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Influence of Aggradation and Degradation on River Channels : A Review

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***Abstract*— Aggradation and Degradation are the fluvial processes mostly associated with a river and its differentiating parameters. Aggradation and degradation are generally influenced by river discharge, sediment load, morphological characteristics of river channel and human interventions. If the river water is unable to transfer the bed load or the channel material then the same is deposited within the channel and channel height increases, aggradation occurs. This also leads to change the river morphology and hydraulic geometry. Degradation is another process which is responsible for the lowering of river bed and also shifting the channel banks. In the present paper an attempt is taken to review the processes of aggradation and degradation and their influence on the river channel.**

***Index Terms*— Aggradation, Degradation, River energy, River Cross sectional change, River Bar, Bank erosion, Riverine Vegetation.**

I. INTRODUCTION

Recent climate change and variation in climatic parameters such as temperature and rainfall directly or indirectly, influencing on fluvial processes of the river. The uneven rainfall and river basin runoffs resulting for the variation in river discharge. Consequently, changing in river discharge causes aggradational and degradational processes of the river. Besides this, human activities and construction of infrastructures like dam and K. T. Weirs (Kolhapur type weirs) also disturbs the aggradational and degradational process of the river channel. Apart from natural processes, human intervention affects directly or indirectly on the channel characteristics and simultaneously influenced on such erosional and depositional processes. Excess use of irrigation in agricultural land and improper use of cultivation practices, as the eroded soil material lastly accommodate in the river channels. Now with the technological advancement, human interventions are increasing today. For example, sand dredging and excavation of silt from river sites are more or less affects on the aggradation and degradation of river channels. The studies of aggradational and degradational characteristics of rivers are the needs for proper management and conservation of river courses.

Aggradation is the accumulation of sediment in river channel. Aggradation means the raising of stream-bed height, resulting for increase in width/depth ratio. When sediment load is increased in upstream then aggradation occurs in the downstream channel, also shows the signs of decrease in channel capacity [1]. If the channel bed appears to be with gravel, then it may aggraded only when the gravel is supplied from the local bank erosion and that too degraded only when a large flood catastrophe occurs [2]. Variations in the discharges reflect the variations in energy available and hence such variations immediately get reflected in the alterations in the channel morphology. Bank-full discharges are often considered to be the channel forming discharges. However, it does not mean that the flows below this condition do not have any role in shaping the channels. The changes caused by the discharge variations can be understood through the detailed study of the channel morphology. Any variation in the discharge is immediately reflected in channel geometry both in plan and profile [3], [4], [5]. Also the excavation of silt activity along the banks and in agricultural fields has resulted in positive and negative impacts in the region and reveals that human intervention has resulted for the increase in width of the channel and influenced on the channel form and plan [6]. Thus, in such study aggradation and degradation alters the channel geometry. River behaviour is more complex because the various processes are operating together and interrelated with each other. Complex river responses in view of aggradation, degradation, accommodation adjustment have studied by Petts in 1979 [7].

Fluvial deposition in terms of aggradation and its associated landforms, fluvial erosion i.e. degradation are the basic processes which are almost responsible for variation in channel cross sections and channel width adjustment. Therefore the study of the causes and influence of these processes is also discussed here.

II. CAUSES OF AGGRADATION AND DEGRADATION

In a region where deforestation takes place, there, the soil erosion becomes a serious problem which also gives rise to aggradational problem. Landslide, earthflow, debris flow and river bank failure also causes aggradation. If within channel, deposition exceeds the equilibrium condition, then it invites flood and sometimes the flow discharge tries to find its way, tends to shift the channel location.

In the field of fluvial geomorphology riparian vegetation and aquatic plants also plays significant role in response to changes in river morphology. "The structure and function of riparian and aquatic vegetation vary along river systems with geomorphological setting, hydrological regime, sediment supply and surface- groundwater connectivity" [8], [9]. Once the aquatic or riverine vegetation established, then it acts as an obstacle and bifurcate the channel flows also trapping the bed load and resulting for accumulation of bed material within the channel. Gurnell et.al. (2012) investigated that such riparian

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and aquatic vegetation acts as a physical ecosystem engineers that modifying the river system, resulting for modifying growing of riverine landforms [9]. There is a strong correlation between vegetation and sediment trapping within the channel. 'Vegetation colonization and growth can provide root-reinforcement of alluvial sediments, and the flow resistance of the vegetation canopy can induce sediment and plant propagate deposition leading to aggradation and spatial extension of vegetated patches within fluvial systems' [9].

