



# **Comparative Assessment of Vulnerability to Drought and Flood in the Lower Teesta River Basin: A SWOT Analysis**

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## **Authors' contributions**

*This work was carried out in collaboration among all authors. Author SJAH designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors SKP and MNH managed the analyses and literature searches of the study. All authors read and approved the final manuscript.*

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## **ABSTRACT**

People repeatedly confronted by natural catastrophe in almost every year such as drought and flood in the lower Teesta Basin area. After the construction of two barrages in *Gozaldoba* and *Dalia* on Teesta River drought and flood occurs almost every year. Intensity and frequency of these calamities are also increasing in an alarming rate, which caused serious damage to livelihoods and economy of this area. The objective of this paper is to find out the drought and flood induced vulnerability in the study area through Strength Weakness Opportunities Threat (SWOT) analysis. By this we can summarize the current state of a space and helping to devise a plan for the future, one that employs the existing strengths, redresses existing weaknesses, exploits opportunities and defends against threats. The study is conducted in *Charkharibari* village of *Tepakharibari* union of *Dimla* upazilla in *Nilphamary* district and *Jigabari* village of *Tepamadhupur* union of *Kaunia* upazilla in *Rangpur* district, taking the locational advantage, flood and drought proneness, topographic

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nature and population diversity under consideration. The study population is finite and sample size was determined by using Kothari's formula. Sample size for *Charkharibari* and *Jigabari* is 200 and 85 respectively; samples were drawn through Simple Random Sampling (SRS) procedure. The relevant data and information used in this study have been collected from both primary and secondary sources. Primary data has been collected through a questionnaire survey and couple of Focus Group Discussions (FGD's) with a view to collect quantitative as well as qualitative data. Results from Strength Weakness Opportunities Threat (SWOT) analysis shows that, between the two villages severity of drought and flood is higher in Charkharibari village. After comparing the strengths *Jigabari* is ahead; comparing weakness, opportunities and threat *Charkharibari* is ahead. Based on the analysis and the findings, it is evident that in terms of vulnerability Charkharibari is more vulnerable than Jigabari. But there are more opportunities for Charkharibari than Jigabari. However, it is evident that proper dissemination of information regarding early warning and assistance from government as well as non-government organizations can significantly improve the coping capacity of people.

*Keywords: Drought; flood; vulnerability; disaster; SWOT; Teesta; Bangladesh.*

## 1. INTRODUCTION

The Teesta River originates in the Himalayas and flows through the Indian States of Sikkim and West Bengal before entering into Bangladesh, where it flows into the Brahmaputra [1]. Flowing through the length of Sikkim, the Teesta River is considered to be the lifeline of the state. The Teesta valley in Sikkim is rich in biodiversity, and the river provides livelihoods for the residents along its entire length of 393 km (245 miles) (Mullick et al 2011). The Teesta River originates from the Pahunri (or Teesta Kangse) glacier above 7,068 meters (23,189 ft.), and flows southward through gorges and rapids in the Sikkim Himalaya [2]. It is fed by rivulets arising in the Thangu, Yumthang and Donkha mountain ranges. The river then flows past the town of Rangpo where the Rangpo River joins, and where it forms the border between Sikkim and West Bengal up to Teesta Bazaar. Just before the Teesta Bridge, where the roads from Kalimpong and Darjeeling join, the river is met by its main tributary, the Rangeet River [3]. At this point, it changes course southwards flowing into West Bengal. The river hits the plains at Sevoke, 22 kilometers (14 mi) northeast of Siliguri, where it is spanned by the Coronation Bridge linking the northeast states to the rest of India [4]. The river then goes merging up with the Brahmaputra after it bifurcates the city of Jalpaiguri and flows just touching Cooch Behar district at Mekhliganj and moves to Fulchori in Bangladesh [5].

### 1.1 Drought in Teesta River Basin

The Teesta has been drying up at different points during the dry season, threatening the Boro cultivation in six northern districts. The once

mighty Teesta is now bereft of water following construction of a barrage upstream at Gojoldoba point in Jalpaiguri of the Indian state of West Bengal. The farmers in Nilphamary, Lalmonirhat, Gaibandha, Rangpur, Dinajpur and Bogra are worried over the bleak prospect of getting required quantum of water from the Teesta for the irrigation of Boro fields [6]. The construction of the barrage on this river across the border to divert its flow of water has badly affected the efficacy of the Teesta Barrage Project. According to Water Development Board, Bangladesh got only about two per cent of the required quantum of water from the border last year [7]. The release of such low quantum of water was adversely affecting navigation, irrigation, fishery and ecology of the lower Teesta riparian area of Bangladesh [8].

