

Assessing the Status of Flood Hazard on the Bank of Mohana River in Kailari Rural Municipalit, Nepal

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ABSTRACT

Purpose: *Kailali holds number of rivers originating from Mahabharat range and Chure range which get flooded every year, causing high losses of agricultural land and the flooding at community level. In order to identify and understand the probable risks in the study area and the methodologies followed to get rid of the flood risk or to protect the land and community from the effect of flood.*

Design/Methodology/Approach: *The study was conducted during the period from March 2022 to May 2023. Field observation, in-depth interview, focus group discussion and questionnaire survey were the major tool applied for the investigation.*

Findings/Results: *The study found that the flood is the major hazard, and the earthquake is the minor one. River encroachment is the major one problem of the river training works and inadequate people's awareness is the minor one. The river down to Chure carries lots of sediment and thus increasing the bed loads. Thus, Chure protection programs must be effectively executed so that the lower plain will be sediment less and the inundation of land will be reduced.*

Originality/Value: *The paper contributes on the effective ways to protect community from flood hazards*

Keywords: Flood, River training structures, Low-cost, Mega structure, Bamboo, Catchment area, Bank erosion, Encroachment of river.

1. INTRODUCTION :

Nepal is profoundly impacted from water-incited catastrophe. As far as relative weakness, Nepal has been positioned as the 30th most in danger to floods and avalanches (UNESCO-IHE 2004 [1]). The Terai area of Nepal is thought of as one of the severest flood risk zones on the planet. The flood happens pretty much consistently in one piece of the nation or the other making death toll and weighty harm actual properties (Ghimire, M., et al. (2023). [2]). It consequences for the existences of the people in question and human settlements. Nepal is one of the much of the time fiascos impacted nations on the planet. Nepal positioned 23rd on the planet as far as the complete normal peril related passings in twenty years from 1988 to 2007. The significant reasons for flooding in Terai locale are high precipitation, soil disintegration, level geography, garbage streams and sedimentation, waterway channel relocation, anthropogenic causes like blockage of seepage framework, deforestation, lack of common sense, plan and development practices of streets, and monstrous increment of settlements along East-West roadway. This issue should be taken care in transport planning also (Mishra, A. K., & Aithal, P. S., (2022). [3]).

2. STATEMENT OF PROBLEMS :

Nepal being rich in water resources. The review region exists in the subtropical storm environment where winter stays cool and summer is blistering. Almost 80% of precipitation happens in the mid-year rainstorm season between June to September and these months are the horrendous months with regards to flooding. As indicated by meteorological station, Aattariya Kailali around 15% downpour happens during the post storm (October) and pre-rainstorm seasons (April to May) and the leftover 5%

throughout the colder time of year (November to February). The mean yearly precipitation is 2400mm with around 90% falling in the storm from June to September. Storm downpours cause sensational floods and shifts in the person and directions of waterways [2].

Flood is the natural hazard that when encounters with the vulnerable elements, has tendency to cause massive loss of both property and life. Development achieved in tenure of time can easily be flushed away in no time.

The people residing in the study area are regular victim of the flood and are always affected by the negative consequence of the flood. Thus, this research aims to study at the impact level by analysing at what level the community are protected by the low-cost technology and is it really worthy or not.

3. OBJECTIVES :

To analyse the status of flood hazard and application of low-cost River training works Mohana River in Kailari Rural Municipality.

