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Research Article

EVALUATION AND EFFECTIVENESS OF RIVER TRAINING WORKS WITH SPECIAL FOCUS ON TINAU RIVER IN RUPANDEHI DISTRICT OF NEPAL

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ABSTRACT

Flood in Tinau River is very common since past decades. It has damaged several houses, cultivated land and live stocks in the past and continues till the date. Hundreds of hectares of cultivated lands have been deposited with sand and debris making the land unsuitable for farming. The governments of Nepal and local bodies have been launching projects for flood control. Various types of structures were built in the past. Millions of Nepalese Rupees have been invested for river training works. However, the river training works is not functioning well. This study was conducted during the period from March 2019 to April 2020. The objective of this study is to evaluation the effectiveness of river training works with especial focus on Tinau River in Rupandehi district of Nepal. Field observation, in-depth interview, focus group discussion and questionnaire survey were the major tools used for the field investigation. The study found that the extraction of river bed materials and unmanaged catchment area are also the causes of the ineffectiveness of the river training works. It also includes lack of monitoring and supervision, socio-political pressure and lack of enforcement of law and policies. Similarly, some other causes are inadequate co-ordination between line agencies, inadequate plan and policies and lack of awareness are the minor causes of ineffective river training works. Furthermore, inadequate maintenance of built up structures, irresponsible of beneficiary group, unmanaged population growth at catchment area were also found causes behind sustainability of the river training works. The study would like to suggest that the river bed extraction should be conducted in a balanced way. And, hydrological, geological and geotechnical studies should be conducted in detail before design of the river training structures. (*Abstract*)

Keywords— River training structures, catchment area, bank erosion, encroachment of flood plain area. (key words)

I. INTRODUCTION

Tinau River originates from the Mahabharat Mountains and follows through the Siwalik Hills to the south of Nepal. It has four tributaries namely Dobhankhola, Sisnekhola, Bhaiskattakhola and Jhumsakhola. The length of this river is about 95 km from Palpa (source) to the Indo-Nepal Border at Marchawar (Rupandehi), Nepal [1]. The width of this river varies from place to place. Generally, the width is very less upstream and it is larger as it flows downwards. The Tinau River occupies 1,081 sq. km. catchment area. This river supplies irrigation water to the farmers as well as water for daily use such as drinking, washing clothes and dishes for people for their everyday life. It has a considerable amount of water in the dry season but during the monsoon, the river carries a huge discharge. The floodwater results in spilling over the banks erode of lands adjacent to the bank, as well as the submergence of the larger plain area especially the downstream of the river.

Since the past decades, the floods in the Tinau River have damaged several houses, cultivated land and live stocks. Several people have lost their lives every year since the past. Some people have become landless due to the floods of the Tinau River. Hundreds of hectares of cultivated lands are deposited with sand and debris during the monsoon, making the land unsuitable for farming. Floods of the Tinau River are washing away the infrastructures built along the banks every year. Transportation facilities become disturbed during the flood [2].

To reduce the flooding problems in recent years, the river has been trained at vulnerable locations from Butwal (E-W highway) to Nepal- India border. Different agencies have undertaken the river training works of Tinau but the dominant role has been played by the Government of Nepal.

Flood in Tinau is a serious problem from the past as it is the cause of losses of different natural resources including human lives. A properly planned, designed and constructed works serve the purpose well but on the other hand improperly designed and constructed infrastructures do not serve the purpose well [3].

The river training works are carried out by considering technical, social, economic and environmental aspects. They have been found helpful in enhancing the confidence of the people. They have confidence that a responsible government agency and stakeholders are working their best to save the people and property from the damaging effect of floods. It is necessary to carry out proper maintenance of the anti-flood infrastructures made in the past. There is a lack of coordination between different stakeholders involved in the river training works. Thus, this study focuses on the aforesaid problems. The objective of this study is to evaluate the effectiveness of river training works with an especial focus on the Tinau River in the Rupandehi district of Nepal.

II. LITERATURE REVIEW

Nepal is situated between the two large and densely populated countries of Asia - China in the North and India in the South, East and West. Ecologically, the country is divided into three regions namely; the Terai, the Hills and the Mountains [4].The Tinau River originating from Mahabharat Mountains flows through Terai and passes into India having 95 Km length and 1081 Sq. km catchment area in Nepal [1]. Like other rivers in the world, the Tinau River has also its civilization. Ancient civilization arose in the valley of the large river including the Tigris and the Euphrates in Mesopotamia, the Nile in Egypt, the Indus in present-day Pakistan, and the Yellow River in China. These valleys were the formation of cities and organized agriculture. They are also known as the birthplace of river engineering which is less known. The first ruling dynasties in Egypt and china were established by ancient river engineers. Around 3100–3000 BC, the first Egyptian pharaoh Menes (Narmer) built a dam across the Nile River to create ideal conditions for his new capital Memphis. Around 2200–2100 BC, the first Chinese emperor Yu the Great designed a flood-control technique that involved giving the river additional space rather than simply building dikes and dams along its banks. The floodwater was diverted into a system of irrigation canals. Then, the river beds were drenched and enlarged to a narrow bottleneck in the Yellow River at Mount Longmen [5]. The Roman Empire mastered river engineering, with the Rhine and Danube bridges among its most notable achievements. The Romans connected different river branches in the Rhine delta, installed a river training mole near Herwen at the bifurcation of the Waal and Rhine ("carvio ad molem" on a tombstone in Nijmegen's Het Valkhof museum), and built groynes made of wood and basalt blocks to protect banks against erosion (archaeological information in Hoge Woerd museum, De Meern). In order to protect the land from fluvial erosion, Groynes were constructed locally throughout the Middle. Long river stretches began to be systematically trained in the 19th century, as evidenced by Tulla's "Rhine rectification" in Alsace and the "Rhine normalization" in the Netherlands. Between 1850 and 1880, hundreds of groynes were built along the Dutch Rhine branches to provide a uniform width because locally broader parts with bars and islands caused ice jams in the winter, which were a major source of dike breaches and flooding. In the following 35 years, the breadth was again reduced by lengthening the groynes, this time to increase navigability. Having a more comprehensive presentation of this history, as well as more current advancements in river training and river management for the Netherlands' Rhine branches. [5].