On the other hand, there should be 10,000 cusecs of water to bring an estimated 111,000 hectares under the Rabi crop program but only 1,000 to 1,200 cusecs are now available in the upstream of the Teesta Barrage. The Indian authorities are reportedly withdrawing the total water from the rivers Teesta and Mohananda through their Gojoldoba and Mohananda Barrages in the upstream. It is found that the average lowest discharge of Teesta was above 4,000 cubic meter/sec before construction of the two barrages — one at Doani in Bangladesh and other at Gojoldoba in West Bengal. But after construction of two barrages the lowest discharge has drastically reduced to 529 cum/sec in 2000 and just after five years in 2005, it came down to just 8 cum/sec [9]. Hence, there requires no further explanation what is going to happen to the fate of the Teesta in the near future. On the other hand, in the Indian part, the mean annual discharge of the Teesta at

Anderson Bridge was about 580 cum/sec a decade back and it declines to 90 cum/sec in the lean months. The peak discharge may be as much as 4,000-5,000 cum/sec. It was estimated that the peak discharge of the river at Jalpaiguri during the devastating flood of 1968 was 19,800 cum/sec [8].

The sediment load in the river increases with high monsoon discharge. It was observed that 72 per cent of the suspended load is transported between July and August when the bulk of discharge flows through the river. And these things altogether create a drought phenomenon in Teesta River Basin every year [8]. Records show that 19 drought periods occurred in Bangladesh between 1960 and 1991, and about 12 of them were in Teesta River Basin area. This means a drought occur every 1.6 years. In the decade between 1985 and 1998 the temperatures in Bangladesh increased by 1 degree Celsius in the month of May and 0.5 degree Celsius in the month of November. This change in temperature is relatively high compared to the IPCC projection of 0.2 degrees Celsius per decade [10]. Despite, this increased warming in Bangladesh, extreme lower temperatures have been observed e.g. the lowest winter temperature (5°C) in 38 years was recorded in 2007. In the last 3-4 decades when climate change began to be observed in the North Western region of Bangladesh, the situation has progressively got worse [11,12]. Surface water has disappeared from ponds and canals and even major rivers have reduced water volume. Deep tube wells, shallow machine wells were used for irrigation and the tube wells were used for domestic needs have been deepened with time as the ground water level continues to go down. Whereas, North Western region had become a food surplus area after introduction of deep well water for irrigation, and the development of Teesta Barrage Project (TBP), such gains are getting lost due to inadequate water [13].

## **1.2 Flood in Teesta River Basin**

Once the Teesta that used to hold water throughout the year now dries up just after the monsoon. Numerous chars and shoals have been emerged on the riverbed. The discharge capacity of Teesta has drastically been reduced due to withdrawal of water and the discharge of heavy silts from the upper catchments. A series of dams and barrages erected over the vibrant river are virtually causing its death. The

shrinkage of the river has been causing heavy erosion almost throughout the year displacing and making destitute hundreds of people every year. It seems certain that the dynamic equilibrium of the river will be impaired with the construction of a series of dams, and the sediment load will be trapped within the reservoirs, reducing their capacity. This, in turn, could compel dam managers to release water during heavy rainfall, causing sudden flash floods in downstream [8].

The most common water-related natural hazard in a deltaic floodplain such as Teesta River Basin is flood. Flooding in Teesta river Basin is the result of a complex series of factors. These include a huge inflow of water from upstream catchment areas coinciding with heavy monsoon rainfall in the country, a low floodplain gradient, and congested drainage channels. Different combinations of these various factors give rise to different types of flooding [14].

Three main types of natural floods occur in Teesta river Basin: flash floods, river floods, and rainwater floods. Flash floods take place suddenly and last for a few hours to a couple of days. Run-off during exceptionally heavy rainfall occurring in neighboring upland areas is responsible for flash floods. Such floods occur as waters from the hilly upstream rush to the plains with high velocity, mauling standing crops and destroying physical infrastructure [15].

Rainwater floods are caused by heavy rainfall occurring over Teesta River Flood Plain (TRF). Rainwater flooding is characteristic of meander floodplains, major floodplain Basins, and old piedmont and estuarine floodplains. Heavy pre-monsoon rainfall (April-May) causes local run-off to accumulate in floodplain depressions. Later (June-August), local rainwater is increasingly accumulated on the land by the rising water levels in adjoining rivers. Thus, the extent and depth of rainwater flooding vary within the rainy season and from year to year [15].