Figure 1: Formation of Bar in Tulshi River and opposite side degradation.

Figure 2: Degradation of Kumbhi river due to excavation activity

If the channel is of mixed load with sinuous thalweg, then the load is resulting for formation of alternate bars. The stability of the channel also depends on the changing characteristics of the river and their cross sectional changes [4]. High or low stability depends on the aggradation or degradation of the channel. Almost these processes are caused by changes of base level or hydrologic conditions; also change the channel cross section and its shape [10]. Mikhailov studied hydrological regime and the formation of bars due to the sediment material discharge and sediment deposition. Mikhailov concluded that there is large number of river bars and river mouth-island situated in various physiographic environments and it changes due to the volume and flow of the river and sediment discharge [11]. Zhanbin et. al in 2004, studied the relation between runoff power and sediment yield module from rainfall of a watershed on the basis of runoff power theory using field observation data from four watershed on the loess plateau [12]. Runoff power and sediment yield are more significant while discussing about these processes. Sinha in his study concluded that, channel geometry and depositional landforms are the results of channel aggradation. Channel aggrades when the rate of sedimentation is greater than the rate of sediment transportation. Further, he added that tectonic activities are also causes to uplift the surface and provide a large amount of sediment for aggradation and degradation processes. Also concluded that the aggradation and degradation processes mostly dominated by channel flow rate and sediment load supply [13].

Stream channels in mountainous terrain can progressively build up (aggrade) or erode (degrade) the streambed in response to changes in sediment supply [14]. Therefore the process of aggradation and degradation depends on many factors like river discharge, river velocity, energy and mainly the sediment supply. Rosgen, in his study summarized the arrangement of a stream into similar stream types. In his research work he defines morphologically similar stream reaches which are classified into seven major categories. Data used in classification involved a high range of hydro-physiographic and geomorphic province from small to large rivers and from headwater stream to coastal plains. A stream hierarchical inventory stream is given which apply the stream classification system. He highlights and given the correlation between the channel sediment and aggradational/degradational processes [15]. At the same time coupled with the natural processes an intervention by man has serious effects on the river morphology and river cross sections [4], [16]. The river characteristics in its plan and section are highly influenced by dam also. The study of Urmodi River also reveals that at the upstream of K. T. Weirs the channel has aggraded and downstream to the K. T. Weir there is a degradation of channel bed [17].

III. Influence of Aggradation and Degradation on River Channels

Aggradation and degradation of river channel also resulting for channel shifts and change in the channel patterns [6], [18]. Deposition of silt, sand and bed material with organic content when deposited in the channel, then bars and riverine islands are formed. These fluvial landforms are responsible for braiding of the channel. The deposition of material, the flow velocity also affects on the channel patterns. According to Schumm in 1977, the descriptive channel patterns are based on cause-and-effect relationship between the various types of sediment load, flow velocity and stream power of the particular river [10], [19].

Table - 1 : Aggradation and Degradation: Causes and Effects

Name of Author/s	Year	Brief Related Research Work
Leopold et al.,	1964	Land use changes can induce channel changes downstream and effects on its depositional and erosional processes [20], [21].
Gregory & Walling,	1973	
Schumm, S.	1977	Hillslopes and upstream reaches of river are closely linked to river channels downstream and their fluvial processes [19].
Cant and Walker	1978	Described responsible fluvial processes and geomorphological elements for developing river channel bars, point bars, sand flats, flood plains [22].
James, L.A.	1997	Decrease in thalweg elevation and flow stages due to channel incision [23].
Hui Fan et al.	2006	Summarised the processes of river mouth bar formation, river bed aggradation and channel distribution/migration [24].
Goswami et al.	2009	Fan morphology & aggradational processes are controlled by tectonic activities [25].
Devkota et al.	2012	"Barrage was constructed at eastern side of the river channel, leading to sedimentation in the western side" [26].
Gilbert, G.K.	1917	In California, hydraulic mining from 1850 to 1884 delivered a pulse of sediment to the Sacramento river system, causing extensive downstream aggradation and widening. [27], [28], [29], [30]
James, A.	1991	
James, L.A.	1994	

The bed load of the river stream also depends on the sources of the bed material, if the river basin or water shed is degraded due to some activities like quarrying, mining or deforestation, then such sites produced maximum amount of potential bed load material. In view of this, Kondolf et. al remarkably observed the distinct changes in land use, bedload sediment production, and channel response in the two different basin area. They have identified that hard-rock, road construction, timber harvest, and historically heavy grazing of uplands, resulted in increased tributary bedload yield. Increased bedload transported to the channel resulted in channel instability and changes the morphological characteristics of river as an effect of aggradation [30].