Dredging and the removal of huge woody debris that produced snags for navigation began in 1824 in the Mississippi River Basin. A century later, river training structures were implemented, which increased navigability even more. Bends were removed and the edges were smoothed out. The stabilization of banks limited the continuous feeding of the [6].

British engineers faced challenges in the 19th century when training the unstable rivers of the Indo-Genetic Plains. Their main concern was how to compress meander or braid belts in order to reduce the span of river bridges. Structures were constructed with the purpose of leading deep channels under the bridge. Correcting errors as they appeared, this was done without the migration of channels upstream to erode the abutments. These longitudinal guiding structures, also known as Bell's bunds, are made up of an upstream curved head, a straight shank, and a downstream curved head. Oberhagemann describes in detail the subsequent developments in training the Ganges, Brahmaputra-Jamuna and Padma rivers over the last century. Vander Wall complements this with additional historical information. Parallel to these hard river training structures, more flexible temporary structures were developed too, such as sandals in South Asia, bottom and surface screens in the former Soviet Union, and submerged vanes in the United States. All of these structures work on the premise of creating a transverse circulation to shift sediment sideways near the bed [5].

River training works are carried out for a variety of reasons, including preventing erosion of land and settlements near to the riverbank, diverting flood water away from the bank, and preventing the river from pouring flood water into the community. Variuos types of river training are in use in the world. Generally, revetments are provided to protect the bank of the river from erosion. Materials such as loose stones, bricks, stones filled in gabions, sand filled in bags are used for such works. Similarly small spurs, usually called studs, are provided to keep the flood water away from the bank. Long spurs are provided to direct the course of the river to a direction away from the bank. The spurs are made of loose stones, stones placed in gabion boxes, bricks, sand bags, bamboo piles, and bamboo mats. Similarly, embankments are built along the river's edge to raise the water level and prevent it from pouring over the edge and into the communities. The embankments are made of earth. These are sometimes protected with revetments and spurs too [3].

All engineering works constructed in a rivet which are required to guide and confirm the flow to the rivet channel and to regulate the river bed configuration for effective and safe movement of floods and river sediment". Flood protection, maintaining a navigable channel, and, last but not least, preventing bank erosion and/or outflanking of a bridge or weir may need river training works. [7].

Transverse structures (e.g., groynes, spur dikes, spurs), longitudinal structures (e.g., bank revetments, guide bunds), and structures on the riverbed are all examples of river training works (e.g., fixed layers, bendway weirs, checkdams). Experienced river engineers provide some practical advice that novices and laypeople may not be aware of. To ensure that the flows do not deflect away from river channel, Groynes or spurs pointing downstream are useful. Groynes that are truly deflecting or repelling have an upstream inclination. Another example is that the heaviest fluvial attack on training structures mostly occurs around bank full conditions rather than flood conditions [8].

- Failure of river training measures

River training works include guide bunds, slope revetments, spurs, cut-offs, flush bunds, bottom panels, studs, and other structures. If properly constructed, these structures can be very practical and structurally effective. They may fail to function successfully if they are not properly positioned, orientated, and/or designed. These river training structures would need to be maintained as well. If built at higher heights, launching aprons can operate as side berms, and under certain situations, they can be undermined by progressive scour at the structure's toe, resulting in structural failure. Similarly, if a sufficient filter is not supplied below the launching apron, it may sink owing to dirt particle removal through the voids at the toe, causing the structure to fail [9].

III. METHODOLOGY

A. Study area

The area along the right and left bank from E-W Bridge to Magarghat and headworks of Marcharbar lift Irrigation System to Nepal India was selected for this study. The total number of Local levels covered under the investigation is 2. All the villages along the right bank and left bank in the area under consideration were affected by the floods in the past.Keep your text and graphic files separate until after the text has been formatted and styled. Do not use hard tabs, and limit use of hard returns to only one return at the end of a paragraph. Do not add any kind of pagination anywhere in the paper. Do not number text heads-the template will do that for you.

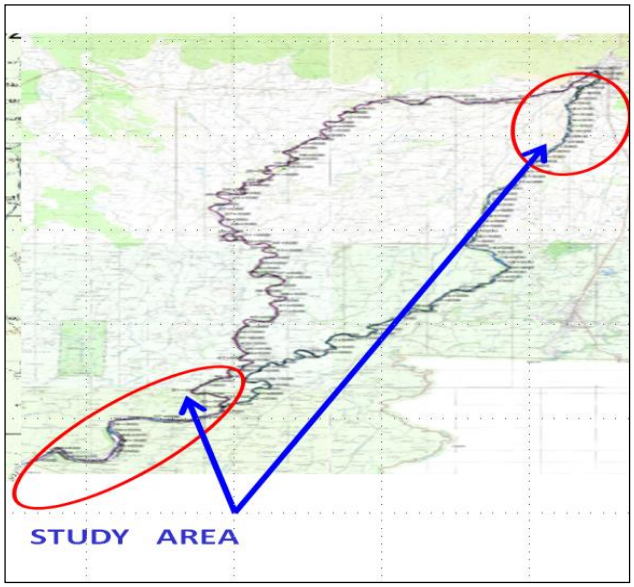


Figure 1 : Study area map

B. Data Analysis

Data analysis was carried out using the Relative *Importance Index (RII)***.**

The RII is used to evaluate the ratings of the respondents. In this research, Likert 5-point scale has been used to determine the relative importance index (RII) for the factors indicating the status of road, causes and effects of problematic road, solutions for better construction and preparedness for better construction of rural roads. 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 the respected topic and ranked at top. Ranking of the attributes/variables are arranged in ascending order [9]:

Item	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Scale	1	2	3	4	5
Item	Very poor	Poor	Good	Very Good	Excellent
Scale	1	2	3	4	5

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

$$RII = \frac{\sum W}{AN} = \frac{5n5 + 4n4 + 3n3 + 2n2 + 1n1}{5N}$$

Where,

W the weighting given to each factor by the respondent, ranging from 1 to 5; n5 number of respondents selecting total strongly agree or always; n4 number of respondents selecting agree or often; n3 number of respondents selecting neutral or sometimes; n2 number of respondents selecting disagree or rarely; n1 number of respondents selecting total strongly disagree or never; and N the total number of respondents.