Normal river floods generally occur during monsoon. A monsoon is traditionally a seasonal reversing wind accompanied by corresponding changes in precipitation [10], but is now used to describe seasonal changes in atmospheric circulation and precipitation associated with the asymmetric heating of land and sea. River floods result from snow-melt in the high Himalayas and heavy monsoon rainfall over the Himalayas, the Assam Hills, and the Tripura Hills outside

Bangladesh. River floods extend beyond the active floodplains and damage crops in parts of the adjoining meander floodplains, mainly alongside distributary channels [16,17]. The timing of the flood (whether early or late) and sometimes the duration of flooding are as important determinants of crop damage as is the absolute height reached by a particular flood. Filled channels deposits reduce the drainage capacity of minor rivers, road and railway bridges and culverts, as well as irrigation and drainage canals [15].

### 1.3 Vulnerability to Flood and Drought

Vulnerability is defined as the susceptibility to harm. Infact, it is inability of a system to withstand against the perturbations of external stressors. Similarly, social vulnerability includes susceptibility of social groups or society to potential losses from extreme events and the ability to absorb and withstand impacts. Natural hazards has differential impacts on different groups in the society, and disaster can only take place when losses exceed the capacity of population to resist and recover. Besides, it is also depends on where people reside, and what

sort of resources they have to cope [18]. In this regard, flood and droughts are recurrent external stressors in the lower Teesta river basin. Therefore, recurrent flood and drought significantly reduce the inhabitants ability to withstand against the adverse impacts of floods and droughts in the lower Teesta river basin area of Bangladesh.

## 2. OBJECTIVES

The objective of this research is to conduct comperative vulnerability study of two flood and drought prone villages of lower the Teesta river basin of Bangladesh through SWOT analysis.

## 3. RISK ASSESSMENT FROM SWOT ANALYSIS

SWOT stands for strengths, weaknesses, opportunities and threats. It is a way of summarizing the current state of a space and helping to devise a plan for the future, one that employs the existing strengths, redresses existing weaknesses, exploits opportunities and defends against threats. [19] Table 1, Fig. 1.

Table 1. SWOT analysis matrix [19]

	Strengths	Weaknesses
Opportunities	How do I use these strengths to take advantage of these opportunities?	How do I overcome the weaknesses that prevent me from taking advantage of these opportunities?
Threats	How do I use my strengths to reduce the impact of threats?	How do I address the weaknesses that will make these threats a really?

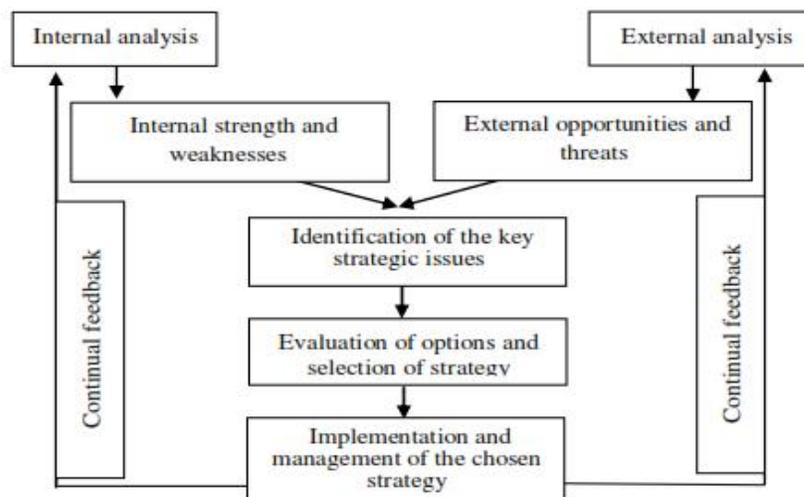


Fig. 1. The process of SWOT [20]

#### 4. SELECTION AND LOCATION OF THE STUDY AREA

The study area has been selected purposively taking the locational advantage, flood and drought proneness, topographic nature and population diversity under consideration. The study is conducted in Charkharibari village of Tepakharibari union of Dimla upazila in Nilphamary district and Jigabari village of Tepamadhupur union of Kaunia upazila in Rangpur district (Fig. 2). Charkharibari village is situated in the right bank of upstream of Teesta River, it lies between 26°12'50" to 26°14'30" north latitudes and between 88°59'10" to 89°1'40" east longitudes (Map-1). Jigabari village is situated in the left bank of upstream of Teesta River, it lies between 25°42'30" to 25°43'40" north latitudes and between 89°28' to 89°29'10" east longitudes (Map 1). Both of the districts are in lower Teesta Basin area. Physically these two districts are located in two natural divisions. They are plain land and low land.

