 8^0c in January	
Washington, USA	-2^0c to 11^0c in March	
New York, USA	1^0c to 10^0c in March	
Lombardy, Italy	-2^0c to 12^0c in February and 4^0c to 15^0c in March	
Île-de-France, France	-2^0c to 9^0c in March	
Grand Est, France	-2^0c to 10^0c in March	
Tehran, Iran	8^0c to 15^0c in March	
Castile and Leon, Spain	-2^0c to 12^0c in February and 4^0c to 15^0c in March	
Tawang, India	-1 ^{0}c to 8^0c in February/ 6^0c to 15^0c in March	***Waiting for contamination*

Source: WHO, https://google.org/crisisresponse/covid19-map and Weather.com

Changing Physio-climatic features indicating poor human adaptation situation to fight health related issues like COVID-19 (McMichael, 2003). If the Tawang valley area gets contaminated, the serious problem will arise in Tawang Basin. Hence, Tawang-Chu river basin is more vulnerable than other low land regions in India to get affected from Covid-19. In fact, the condition will become more vulnerable after contamination as this mountainous and rugged region is physically isolated and less accessible than other regions of the country.

Conclusion

It has been revealed by extracting and analysing data, that temperature is changing and its impact on mountain vegetation can be easily seen including characteristic ecological system and its services. The ecosystem is coping to rearrange itself with its changing parts and mechanics. Study extracts that Monpa tribes, which are completely dependent on these mountainous physio-climatic characteristics, are highly sensitive to the changing circumstances. They may lose their anthropogenic identity by adopting changes.

The changing trend of temperature is reducing the natural distance between human and animals and it may lead to generate disturbances in human world (McMichael 2003).

Therefore, in this situation, it can be difficult to replace human adaptation in a sustainable way because the recombination process of ecological services can affect the rate of human adaptation. It has been also illumined that changing trends of vegetation and climatic features may become a menace for biodiversity. Many flora and fauna are already in the path of extinction (IUCN 2004). Hence, on the basis of spatial analysis of Physio-Climatic changes in the study area, advocate that, mountain ecology is facing serious negative changes not only creating problems for humans but also for the entire biome.

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