C. Method of Data Collection

Field observation, in-depth interview, focus group discussion, and questionnaire are the major tools used during field investigation of this study.

D. Period of Study

The study was carried out during the period from March 2019 to April 2020.

IV. RUSULT AND DISCUSSION

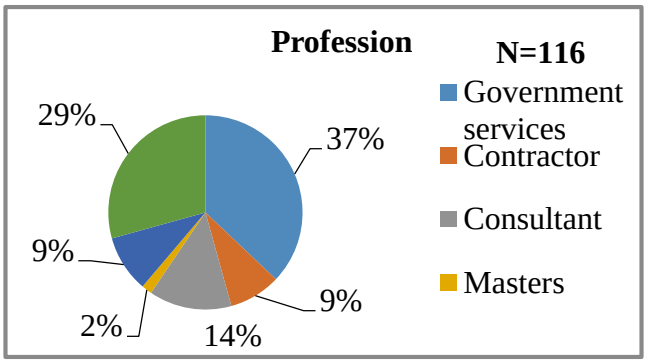
A. Classification of respondents based on Profession

The respondents were maximum involved government service related to river training agencies. The data shows that 37% was government services 14 % consultant, 9% contractor 9% business man/private sector 2 % teacher and 29% was involved other profession.

Figure 2 Classification based on profession (Field survey, 2020)

B. Major problems of river training works in Tinau river

There were 12 major problems listed related to river training works in Tinau River. The respondents responded differently for different problem. However, they ranked the big problem as **over extraction of river bed materials** is the major one (RII= 0.75) and **unmanaged catchment area** is the minor one (RII=0.65). All options and their respective values are presented in figure 3.



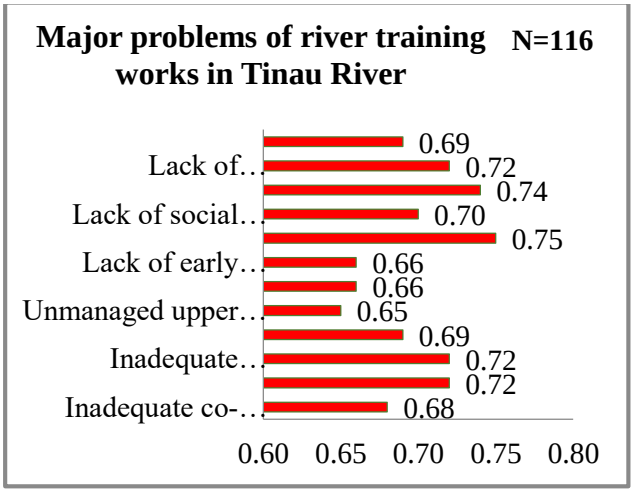


Figure 3: Major problem of river training works in Tinau River

C. Causes of inadequate co-ordination between line agencies

There were 5 major causes listed related inadequate co-ordination between line agencies. The respondents responded differently for different causes. However, they ranked the inadequate plan and program is the major one (RII= 0.72) and lack of co-ordination skilled was the minor one (RII=0.48). All options and their respective values are presented in figure 4.

D. Causes of river encroachment

There were 5 major causes listed related river encroachment problem. The respondents responded differently for different causes. However, they ranked the population growth was the major one (RII= 0.76) and lack of awareness was the minor one (RII=0.68). All options and their respective values are presented in figure (figure 5).

E. Causes of inadequate monitoring and evaluation

There were 5 major causes listed related inadequate monitoring and evaluation. The respondents responded differently for different causes. However, they ranked the lack of monitoring and evaluation tools was the major one (RII= 0.73) and lack of incentive for staff was the minor one (RII=0.66). All options and their respective values are presented in figure (figure 6).

F. Causes of inadequate maintenance of built structure

There were 5 major causes listed related inadequate maintenance of built structure. The respondents responded differently for different causes. However, they ranked the irresponsibility of concern agencies was the major one (RII= 0.72) and lack of skilled manpower was the minor one (RII=0.67). All options and their respective values are presented in figure (figure 7).

G. Causes of unmanaged upper catchment area

There were 6 major causes listed related inadequate maintenance of built structure. The respondents responded differently for different causes. However, they ranked the population growth was the major one (RII= 0.73) and unmanaged landslide and traditional agricultural system was the minor one (RII=0.69). All options and their respective values are presented in figure (figure 8).

H. Causes of inadequate people's awareness

There were 5 major causes listed related lack of inadequate people's awareness. The respondents responded differently for different causes. However, they ranked the for lack of co-ordination between concern agencies and people's was the major one (RII= 0.71) and lack of budget for awareness program was the minor one (RII=0.69). All options and their respective values are presented in figure (figure 9).

I. Causes of lack of early warning system

There were 5 major causes listed related lack of early warning system. The respondents responded differently for different causes. However, they ranked irresponsibility of concern agencies and lack of flood siren place to place was the major one (RII= 0.7o) and waiting only DHM data was the minor one (RII=0.69). All options and their respective values are presented in figure (figure 10).

J. Causes of lack of social participation

There were 5 major causes listed related social participation. The respondents responded differently for different causes. However, they lack of transparency was the major one (RII= 0.72) and lack of social worker was the minor one (RII=0.68). All options and their respective values are presented in figure (figure 11).