#### 5. SWOT ANALYSIS OF CHARKHARIBARI VILLAGE

The SWOT analysis and summary of Charkharibari village is presented in (Table 2).

#### 5.1 Analysis Summary of Charkharibari Village

Charkharibari is situated in a charland (Island) which is located on the right bank of Teesta river in Bangladesh. From the SWOT matrix (Table 5) of this area we can see that the major strengths of this place are followings. This settlement is located on the border of India and Bangladesh. To the north of this community is India (Koochbihar district). There is an "India-Bangladesh Combined Teesta Dam Project" is going on. Although, part of dam which located in India is already completed but, in Bangladesh part where this village is situated the construction is going on. Till now only 600 ft. of this dam is completed. Another 600 ft. has completed by the end of 2017. Another important strength is, there are plenty of stones just beneath the surface of this village. After digging of 3-4 feet beneath the surface these stones can be easily collectable. A large number of population of this community is youth and adults. Remaining cultivable agricultural land of this village is very fertile. There are a huge number of weaknesses of this area and they are listed as follows. Location of this village is unstable. Though, this locality is situated on a more than 40 years old charland but the charland is still eroding in different places.

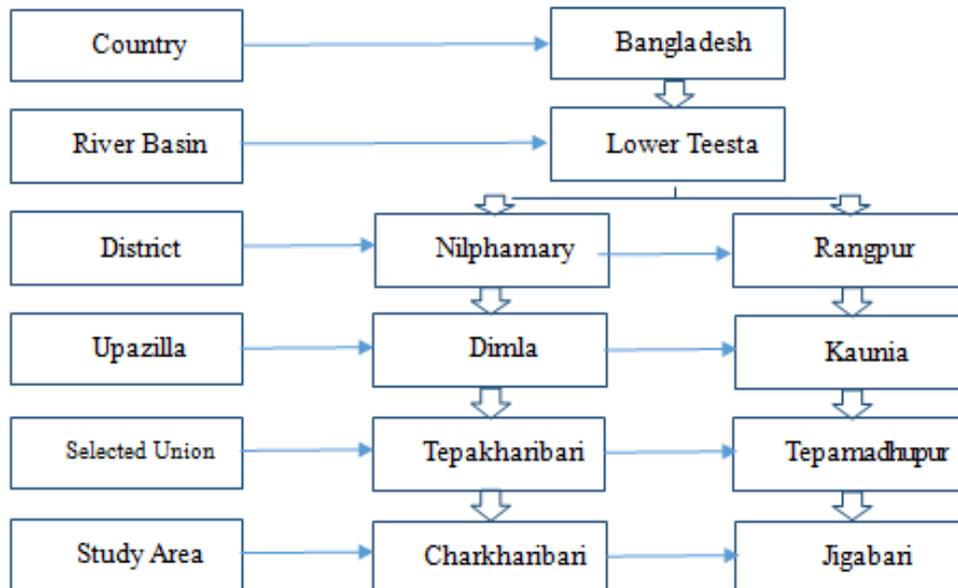
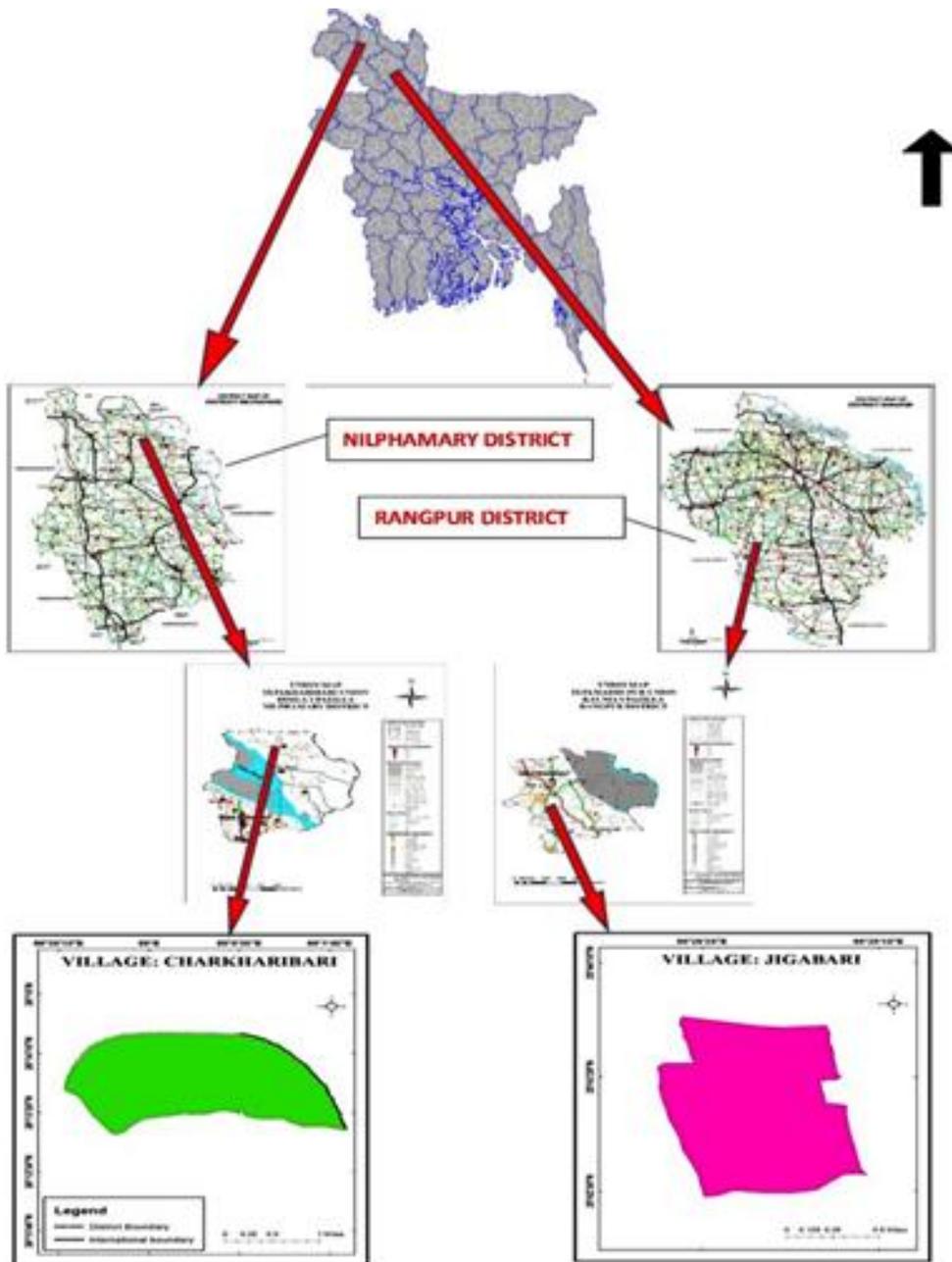