4. METHODOLOGY :

4.1 Study Area:

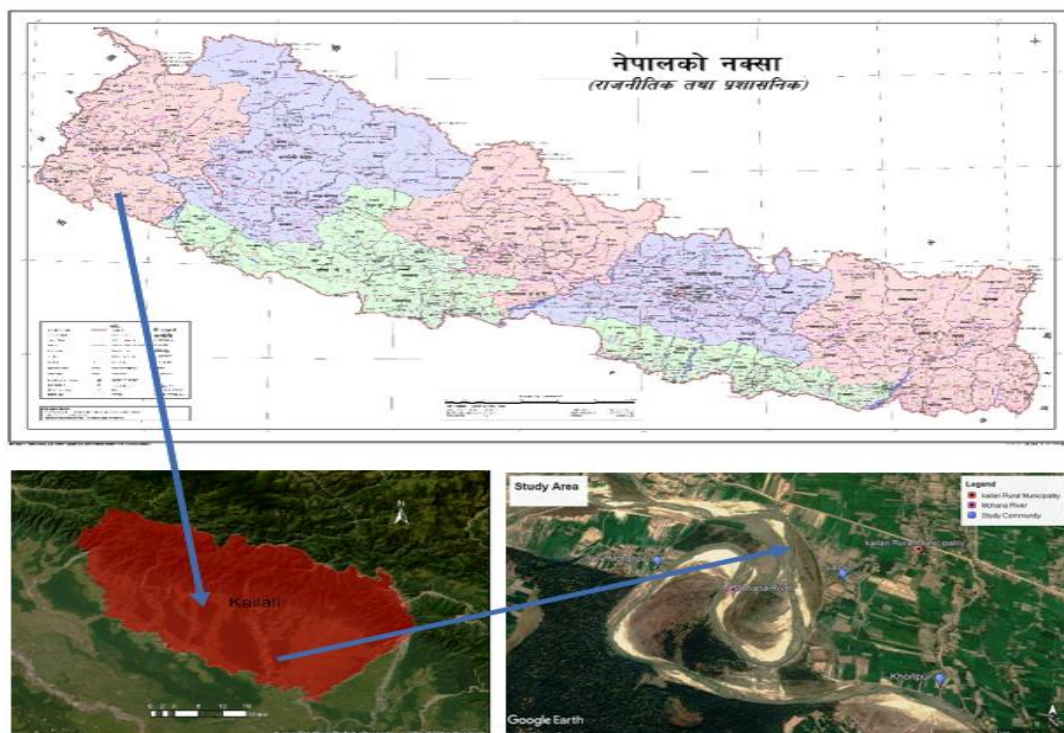


Fig. 1: Study Area

Mohana river flows touching the boundaries of Kailari Rural Municipality. Lalpur, New Mohanpur, Khonpur, Badka Ratanpur are adversely affected by the flood of Mohana River. These are the community that is situated right at the bank of the Mohana River. Majority of the people of the area are dependent on traditional agriculture. The river has affected their agricultural land a lot. The people are facing lots of problems due to the flood that Mohana River carries. The figure 1 explains in detail about the area that is studied [4].

4.2 Nature and source of data:

4.2.1 Nature of data:

Qualitative Data

The data deals with quality, so that they are descriptive rather than numerical in nature. They are generally not measurable, and only gained mostly through observation. Narratives often make use of adjectives and other descriptive words to refer to data on appearance, color, texture and other qualities. Qualitative data has been found out by field observation, focus group discussion and interview.

Quantitative Data

These are data that deal with quantities, value or numbers, making them measurable were obtained from questionnaire survey.

The Primary data are collected by semi structured questionnaires, in-depth interviews, focus group discussion and field observation in Mohana River.

In this study, primary data as questionnaires is collected among the questionnaires distributed. The respondents are affected area villagers, social worker and concerned authority. Also, professional expert interview is also taken for this study. Focus group discussions were also conducted at along the Mohana River.

Field observation:

In this method visiting the alignment and observing the main issued areas is carried out which could be particularly helpful to collect the real data. The affected within the area under consideration is taken for the study. The data of different structural measures collected from related agencies are verified in the field and physical verification of the function of the anti-flood measures in the area under consideration is done to get real picture of the works done in the past.

Focus group discussion:

Discussion with the related community group is conducted and the data is collected according to the structured question. Local users and local public representatives are involved in each FGD.

In depth interview:

In depth study is conducted with the public representatives of the study area and with the expertise of river training works. Data were collected, verified and analyzed.

Questionnaire survey:

In this study, scaled questions are used to get the responses from the representing the involving river training works in Mohana river and other such as Engineer, consultant, contractors, teacher, social worker and policy makers.

4.2.2 Data Analysis:

Collected data are grouped and analyzed by frequency analysis using MS- Excel.

Relative Importance Index (RII):

The RII is used to evaluate the ratings of the respondents. In this research, Likert 7-point scale were used to determine relative importance index (RII) for the factors indicating status of river, causes and effects in river/community, solutions for better river training and preparedness for better river training. The value of RII is in the range of 0 to 1 (0 not inclusive). The higher the value of RII, the more important the attributes/variables of respected topic and ranked at top. Ranking of the attributes/variables are arranged in ascending order:

Table 1: Relative Importance Index (RII)

Scale	1	2	3	4	5	6	7
Item	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree

The formula for deriving RII for each factor is given as follows: -

$$RII = \frac{\sum W}{AN} = \frac{(7n7 + 6n6 + 5n5 + 4n4 + 3n3 + 2n2 + 1n1)}{7N}$$

Where, W the weighting given to each factor by the respondent, ranging from 1 to 7; n7 number of respondents selecting total strongly agree; n6 number of respondents selecting total agree; n5 number of respondents selecting total somewhat agree; n4 number of respondents selecting Neither agree nor disagree; n3 number of respondents selecting somewhat disagree; n2 number of respondents selecting disagree; n1 number of respondents selecting total strongly disagree; and N the total number of respondents.