K. Causes of socio-political pressure

There were 5 major causes listed related socio-political pressure. The respondents responded differently for different causes. However, they lack of creates conflict among people and agencies, lack of ethics and corrupted mentality of representatives was the major one (RII= 0.71) and no strong rules and regulation and lack of rule of law was the minor one (RII=0.69). All options and their respective values are presented in figure (figure 12).

L. Causes of lack of enforcement law and policies

There were 5 major causes listed related lack of enforcement law and policies. The respondents responded differently for different causes. However, they creates monopoly and lack of transparency was the major one (RII= 0.74) and misuse of budget was the minor one (RII=0.69). All options and their respective values are presented in figure (figure 13).

M. Causes of inadequate flow of budget

There were 5 major causes listed related inadequate flow of budget. The respondents responded differently for different causes. However, lack of policies was the major one (RII= 0.73) and limited government budget was the minor one (RII=0.67). All options and their respective values are presented in figure (figure 14).

CAUSES OF FALIURE OF RIVER TRAINING WORKS

All types of causes are presented in the figure here under (fig 4 to fig 14)

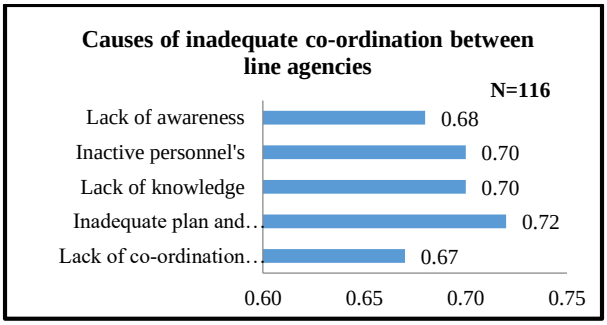


Fig. 4: causes of inadequate co-ordination between line agencies

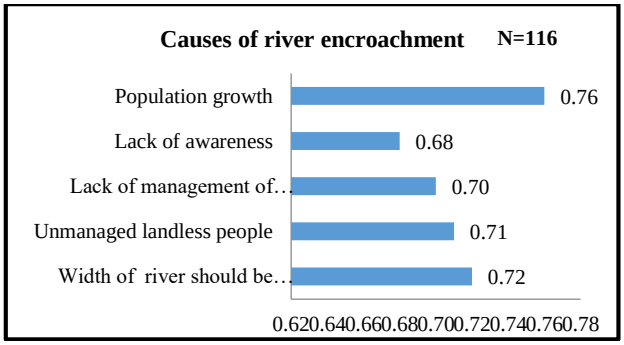


Fig. 5: Causes of river encroachment

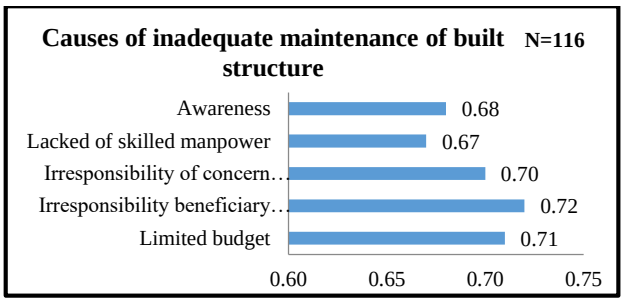


Fig. 6: Causes of inadequate maintenance of built structure

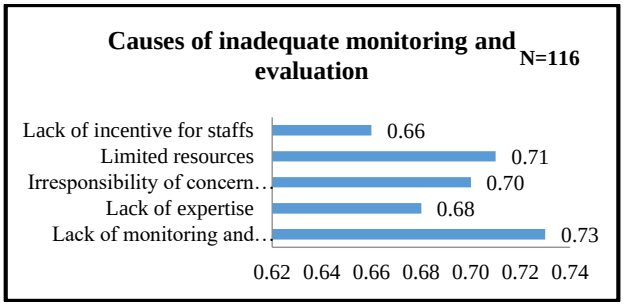


Fig.7: Causes of inadequate monitoring and evaluation

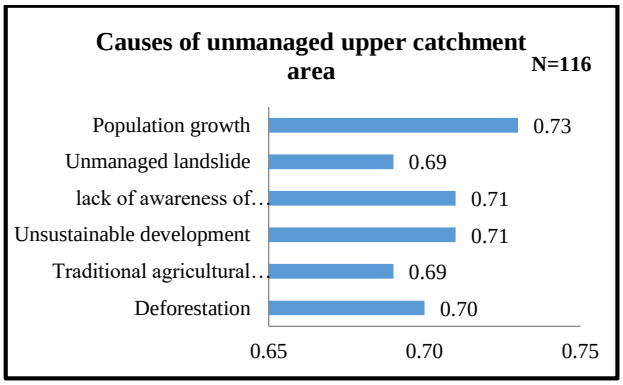


Fig. 8: Causes of unmanaged upper catchment area

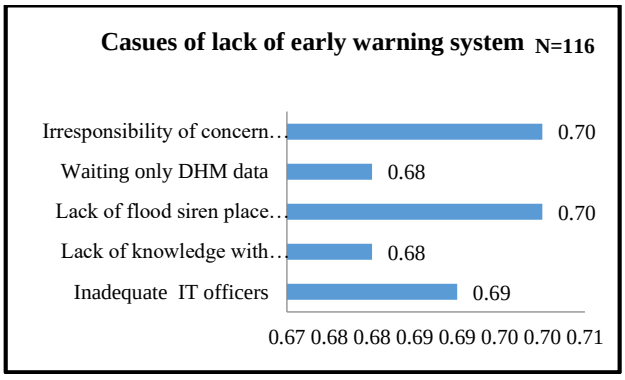


Fig. 9: causes of lack of early warning system

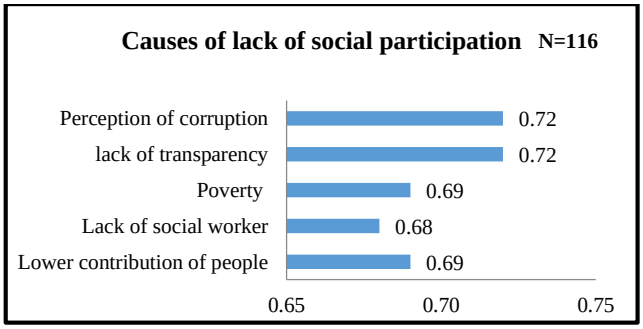


Fig. 10 : Causes of lack of social participation

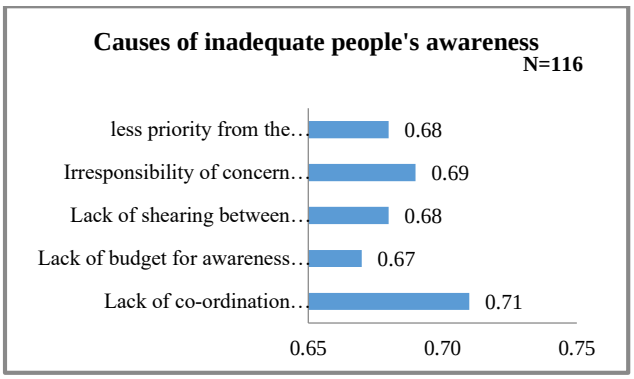


Fig. 11: Causes of inadequate people's awareness

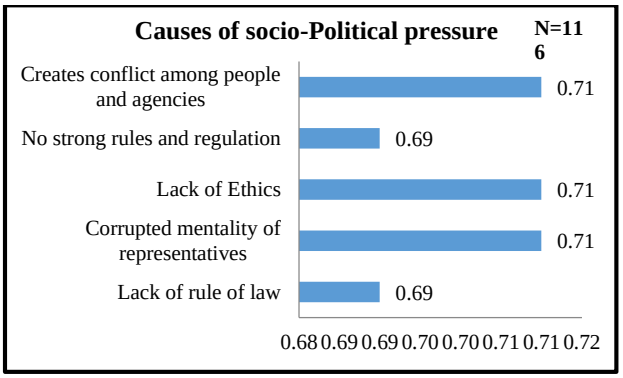


Fig .12: Causes of socio-political pressure

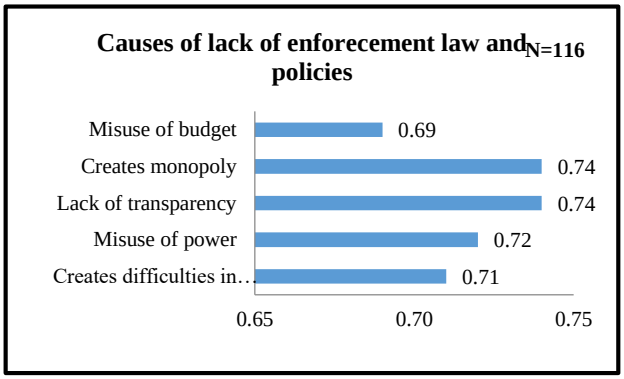


Fig .13: Causes of enforcement law and policies

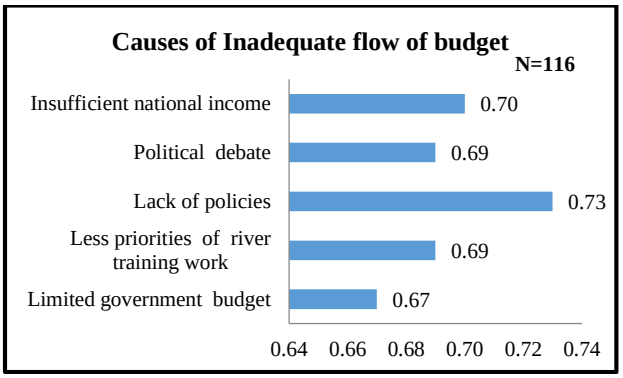


Fig. 14: Causes of inadequate flow of budget