Shifts in channel locations due to natural and manmade erosion accelerate after the floods. Both the processes i.e. depositional and erosional are causing channel degradation [16], [18]. Once, accumulation of bed material within the channel supposed to form bars or river islands, then the flow diverted to their opposite direction, resulting for bank erosion (fig. 1). Figure 2 shows bank degradation due to alluvium excavation, which increases the channel width and changes river morphology. Table No. 1 highlights some pioneering work that is related to these processes. Most of the rivers experienced the catastrophes, like flood, when channel migrates and becomes wider due to degradation. Widening in sinuous channels occurs as a result of outer bank retreat, also causes due to toe scouring and due to the growth of alternate or point bar [31], [32], [33]. Degradation of channel in terms of bank erosion takes place due to river energy and erosive forces. Also depends on the distribution of grain size and type of bank material. Degradation also controlled by cohesiveness and non-cohesiveness of transported and bank material [33]. The erodibility of bank-soils may increases due to processes of weakening and weathering. Swelling and shrinkage of soil during wet and dry period also affects on bank erosion [33].

Gogoi et. al. examined the channel migration study of Subansiri river of Assam with applying remote sensing and GIS technology. Subansiri River is major tributary of River Brahmaputra, characterized by extremely dynamic and unstable alluvial channel. Author studied the pattern of channel shifting and other various changes for the period from 1828 to 2011. In Subansiri they had been found five different types of channel shifts. (1) Alternate bar-induced shifting (2) Neck cut off (3) Chute cut off (4) Meander shift (5) Avulsion or rapid diversion. During flood Subansiri River flows with a large discharge and heavy sediment and it causes river unstable extremely. Channel patterns also changes continuously and developed new channel. River channel bars and meandering thalweg formation is common. Between embankment area, river has been restricted and resulted in rising of river bed. The maps and recorded history of flood shows that, the gap made in embankments rapidly occurs bar development, bank erosion and channel migration. "River channel migration is the lateral movement of an alluvial river channel across its flood plain due to processes of erosion and deposition on its banks and bars". [34].

While considering the processes of aggradation and degradation 'the bed and bank material is also important for the resulting depth and width. The relative erodibility of bed and banks will determine whether erosion will be vertical or horizontal and, mainly, the grain sizes of the transported material together with the hydraulic conditions will determine whether deposition will occur on the bed or on the banks' [35]. Brandt in his study also concluded that, 'Changes in water and sediment input to the downstream reach may induce a change in planform configuration' [35].

Gaeuman has studied the channel responses to changes in stream flow and sediment supply in the lower reaches of Duchesne River. Gravel-bed and sand-bed reaches of the lower Duchesne River showed particular adjustments to the discharge and sediment supply. "Sand-bed reaches tended to adjust to all perturbations with rapid bed-level changes, whereas the gravel-bed reaches adjusted primarily through width changes. The gravel bed reaches aggraded only when gravel was supplied to the channel through local bank erosion and degraded only during large floods" [2]. The avulsions in Duchesne Reaches has caused by bed aggradation. Authors in the same study have also concluded that aggradation is also promoted to the bank erosion and resulting for degradation of channel [2].

As discussed earlier that, aggradation and degradation affects on the channel pattern, in view of this, such processes and activity of river become very important and critical when

property or political boundaries follow the line or thalweg of river. Therefore all these characteristics and functions of river behaviour is significant in terms of boundary law and forensic geomorphology [10].

IV. CONCLUSIONS

Aggradation and degradation of channel depends on the river discharge and river energy that has used to transport the bed material. Type of bed material whether it is of: silt, sand, gravel or boulders also affects on these processes. Above discussions reveals that the study of aggradation and degradation is important to the geomorphologist and engineers in connection with sediment transport, depositional locations of sediments and their direct and indirect responses to bank erosion.

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