5. RESULT AND DISCUSSION :

5.1 The status of flood hazard and the associated risk level:

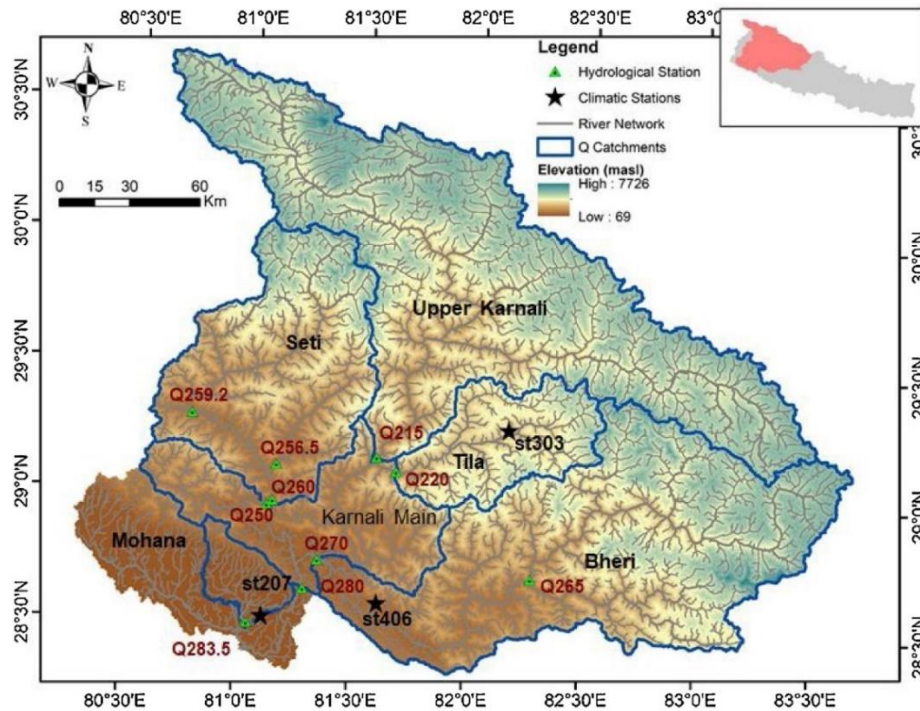


Fig. 2: Mohana River

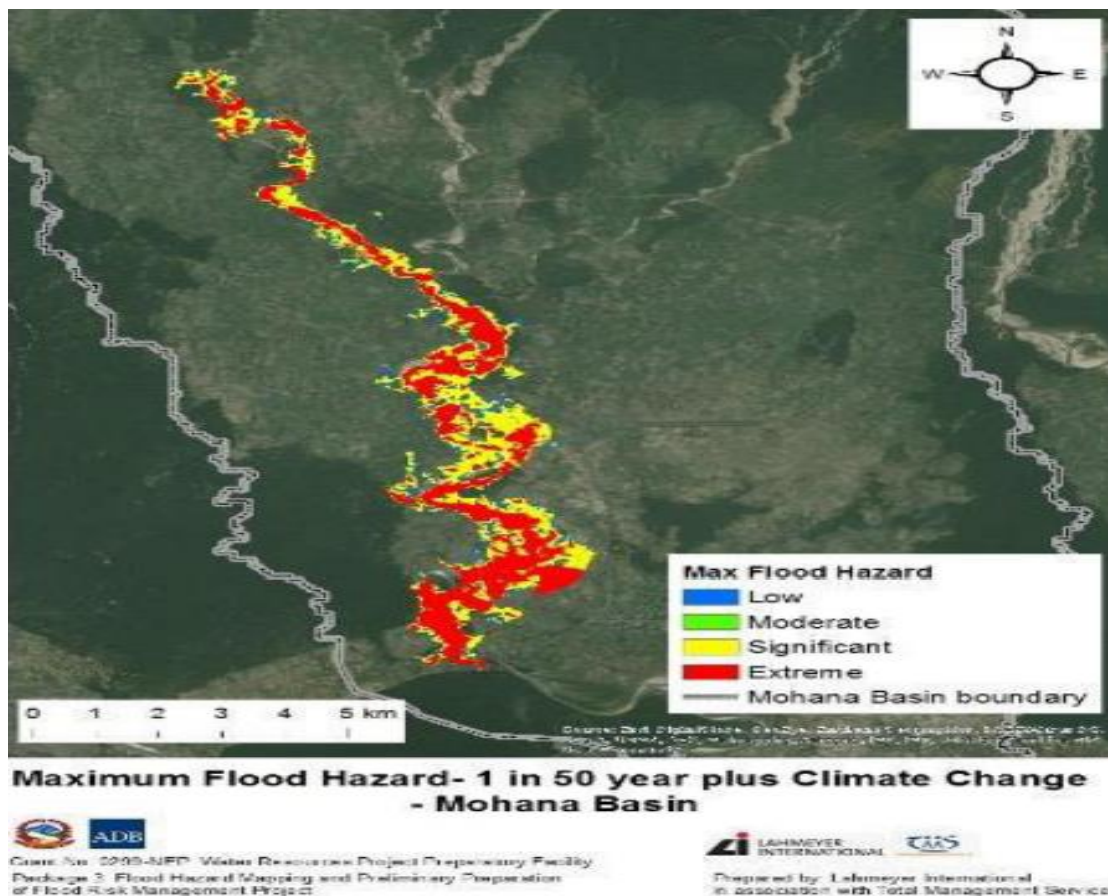


Fig. 3: Hazard Map of Mohana Basin

Prevailing hazards and their risk level in target community

There were 6 major prevailing hazards listed in the target communities. The respondents responded differently for different hazards. However, during study the hazard and the risk associated with the hazards, the hazard Flood (RII=0.85) was ranked as bigger or major hazard and Earthquake as the minor one (RII=0.21). All options and their respective values are presented in figure (figure 4.).

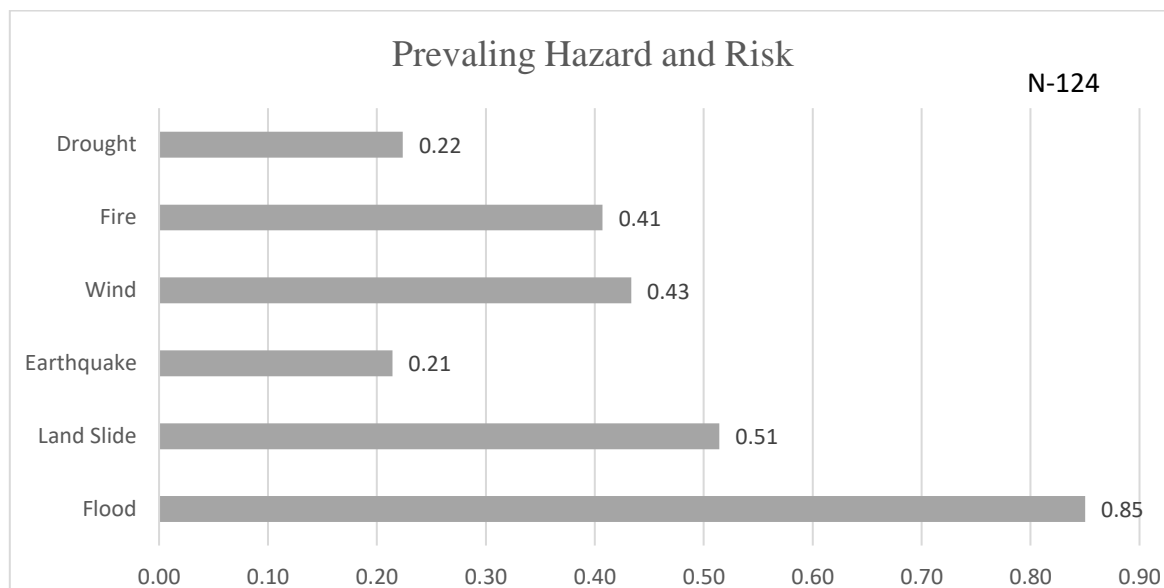


Fig. 4: Respondent analysis on prevailing hazards and risk in target community.

From above RII analysis, it is seen that the flood stands at top level of hazard making adverse effect to the community and settlement.

Generally, at the time of monsoon, the river carries large amount of discharge and gets flooded everywhere getting inundation of nearby cultivation land, settlement, erosion. When monsoon goes, the area is dry again. And there exist other types of hazards such as drought, fire. Further studies are required in case of fire and other hazards.

From above RII analysis, it is seen that the flood stands at top level of hazard that holds maximum risk to the community and the settlement. Mohana river originate from Mahabharat range, crosses Chure range and flows down to terai of Sudurpaschim Province. The watershed area of Mohana alone is 3730 km². Major cause of flooding in Mohana is the rainfall and the rainwater carried out by other rivers those are originated from Chure. The floods that come from chure originated rivers are flash flood type and carries lots of sediments and gets deposited in nearby lands. The area nearby Mohana river gets sufficient water for irrigation purpose but, there are some areas which get sedimented by the Chure originated rivers. Due to this, those area suffers from drought.

At the time of flood, there is inundation, cutting everywhere. Houses are destroyed, agriculture are destroyed, cattle are washed away, few casualties with human as well. The situation is very vulnerable and thus causing excess loss. When the flood is over, the sediments those are carried during flood, get deposited everywhere turning out the agriculture land into desert. So, for running livelihood smoothly, innovation for doing agriculture in those barren land is must. There are many technologies of doing riverbed farming, this could be adopted. So, innovative technology will be required for doing cultivation in that area. There are some initiatives done in Sahara Desert.