N. Effect of inadequate co-ordination between line agencies

There were 5 major effect listed related inadequate co-ordination between line agencies. The respondents responded differently for different effect. However, higher cost was the

major one (RII= 0.76) and duplication and delay in works was the minor one (RII=0.69). All options and their respective values are presented in figure (figure 15).

O. Analysis on effect of river encroachment

There were 5 major effect listed related river encroachment. The respondents responded differently for different effect. However, increased depth of river was the major one (RII= 0.73) and bank erosion was the minor one (RII=0.69). All options and their respective values are presented in figure (figure 16).

P. Analysis on effect of inadequate monitoring and evaluation

There were 5 major effect listed related inadequate monitoring and evaluation. The respondents responded differently for different effect. However, project delay was the major one (RII= 0.75) and difficult in policy making and low quality of work was the minor one (RII=0.72). All options and their respective values are presented in figure (figure 17).

Q. Effect of inadequate maintenance of built structure

There were 5 major effect listed related inadequate maintenance of built structure. The respondents responded differently for different effect. However, life of structure decreased was the major one (RII= 0.75) and loss of national budget was the minor one (RII=0.68). All options and their respective values are presented in figure (figure 18).

R. Effect of unmanaged upper catchment area

There were 5 major effect listed related unmanaged upper catchment area. The respondents responded differently for different effect. However, increases flood frequency and increases soil erosion was the major one (RII= 0.72) and decreases water resources was the minor one (RII=0.69). All options and their respective values are presented in figure (figure 19).

S. Respondent's analysis on Effect of inadequate of people's awareness

There were 5 major effect listed related inadequate of people's awareness. The respondents responded differently for different effect. However, increases cost was the major one (RII= 0.74) and conflict between office and people was the minor one (RII=0.69). All options and their respective values are presented in figure (figure 20).