Fig. 2. Selection of study area



**Fig. 3. Location map of study area**

There is no road network in this area. The only communication system with the inland is by boat which is also very time consuming due to dried up of river bed. There is no permanent educational institution here. There is only one primary school in this village but right now it has no permanent structure. As a result, the literacy rate is very low. There is also no permanent health center in this village. River bank erosion is

very active in this village. Presently, it is eroding in 6 different places along the bank line. Almost 85% area of this village has no flood protection dam. and there is no flood shelter center. There is no electrical grid connection in this village as a result there is no industrial development. And there is no modern high efficiency irrigation system such as deep tube wells in this village. Scarcity of drinking water is severe. Sand cover

is severe in this village. The agricultural production is totally uncertain. Most of the agricultural land of this area is single cropped. As a result, there is no permanent village market or hut. Several Non-Governmental Organization's (NGO's) have already closed their micro-credit or other development programs in this village. There are several opportunities such as; this village can be suitable for import-export and other border related market business. A quite large number of unemployed workforces are ready. Planned stone collecting can create a huge workplace for the local inhabitants as well as for businessmen also. If the "India-Bangladesh Combined Teesta Dam Project" could be completed earlier, then the village would be saved from riverbank erosion and flood. Fishery based market or industry can be grown here. There are several threats for this settlement. These are as follows – sand cover rate has increased and it completely destroys the agricultural land. Rate of riverbank erosion has accelerated due to unplanned stone collection. Number of flash flood has increased, similar finding was found by Hossain *et al.* [21]. Intensity and duration of flash flood has increased also in an alarming rate. During summer season the temperature threshold has increased resulted in severe heat stress while, during winter season the temperature threshold has decreased resulted in severe cold wave. Intensity and duration of drought have increased. This is the Strength Weakness Opportunities Threat (SWOT) analysis summary of Charkharibari.

## 6. SWOT ANALYSIS OF JIGABARI VILLAGE

The SWOT analysis and summary of Jigabari village is presented in (Table 3).