From the Fig. 5, it is seen that even in Sahara Desert also, the farming has been started. The Sahara Desert is an arid environment with little, if any, rainfall. Further, obtaining credible estimates of rainfall in the region is a major challenge. Thus, other variables (e.g., temperature, air mass movement, vegetation cover, latitude and longitude, etc.) have been used for estimating the effective rainfall amount [5]. where the climate is characterized by low rainfall, relatively low production levels, land pathways often suffering from advanced degradation. Here we see that there are lots of initiatives taking place around the globe. In case of the study area as well the scenario is almost same that is heavy

sedimentation. If the similar methodology can be adopted as that of Sahara Desert, here also the agriculture can be done even in the worst scenario of sediment deposition. So, study on feasibility of that technology is also must for running the livelihood of the community along the Mohana River.



Fig. 5: Agriculture initiation in Sahara Desert

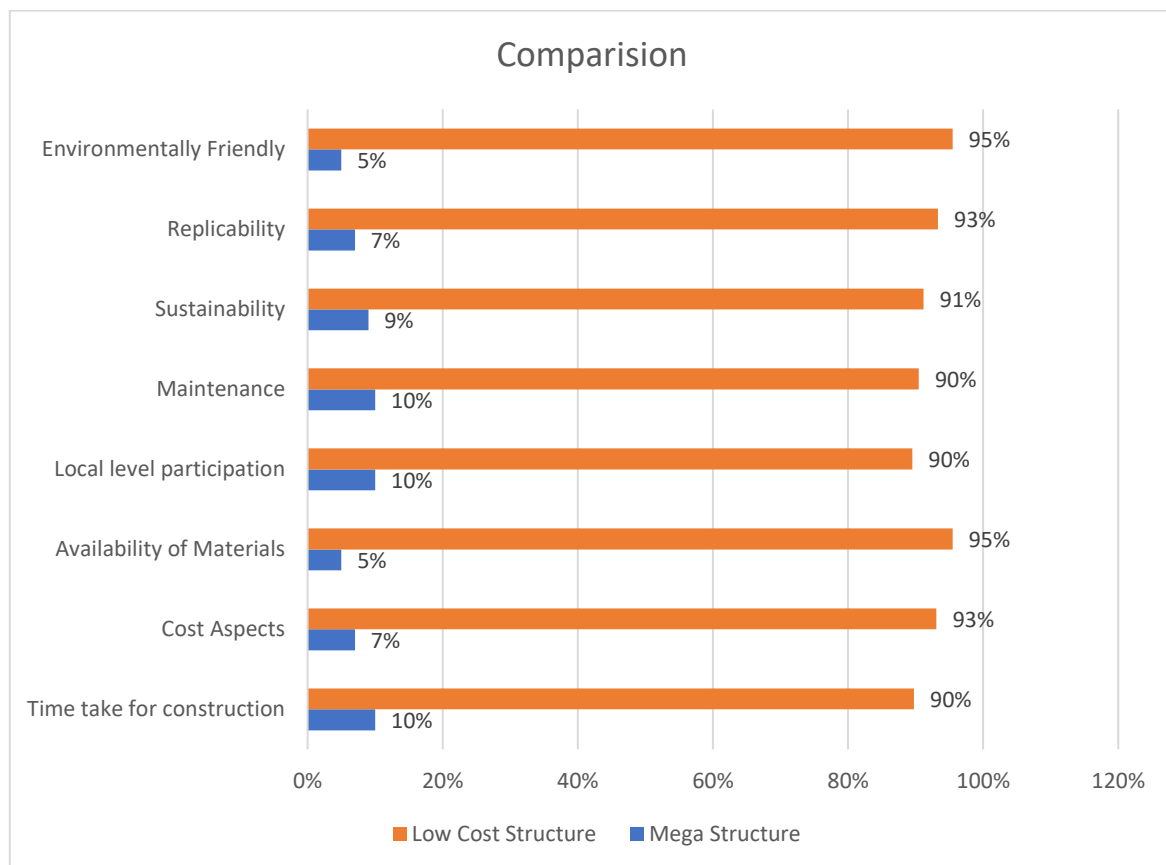


Fig. 6: Combined comparison of mega structure and low-cost structure

5.2 Cost effectiveness of different parameters of river training solutions (Mega structural protection works and Low-Cost protection works) of river protection measures in Mohana River.

There were 8 major parameters listed related to cost effectiveness of different parameters of river training solutions in Mohana River. The respondents responded differently for different solution. From the comparison, it was seen that the low-cost technology is highly preferred at the local level. This could be also due to quick construction adopting low-cost construction methodology at the time of emergency.