T. Analysis on effect of lack of early warning system

There were 3 major effect listed related lack of early warning system. The respondents responded differently for different effect. However, environment degradation was the major one (RII= 0.74) and difficult in flood forecasting was the minor one (RII=0.70). All options and their respective values are presented in figure (figure 21).

U. Effect over extraction of river bed materials

There were 5 major effect listed related over extraction of river bed materials. The respondents responded differently for different effect. However, damages built structure was the major one (RII= 0.74) and increases land inundation was the minor one (RII=0.71). All options and their respective values are presented in figure (figure 22).

V. Effect of lack of social participation

There were 5 major effect listed related lack of social participation. The respondents responded differently for different effect. However, decreases life of structure was the major one (RII= 0.74) and creates conflict between people was the minor one (RII=0.69). All options and their respective values are presented in figure (figure 23).

W. Analysis on effect of socio-political pressure

There were 5 major effect listed related socio- political pressure. The respondents responded differently for different effect. However, project delay was the major one (RII= 0.74) and conflict and quarrel was the minor one (RII=0.68). All options and their respective values are presented in figure (figure 24).

X. Analysis on effect of lack of enforcement of law and policies

There were 5 major effect listed related lack of enforcement of law and policies. The respondents responded differently for different effect. However, uncertainty of work was the major one (RII= 0.72) and creates violence was the minor one (RII=0.69). All options and their respective values are presented in figure (figure 25).

Y. Analysis on effect of onadequate flow of budget

There were 5 major effects listed related to inadequate flow of budget. The respondents responded differently for different effects. However, cost increase and project delay were the major ones (RII= 0.73) and conflict between office and contractor and deactivated staffs were the minor ones (RII=0.70). All options and their respective values are presented in figure (figure 26).

EFFECTS OF FALIURE OF RIVER TRAINING WORKS

All types of effects are presented in the figure here under (fig 15 to fig 26)