### 6.1 Analysis Summary of Jigabari Village

Jigabari is located on the left bank inland of Teesta River in Bangladesh. From the Strength Weakness Opportunities Threat (SWOT) matrix (Table 5) of this territory we can see that the major strengths of this locality are followings. The area has a flood protection dam. There are a number of educational institutions in this area. It has stunning literacy rate of more than 70%. There is semi-permanent health care center in

this community. This village is directly connected with nearby city and other areas by road network. This locality is connected with national electrical grid. Several NGO's are working in this area on micro-credit and other programs. The agricultural land is very fertile and more 50% of them are triple cropped. There are a number of fresh water ponds available here. This area is engulfed with several problems and these are as follows. The flood protection dam is severely damaged and has a number of cracks and leakage. During flood water enters in the village through these cracks. Almost 50% land of this village is low lying, as a result flood water remain stagnant on those areas. There is no pucca road network in this settlement. During flood all these Kacha road become inaccessible. The ground water table is declining in an accelerated rate. As a result the fresh water ponds dried up during pre-summer and summer. Drinking water problem get worse on those periods. Number of landless family is around 35-40%. There is severe level of arsenic contamination in the ground water. Except agriculture there is almost no other type of economic activity is found, and fishing opportunity is very limited. During critical climatic stress periods the villagers' doesn't get enough relief. There are several opportunities for this place and the climate and geomorphology is suitable for agricultural production throughout the year also. Seasonal vegetables can be grown as side products. Connectivity with nearby city is good, so agro-products can be sold directly in the city. In the high ground "Indian Bay Leafs – Tejpata" can be cultivated which is highly profitable. Agro-based industry can be established. By taking effective measures 50% of the double cropped land can be converted into triple cropped. There are several threats for this village. These are as follows, several parts of village is getting more water logged. Health related problems are relatively high. Number of flash flood has increased. Intensity and duration of flash flood has increased and also in an alarming rate. During summer season the temperature threshold have increased resulted in severe heat stress, and meanwhile in winter season the temperature threshold have decreased resulted in severe cold wave. Intensity and duration of drought has increased. This is the Strength Weakness Opportunities Threat (SWOT) analysis summary of Jigabari.

**Table 2. SWOT analysis of Charkharibari village**

<b>Internal Factors</b>	
<b>Strengths (+)</b>	<b>Weaknesses (-)</b>
<ol style="list-style-type: none"> <li>1. This settlement has an international boundary.</li> <li>2. The village has a river protection dam.</li> <li>3. There is plenty of hard rock just beneath the soil.</li> <li>4. The numbers of youths are very high in this village.</li> <li>5. The remaining soil of this village is very fertile.</li> <li>6. The community has a quite a large number of solar powered house.</li> </ol>	<ol style="list-style-type: none"> <li>1. This settlement is situated in a very unstable Char land.</li> <li>2. There is no road network in the village.</li> <li>3. There is only one type of communication system and it is by boat.</li> <li>4. Due to several active forming Char lands in the river bed the communication system is very remote and time consuming.</li> <li>5. There is no permanent health care center.</li> <li>6. There are no permanent educational institutions and thus literacy rate is very low.</li> <li>7. This village is eroding in different places for last 6 years due to irregular river flow.</li> <li>8. There is flood shelter center in this village.</li> <li>9. At present there is not enough flood protection measure in this locality.</li> <li>10. There is no electrical grid in this area.</li> <li>11. Several Non-Governmental Organization's (NGO's) have closed their program in this village.</li> <li>12. The remaining agricultural land is filled with 3-4 feet of sand.</li> <li>13. Severe scarcity of drinking water.</li> <li>14. Limited types of agricultural crops can be grown.</li> <li>15. This community doesn't have any permanent market place.</li> <li>16. There is no modern high efficiency irrigation system such as deep tube wells.</li> </ol>
<b>External Factors</b>	
<b>Opportunities (+)</b>	<b>Threats (-)</b>
<ol style="list-style-type: none"> <li>1. Suitable for import-export and other border related market business.</li> <li>2. A quite large number of unemployed workforces are available.</li> <li>3. Planned stone collection can create a huge workplace for the locals as well as for businessmen.</li> <li>4. If the combined dam projected could be completed earlier, then village would be saved from riverbank erosion and flooding.</li> <li>5. Plenty of opportunity for fishing.</li> </ol>	<ol style="list-style-type: none"> <li>1. Increased rate of sand cover in the agricultural field.</li> <li>2. Rate of riverbank erosion is accelerated due to unplanned stone collection.</li> <li>3. Frequency of flash flood has increased.</li> <li>4. Intensity of flood has increased.</li> <li>5. Intensity and duration of drought has increased.</li> <li>6. In summer, heat stress has increased.</li> <li>7. In winter, cold wave has increased.</li> </ol>