From the KII, it is found most of the local people are in favour of low-cost river training works. They said, this requires less budget, materials are easily available and there is good community participation and can be completed in quick time. There are many NGOs, INGOs, red cross who do this kind of works. They further said, at least their land and property are saved due to this technology. Else, if they wait the government. Saveral manuals has suggested the methods [6-10].

Table 2: Cost of low-cost river training works
Structural Mitigation Schemes (Bioengineering and Bamboo Structure)
April 2020 to March 2021

District	River system	Community	Name of Scheme	Length (rn)	Total cost	MRED	Community	Benefited		Area protected in Bigaha
								HHS	Valuable HHS	
Kailali	Mohana	Basanta	Bamboo Mitigation	200	353,072.00	196,582.00	156,490.30	162	36	10
Kailali	Mohana	Badka Ratanpur	Bamboo Mitigation	220	405,807.00	205,807.00	200,000.00	100	40	12
Kailali	Mohana	New Bishanpur	Bamboo Mitigation	200	353,072.00	196,582.00	156,490.00	86	13	8
Kailali	Mohana	Khonpur	Bamboo Mitigation	200	234,240.00	196,888.00	37,352.00	79	13	20
Kailali	Mohana	Lalpur	Bamboo Mitigation	200	363,510.00	196,760.00	166,750.00	49		9
Kailali	Mohana	New Mohanpur	Bamboo Mitigation	300	303,975.88	247,947.88	56,028.00	86		1
Total				1,320.00	2,013,676.88	1,240,566.88	773,110.00	562	118	70
Const of Construction					1,525.51					

(Source: River Training Works, NRCS, Mercycorps Nepal, 2020; office record)

Table 3: Cost of mega structure river training works
Name of Project: Hadiya River Training Project
Name of Work: Construction Revetment
Length : 6:00 AM

SN	Description of Work	Quantity	Rate (NRS)	Unit Per	Amount (NRs)
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1	Earth work in excavation of soft clay & silty soils for launching including 10m lead & 1.5m lifts.	360.00	281.19	m ³	101.228.40
2	Boulder supply and filling in gabion boxes 2*1*.4 and 1.6*-1*.4 including stretching closing and tying etc. all complete.	864.00	4.500.00	n ³	3.888.000.00
3	Supply and Making 10 Gauge Medium Zinc Coating G. I. Wire rectangular gabion boxes of 21*.4 and 1.6*1*.4 see with two way knot having mesh see 150mm x 150mm including cutting. netting etc all complete according to site incharge.(Derived from 2.0 x 1.0 x 0.5m =7.00 rif)	7.008.00	195.18	m ²	1,367,852.98
4	Gabion construction work including placing in position tying gabion by 12 SWG LIZC GI tightining wire closing from the top As per Norris of DOLIDAR Sib 44.2.	840.00	105.81	Kg	88.880.40
5	Supply. Laying and joining of NP2 class (45cm dia & 2.5m long) humpipe and its accessories with 1:2 cement sand mortar. jute etc. including haulage upto 100m distance all complete	4.00	10.505.86	2.5 Rm	42.023.45
Sub Total					5,487,985.23
Construction Management Cost @2%					109,759.70
Total					5,597,744.93
Grand Total					5,597,744.93

(Source: River Training Works, CFGORRP/DHM/UNDP)

Table 3.a represents an estimate of the low-cost river training works that is combination of bamboo works followed by bioengineering. Table 4.3.b represents estimate of river training works that is done using gabion boxes. In case of low-cost river training works, the cost per meter is around Nrs 1500 and in case of mega structure; the cost per meter is around Nrs 9000. From this we see that the low-cost river protection works is almost 6 times cheaper than that of the mega structure one. Its technicality can be assessed from manuals and documents [11-15].

5.3 Consistency of samples:

To check the consistency of the samples collected during study, t-test was done. From table 4, it is seen that the value of t is nearly equal to zero, this signifies there is uniformity in sample. Also, the difference of individual mean is almost constant, means there is uniformity in survey of both samples.

Table 4: T-test to check the uniformity of the sample.

Parameters	Protection works		Calculated Test	Mean		Mean difference
	Mega Structure	Low cost		Megha	Low cost	
Time taken for construction	0.13	0.90	9.43E-89	1.98	6.39	4.41
Cost Aspects	0.10	0.93	3.47E-83	1.75	6.51	4.76
Availability of Materials	0.21	0.95	1.44E-72	2.63	6.80	4.17

Local level participation	0.06	0.90	9.43E-89	1.49	6.46	4.97
Maintenance	0.09	0.90	3.47E-83	1.75	6.51	4.76
Sustainability	0.05	0.91	1.44E-72	2.63	6.80	4.17
Replicability	0.03	0.93	2.16E-89	1.49	6.46	4.97
Environmentally Friendly	0.06	0.95	7.45E-74	1.32	6.49	5.17
			total	15.03	52.41	
			Mean of Mean	1.88	6.55	4.67

Low-cost river protection works also termed as soft engineering has comparatively lesser strength at the beginning but the strength increases during long run. In case of the mega structure, the scenario is just opposite.