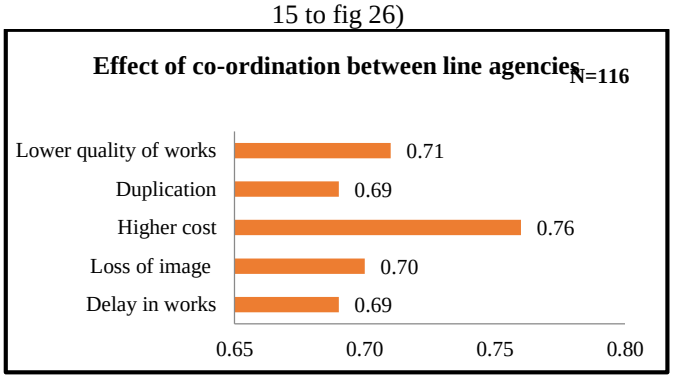


Fig.15 Effect of inadequate co-ordination between line agencies

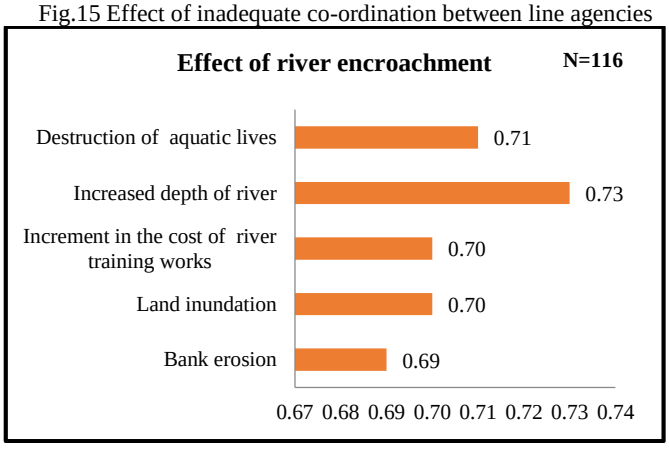


Fig .16 Effect of river encroachment

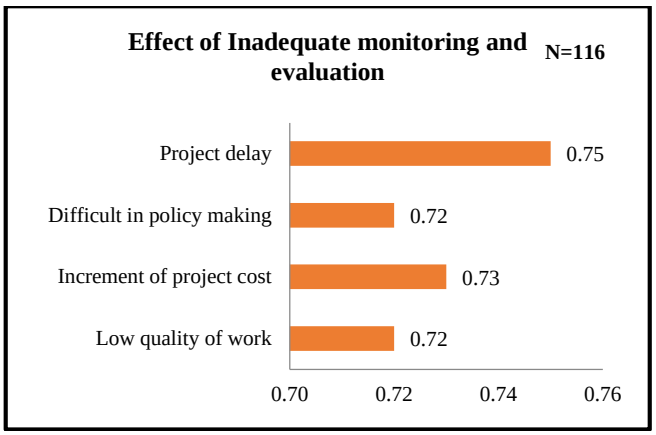


Fig. 17: Effect of inadequate monitoring and evaluation

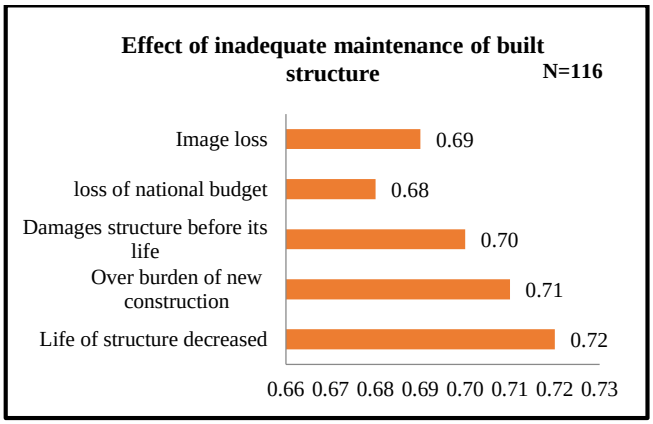


Fig. 18: Effect of inadequate maintenance of built structure

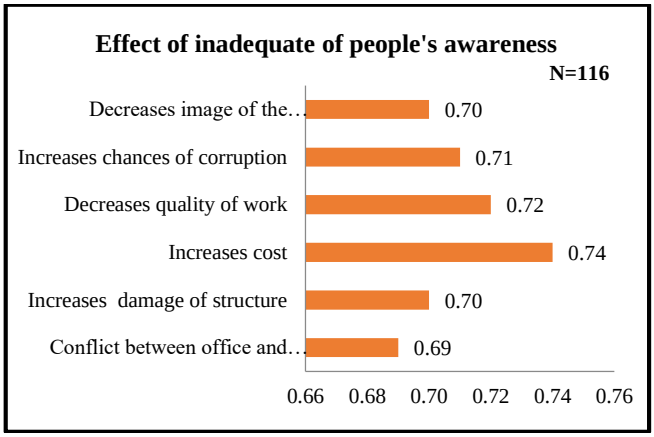


Fig.19: Effect of unmanaged upper catchment area

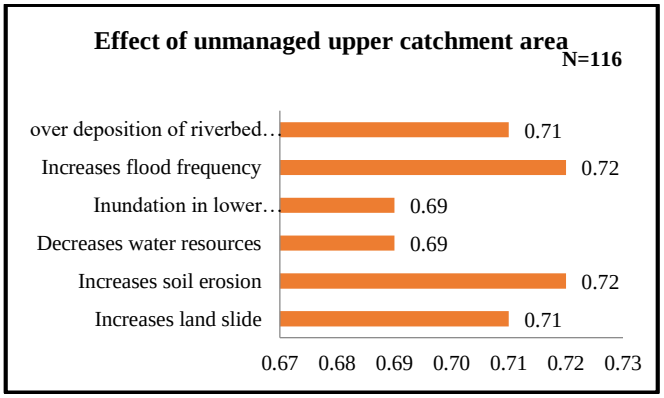


Fig 20: Effect of people's awareness

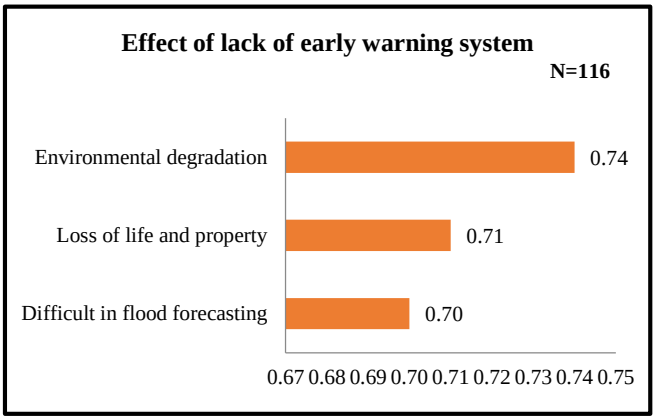


Fig.21: Effect of lack of early warning system

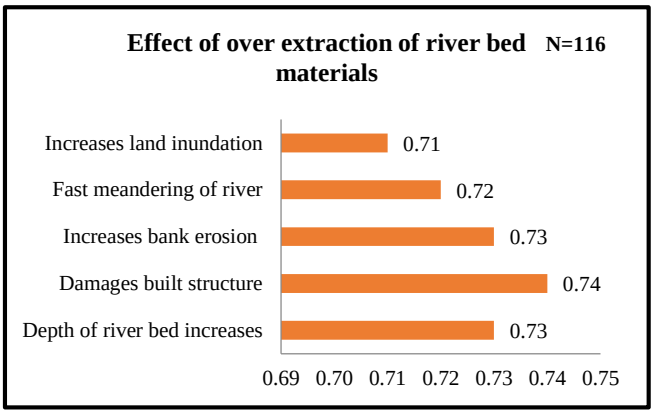


Fig.22: Effect of over extraction of river bed materials

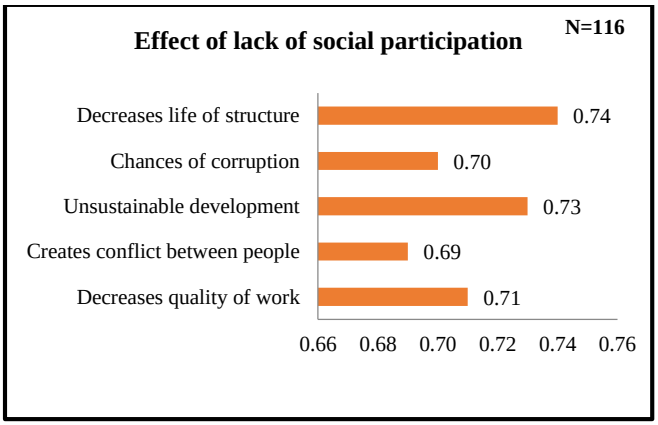


Fig.23: Effect of lack of social participation

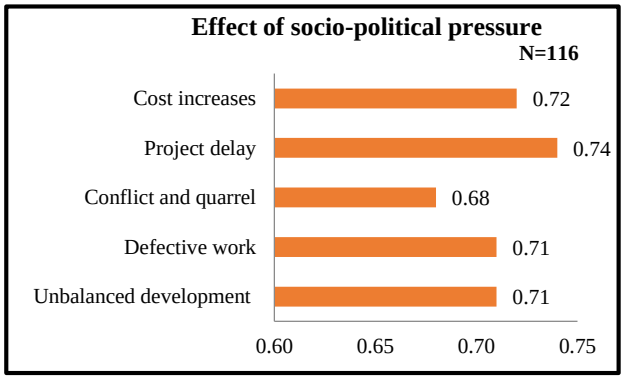


Fig.24: Effect of lack of socio-political pressure

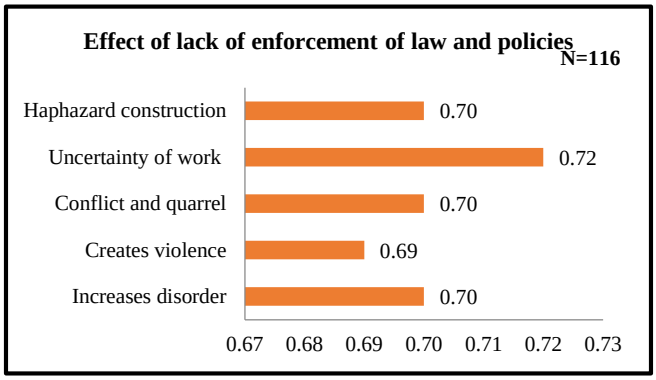


Fig.25: Effect of lack of enforcement of law and policies

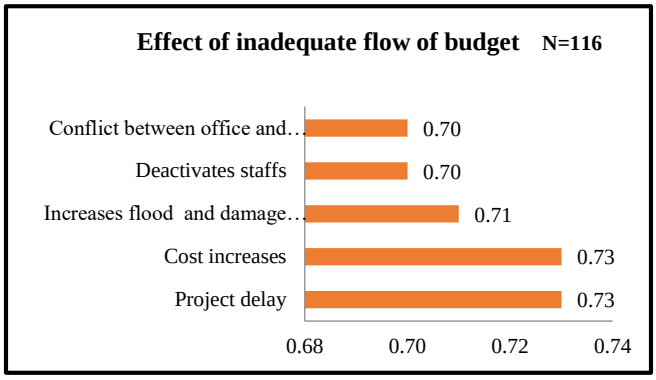


Fig. 26: Effect of inadequate flow of budget

Z. Solution of river training problem in Tinau River

There were 12 major solutions listed related to river training problems in Tinau River. The respondents responded differently for different solution. However, they ranked the higher priories for regular monitoring and evaluation during construction and after construction (RII= 0.76). And, co-ordination between line agencies was the minor one (RII=0.70). All options and their respective values are presented in figure (figure 27).

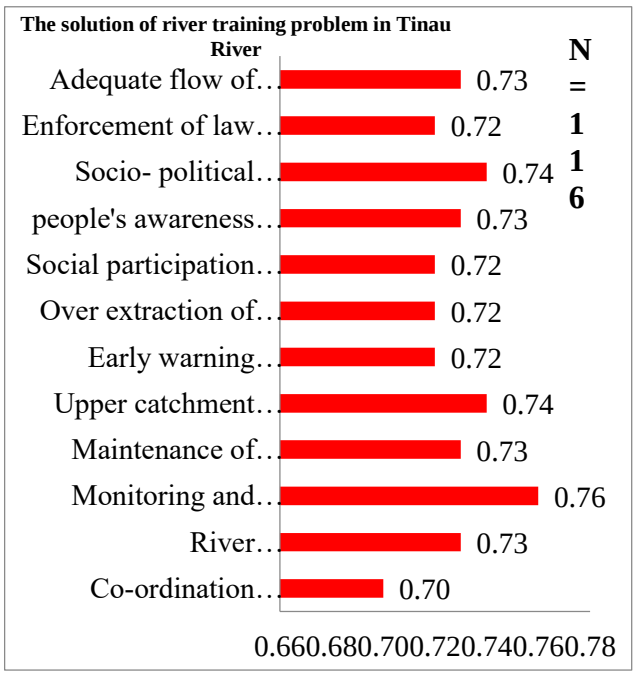


Fig.27: The solution of river training problem in Tinau River

During IDI it was discussed on the status of effectiveness of river training works in Tinau River, problems faced by users, causes of problems and their solutions. The experts replied as Hydrological investigation, Soil investigation, Local participation, and Study of past history, is necessary for the reliable river training works.

V. Conclusions