**Table 3. SWOT analysis of Jigabari village**

<b>Internal Factors</b>	
<b>Strengths (+)</b>	<b>Weaknesses (-)</b>
<ol style="list-style-type: none"> <li>1. It is a highly agriculture dependent and productive area.</li> <li>2. Literacy rate is more than 70%.</li> <li>3. A flood protection dam is in the settlement.</li> <li>4. Connectivity with the city is good.</li> <li>5. This community is connected to the national electric grid.</li> <li>6. There is a semi-permanent medical center.</li> <li>7. Location of this village is in inland.</li> <li>8. Several NGO's are working here.</li> <li>9. Almost 50% of the agricultural land is very fertile (triple cropped).</li> <li>10. There are a number of fresh water ponds in the locality.</li> </ol>	<ol style="list-style-type: none"> <li>1. The flood protection dam is highly damaged and has a number of cracks.</li> <li>2. Almost 50% land of the vicinity in low lying.</li> <li>3. Flood water remain stagnant in several parts of the area.</li> <li>4. There is no pucca road network.</li> <li>5. There is no permanent medical facility in the village.</li> <li>6. The fresh water ponds are dying.</li> <li>7. During drought, there is a severe drinking water problem.</li> <li>8. During flood, locals get very less or no relief.</li> <li>9. Number of landless family is around 35-40%.</li> <li>10. Arsenic contamination is found in the ground water.</li> <li>11. Except agriculture there are almost no other economic activities available.</li> <li>12. This community doesn't have any permanent market place.</li> <li>13. Limited fishing opportunity is available.</li> </ol>
<b>External Factors</b>	
<b>Opportunities (+)</b>	<b>Threats (-)</b>
<ol style="list-style-type: none"> <li>1. Climate and geomorphology is suitable for agricultural production throughout the year.</li> <li>2. By taking effective measures, 50% of the double cropped land could be converted to triple cropped.</li> <li>3. Connectivity with city is good, so, agro-products can be sold directly to the city.</li> <li>4. In the high grounds "Indian Bay Leafs – Tejmeta" can be cultivated which is highly profitable.</li> <li>5. Seasonal vegetables can be grown.</li> <li>6. Agro-based industry can be established.</li> </ol>	<ol style="list-style-type: none"> <li>1. Village is getting more and more water logged day by day.</li> <li>2. Level of underground water is falling rapidly.</li> <li>3. Intensity of flood has increased.</li> <li>4. Intensity and duration of drought has increased.</li> <li>5. In summer, heat stress has increased.</li> <li>6. In winter, cold wave has increased.</li> <li>7. Health related problems are relatively high.</li> </ol>

**7. SUMMARY OF COMPARATIVE VULNERABILITY ANALYSIS**

Vulnerability to flood and drought is analyzed through SWOT analysis for Charkharibari and Jigabari villages. It is found that Charkharibari is more vulnerable than Jigabari village. On the contrary, Charkharibari has more opportunity than Jigabari village. However, based on SWOT analysis concept strategy has prepared in the following section of the study.

**8. SWOT MATRIX ANALYSIS FOR THE CONCEPT STRATEGY**

The Strength Weakness Opportunities Threat (SWOT) analysis is useful to decide the next step of making the concept strategy accurately. After doing this technique, every factor in Strength Weakness Opportunities Threat (SWOT) can be divided into four categories by using the cross tabulate table to identify it. These are strength and opportunity, strength and threat, weakness and opportunity, and weakness and threat. Each

**Table 4. Summary of comparative vulnerability analysis**

<b>Sl.</b>	<b>Factor</b>	<b>Charkharibari</b>	<b>Jigabari</b>
1.	Locational advantage	Situated in a remote island (charland).	Located in stable mainland.
2.	Flood protection	Has no flood protection dam.	Has a fully operational flood protection dam.
3.	Human resource	Have a large working class people.	Quite low numbers of working class people.
4.	Cultivable land	Mostly barren land.	Plenty of cultivable fertile land.
5.	Agricultural productivity	Substantial agricultural activity resulting very little agro-income.	Deep irrigation system provides triple crops in a year.
6.	Transportation system	Water logged and has no to little formal transportation system.	Holds far better interconnected formal transportation system.
7.	Literacy rate	Low.	High.
8.	Fresh water source	Scarcity of resource.	Adequate resource available.
9.	Administrative, institutional and organizational capabilities	Very little activities such as lack of educational institutions, electricity connection, tap water supply, healthcare facilities, and highly efficient irrigation system etc.	Has wide spread activities with far reaching capabilities.
10.	Major threats	Sand cover in the arable land is very severe and river bank erosion is also a major threat in this village.	Arsenic contamination in ground water is very acute here.
11.	Natural resources	Plenty of excavatable rock and boulders, which can be used in construction purpose.	No such resource is available.
12.	Future possibilities	Has plenty of fishing opportunity and after a certain period this locality will be protected from flood. Plenty of non-agro workplace can be created (such as stone collecting, border related import export business and boating) here.	Agro based industries can be established here.