5.4 The Opportunity of low-cost river training works:

Below are the opportunities related to the low-cost river training works identified during the study.

Local Economic Enhancement:

The low-cost river training is the work is that methodology of embankment where the local people are involved in the entire stages utilizing majority of the local resources available locally. This does two economic activities at the local level. One is that this creates short term occupation causing increase in local income. Second is that, this technology uses local resources such as bamboo that ultimately increases the local economy. Thus, this technology uplifts the local economy of that certain place where it is executed.

Environment Protection:

The low-cost river training works are executed by locally available natural resources that have almost negligible impact on the environment. There are several bioengineering techniques done for protection of riverbank. These are absolutely environment friendly. This allows the flow of the river confined to their natural flow direction. Thus, the low-cost river protection measures are also one of the environment protection measures.

Cheaper and Replicable technology:

This technology is cheaper and requires very low technical knowledge. Thus, this technology is highly replicable. During study it was seen that most of the communities have adopted the same technology that was initiated by some other community. Also, the materials used in this technology are very cheaper and can be available almost everywhere. Bamboo is one of the best example of the materials that is available everywhere.

Lesser time required and less qualified/trained human resource is needed:

This technology is executable in very less time. Also, this technology can be done by the human resource with limited technical knowledge. This is the reason why this technology is highly preferable during the time of emergency where there is limited time, budget and limited availability of trained human resources.

Easy maintenance:

This technology is very easy to maintenance. The maintenance can be done by utilizing local resources. For the maintenance of other heavy protection works, one need to wait for the government agencies, and this takes more time. But in this case, the repair and maintenance are done at local level utilizing local resources. A minimum of budget is sufficient for its maintenance. And this budget can also be easily managed by the local government as well [16-22].

5.5 The Challenges of low-cost river training works:

Below are the challenges related to the low-cost river training works identified during the study.

Poor policies and inactive support from government

During study, it is found that there are not any dedicated policies or acts formulated in regard to implementation and execution of these kinds of low-cost river protection measures. Even government of Nepal, either local level or provincial level or the federal level, none of these levels have any active or direct support in this type of technology. The importance is given to the high or mega structures and the periodic planning is done accordingly. During the planning, the smaller structures those play very vital roles during the time of emergency are generally avoided or taken at least priority. This is one of the reasons why the local people prefer the low-cost structure as this technology provides the immediate reliefs than that of the one which come through numerous stages of planning process and due to limited budget available to the government, the mega-structure do not cover all the affected areas.

Also, from very beginning, the non-government agencies are involved with construction of low-cost technology. This is because the non-government agencies implement those activities under certain project which has limited budget and certain fixed duration. So, to achieve more impact, they prefer to go with low-cost technology that will make more impact within less budget and result can be delivered in quick time.

Now, the government believes that these kinds of protection works are of the non-government agencies. The government agencies exist for only mega or massive structures. This misunderstanding has also created issues in implementation of low-cost river protection works at local levels.

Local government believes that this kind of river protection works are to be executed at the time of emergency conditions only. The government believes that these low-cost technologies are for sort term only, this cannot continue the functionality in long run. This is the reason why the government agencies do not put more priorities on these kinds of technologies of river protection.

Geographical Challenges

From study it is found that the low-cost technology such as the structure constructed out of bamboo are suitable in plane land where the river grade is very mild. In case of the upper chure and the hilly areas where the grade of river is very high, this technology fails in its functioning. So, the technology is best suited in low plane area where the slope of river is very mild. For the river with the high grade, this technology is found not be suitable[16-22].

5.6 Some issue found during observation

Some of the issues were identified during study. These are as presented in the table 5.

Table 5: Issues found during observation

Location	Issues	Proposed solution
New Mohanpur, Lalpur, Khonpur, Bishanpur of Kailari Rural Municipality	Excessive riverbank erosion and inundation of nearby cultivation land and settlements.	Appropriate structures of appropriate technology to be constructed.
	There is regular riverbed aggregation due to siltation carried from upstream.	Deforestation in upstream need to be stopped and conservation of forest in upstream must be done.
	Temporally structural measures were constructed such as bamboo piling spurs and revetment i.e., emergency solution only.	Gabion structures such as stud, spurs, revetment with embankment to be constructed.