The over extraction of river bed materials is the major problem of river training works (RII=0.75) and unmanaged catchment area is the minor problem (RII=0.65). Other problem such as river encroachment, lack of monitoring and evaluation, socio-political pressure and lack of enforcement of law and policies are also problems of river training works. Some major causes of river training works have been found to be inadequate co-ordination between line agencies, inadequate plan and policies (RII=0.72) and lack of awareness is as minor causes (RII =0.68) . As well as higher cost was the major effect (RII=0.76) of that problem. Major causes are seen as inadequate monitoring evaluation was lack of monitoring and evaluation tools (RII=0.73) and lack of incentive for staff was minor one (RII =0.66) and its effect analysis, project delay has been major one (RII=0.75 of that problem. Causes on inadequate maintenance of built structure, irresponsible of beneficiary group have been major causes (RII=0.72) .Its effect is decrease in life of structure (RII=0.72). Unmanaged catchment area has been found population growth as major cause (RII=0.73) and traditional agricultural system, a minor one (RII=.69). Its effect has increased soil erosion and higher flood frequency was major one (RII=0.72). Decrease water resources and inundation in lower catchment area have been found to be minor ones (RII=0.69). Causes on over extraction of river bed materials is the corruption (RII=0.74). River bed materials is the source of income for poor people's (RII=.67) .It's effect is damage built structure (RII=0.74) and increased land inundation is minor one (RII=0.71). Causes on socio-political pressure are lack of ethics, corrupted mentality of representatives and creates conflict between peoples and agencies (RII=0.71) and no strong rule and law was minor one (RII=.69).It's effect is project delay (RII=0.74) and conflict and quarrel is minor one (RII=0.68). The solution of river training problem is regular monitoring and evaluation during construction and after construction (RII=0.76) and co-ordination between line agencies is the minor one (RII=0. The study would like to suggest that the River bed extraction should be conducted in a balanced way. The design of structural measures should be conducted on the basis of model studies and detailed discussions with local authority. Furthermore,

Periodic maintenance of structures should be conducted and responsibility should be clearly defined for operation and maintenance work. And the last but not the least landless people's should resettled.

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