**Table 5. The concept strategy of Charkharibari village**

<b>Internal External</b>	<b>Strength</b>	<b>Weakness</b>
<b>OPPORTUNITY</b>	Due to an international boundary there is plenty of possibility for border related export-import business.	After completing the dam there is a possibility of improved communication system.
	As the youth rate is very high so there is a ready work force available.	After completing the dam there is a possibility reduced flooding and riverbank erosion.
	Planned stone collection can create a strong income source.	After completing the dam there is a possibility of improved educational facility.
	Fishing opportunity can create another huge income source.	After completing the dam there is a possibility of improved health facility.
	After completing the dam the village can be agriculturally productive because the remaining land is very fertile.	Solar powered irrigation can be helpful to solve the water scarcity problem.
<b>THREAT</b>	Due to an international boundary there is threat of smuggling.	Sand cover is a large threat to agro-production.
	Due to high unemployment there is threat of high crime rate.	Increased heat stress in summer coupled with water scarcity could worsen the situation.
	Unplanned stone collection can accelerated the rate of riverbank erosion.	High riverbank erosion rate would slow the dam construction.
	Illegal fishing equipment can lead to extinction of several local varieties.	Increased intensity of climatic stresses will hamper the possible future economic sectors.

**Table 6. The concept strategy of Jigabari village**

<b>Internal External</b>	<b>Strength</b>	<b>Weakness</b>
OPPORTUNITY	<p>By taking cheap effective measures such as sand filling 50% of the low lying land can be converted into high lands.</p> <p>Agro-based market and industries could be established if the village's inter-connectivity gets improved.</p> <p>Because of high literacy rate, empowerment efforts and providing knowledge on disaster management would be easy.</p> <p>Due to national grid electrical availability urbanization rate in this village will be faster.</p> <p>NGO's working in this village can improve health facility.</p>	<p>Poor condition of the dam will lead to more flooding in near future.</p> <p>By cheap sand filling from the nearby Teesta river, the flood water stagnant area can be reduced.</p> <p>About 35-40% landless family member could be an instant workforce.</p> <p>Agro-based market and industries would diversify income sector.</p> <p>Low lying areas can be used for fish cultivation.</p>
THREAT	<p>Using high efficiency irrigation system such as deep tube wells would lead to future underground water scarcity.</p> <p>Due to high literacy rate there is threat of high civil society migration rate.</p> <p>Unequal distribution of agricultural land would cause future severe economic discrimination.</p> <p>As the ground water is declining rapidly in future this village could turn into a non-agro productive area.</p>	<p>Increased heat stress in summer coupled with water scarcity could worsen the situation.</p> <p>Increased intensity of climatic stresses would hamper the possible future economic sectors.</p> <p>High ground water declination rate would slow down the agro-production rate.</p> <p>Overall agro-production cost would be increased.</p>

category will produce different plans based on a combination of conditions and problems. The combination of the positive and negative aspects should be combined, so that there are positive aspects to overcome the negative aspects that exist in synergy. The concept strategy of two villages can be seen to the (Tables 5 and 6).

## 9. CONCLUSION

Based on the analysis and findings of this research, following conclusions are drawn. In the lower Teesta Basin area, people repeatedly confronted by natural catastrophe in almost every year such as drought and flood. In terms of vulnerability Charkharibari is more vulnerable than Jigabari. But there are more opportunities for Charkharibari than Jigabari. So, drought and flood induced critical periods are more acute in Charkharibari village. Besides, coping capacity against these critical periods are highly influenced by income, occupation, education, frequency and duration of hazards. Peoples' demand varies during and after these critical periods [22]. However, it is evident that proper dissemination of information regarding early warning and assistance from governmental as well as non-governmental organizations can significantly improve the coping capacity and reduce the vulnerability of the inhabitants' of Charkharibari village.

## CONSENT AND ETHICAL APPROVAL

The authors confirm that the ethical policies have been adhered to. As per international standard or university standard guideline ethical approval & participant consent has been collected and preserved by the authors.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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