From study it is seen that majority of local people of study area preferred low-cost river protection works over the mega structure for riverbank protection works. The study showed that the low-cost riverbank protection works have the positive aspects with environment friendly, replicability, sustainability, maintenance, participation, availability of materials, cost and time take for construction. People prefer more low-cost technology over the mega structure. Further there are lots of opportunities related to the low-cost river training works such as this technology enhances the local economy, protecting environment, cheap and replicable technology, lesser time required for construction along with less trained human resources and easy in maintenance [23]. Besides the opportunities, there are

some challenges of low-cost training works are identified as poor policies and inactive support from the government, geographical challenges such as this technology is site specific. This technology looks efficient on the plane area and less functional in the hilly area where the river is steeper.

Human settlements in the Sundarbans deltaic locale of India have taken on a technique for raising banks along the riverside to forestall stream water from gushing out over into the colonized regions. These dikes foster undermines at the toe district that led to disappointment from the whirling flows combined with flowing floods serious areas of strength for and to safeguard the bank from disintegration, the dike face is covered with bamboo logs, as bamboo is effectively accessible locally and is financially suitable [19]. Notwithstanding, from field examinations the utilization of bamboo logs for the anticipation of dike disintegration is viewed as insufficient in the Sundarbans area. The current examination was completed to form knowledge into why the utilization of bamboo logs for dike assurance doesn't address an ideal answer for bank adjustment. The ongoing work accentuates an evaluation of the violent stream qualities in vicinity to the bamboo logs and silt bank interface [25]. Shakes and sand are uncommon in the Sundarbans region of the lower Indo-Gangetic Plain; in this way, bamboo logs are the least expensive and just promptly open material for bank assurance. Bamboo logs offer underlying qualities permitting them to act as an important essential development material [22-27]. The organic attributes of the bamboo like fast development, simple multiplication, and root union elements increment its high vegetation spread capacity. Accordingly, bamboo fills in as the great asset for soil bioengineering and is generally utilized for adjustment and slant security purposes [22-27].

From various initiatives across the globe, it is seen that there is extensive practice of low-cost river protection works, especially the bamboo works. In this study also similar impression is found at study area. So, this technology looks more effective in context to the developing countries like Nepal and the vulnerable community who lives near the riverbank. The green approaches have been found to be imitated in Banking to Building sector of Nepal which shows further analysis to promote cost effective and environmental approaches (Mishra & Magar, 2017: Mishra & Rai, 2017: Mishra, & Aithal, 2022: Mishra, A. K., & Aithal, 2023) [27-31].

6. CONCLUSION :

From the study, it is seen that the flood stands at top level of hazard that holds maximum risk to the community and the settlement. Mohana river originate from Mahabharat range, crosses Chure range and flows down to terai of Sudurpaschim Province. Major cause of flooding in Mohana is the rainfall and the rainwater carried out by other rivers those are originated from Chure. The floods that come from chure originated rivers are flash flood type and carries lots of sediments and gets deposited in nearby lands. The area nearby Mohana river gets sufficient water for irrigation purpose but, there are some areas which get sedimented by the Chure originated rivers. Due to this, those area suffers from drought. At the time of flood, there is inundation, cutting everywhere. Houses are destroyed, agriculture are destroyed, cattle are washed away, few casualties with human as well. The situation is very vulnerable and thus causing excess loss. When the flood is over, the sediments those are carried during flood, get deposited everywhere turning out the agriculture land into desert. So, for running livelihood smoothly, innovation for doing agriculture in those barren land is must. There are many technologies of doing riverbed farming, this could be adopted. So, innovative technology will be required for doing cultivation in that area. There are some initiatives regarding cultivation is done in Sahara Desert and this could also be followed.

From study it is seen that majority of local people of study area preferred low-cost river protection works over the mega structure for riverbank protection works. The study showed that the low-cost riverbank protection works have the positive aspects with environment friendly, replicability, sustainability, maintenance, participation, availability of materials, cost and time take for construction. People prefer more low-cost technology over the mega structure. Further there are lots of opportunities related to the low-cost river training works such as this technology enhances the local economy, protecting environment, cheap and replicable technology, lesser time required for construction along with less trained human resources and easy in maintenance. Besides the opportunities, there are some challenges of low-cost training works are identified as poor policies and inactive support from the government, geographical challenges such as this technology is site specific. This technology looks efficient on the plane area and less functional in the hilly area where the river is steeper. From various initiatives across the globe, it is seen that there are extensive practice of low cost river protection works,

especially the bamboo works. In this study also similar impression is found at study area. So, this technology looks more effective in context to the developing countries like Nepal and the vulnerable community who lives near the riverbank. The nature-based solutions such as implementation of low-cost river embankment works with bamboo supported by extensive bioengineering must be done for long term solution. This creates short term employment as well as making extensive use of local resources.

7. ACKNOWLEDGEMENT :

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