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Sediment Yield in the Mora Dhansiri River Catchment in Assam, India

Rana Sarmah, Guwahati, Assam

Abstract

This study attempts to estimate rate of sediment yield in a small size floodplain catchment with little physiographic and high climatic variations. Sediment yield rates are estimated adopting a field based conventional method for the period 2009-14. It has been estimated that rate of sediment yield in the study area is 618 t/km2/y. The average rate of sediment yield is estimated to be 417t/km2/y at gully-1, 451 t/km2/y at gully-2, 865 t/km2/y at gully-3, and 742 t/km2/y at gully-4 with an average of 618 t/km2/y for all gullies during 2009-14. Rate of sediment yield is increasing downstream in the order of 8t/km2/y/km primarily because of downstream fining of soil texture and increasing saturation level of the ground. It is found that rainfall of ground saturated period (July to October) has increased by 318mm (49%) during 2009-10 which yielded increase insediment yield of 127 t/km2/y (23%). This relation in 2010-11 became 266mm (27%) to 85 t/km2/y (12%) and in 2011-2014 36mm (3%) to 32 t/km2/y (5%). Thus, sediment yield rate is strongly determined by variation in rainfall of ground saturated period. It id also found that high rate of sediment yield in the stuy area is basically because of floodplain character of the basin with high anthropogenic interventions by tillaging the agricultural lands during the high runoff period. Study area is intensively cultivated, and thuspersistency of this high sediment yield rate will invitehazardslike drainage congestion, channel shifting, flood, etcaffecting agricultural practicesin recent future.

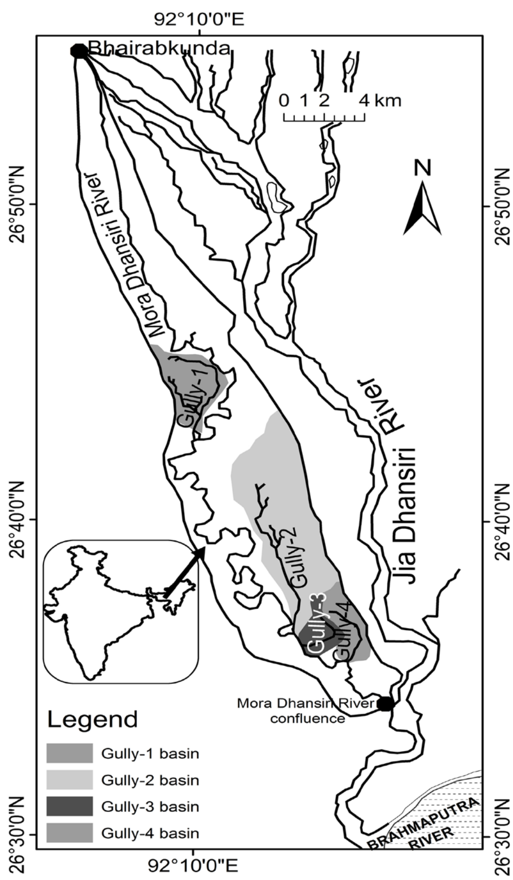
Key words: *Sediment yield, Mora Dhansiri River, Soil texture*

Introduction

Sediment yield is the amount of detached or separated earth material inriver catchments by various means of running water and transported elsewhere. It is high in rainfed river catchment in tropics. Floodplain river catchment produces sediments by fluvial processes such as rain splash, rill erosion, leaf drip, sheet wash, running cropland runoff which are derive by rills, gullies, streams, rivers, etc and delivered to the emptying river or lake or sea. Sediment yield is highly accelerated by human interventions like land tillage in croplands, unscientific landuse practices in tilting ground, construction of surface transportation routes, etc and thus have far reaching effect on agricultural productivity and landscape change. Local depressions where some eroded sediments are deposited are not considered as sediment yield and are referred as soil loss (Renard et al., 1997). Sediment yield is the amount of eroded soil that is delivered to a point in the watershed that is remote from the origin of the detached soil particles (Renard et al., 1997). Sediment yield denotes the rate at which sediment passes a particular point in the drainage system and is usually expressed as volume (m^3) or weight (ton) of sediment removed per unit of basin area (km^2) per unit of time (year) (Goswami, 1985, 1998). Sediment yield is the amount of sediment derived from land surface and thus it has area component in its unit of measurement; while sediment load comprise sediment derived from land surface and ultimately delivered to the stream, streams banks, and bed which does not have area component. The definitions of soil erosion, soil loss, and sediment yield as adopted in this study have similarity with the definitions used in RUSLE (Renard et al., 1997). Changes in sediment yield reflect changes in basin conditions, including climate, soils, erosion rates, vegetation, topography, and land use (NIH, 1999, Hooke, 1979). Long term changes in sediment yield accompany land use conversion, such as from natural to commercially harvested forest, from forest to agriculture, or from agriculture to urban use (NIH, 1999). Some of the conversions may be reversible, such as the conversion of forest to agricultural use and subsequent recovery of the forest following abandonment of farms (Morris and Fan, 1997). Several studies (Klaghofer, et al. 2002; Bathurst, 2002, Bobrovitskaya, 2002; Goswami, 1985, 1998; NIH, 1999) have been done across the globe on sediment yield for various sizes of catchments. But in most of the studies floodplain catchments of very small sizes are not attempt. Thus this study takes into account the small size of floodplain river catchment for study of sediment yield.

Study area

The study area is the Mora Dhansiri River basin (Fig 1) which extends from 26º33′84″N to 26º53′49″N and 92º07′04″E to 92º16′05″E and covers a size of 151.87 km^2. It is a tributary river basin of the JiaDhansiri River. JiaDhansiri River is a tributary river of the Brahmaputra River in India. The Mora Dhansiri River is entirely flowing through the floodplain of the Jia Dhansiri Riverin northwest to southeast direction. Almost one half of the basin falls in the piedmont zone while the second half occupies small part of the young floodplains of the northern Brahmaputra valley. It is basically feed by rainwater during monsoon season.



However, a bifurcated distributary of the JiaDhansiri River located in the piedmont region partially feeds the Mora Dhansiri River. Because of coarse soil texture and high rate of water seepage in this area, sediment yield is substantially low. The surface generally dips toward the south and comprises very coarse clastic materials viz. boulders, cobbles, pebbles, and sands of various grades (Sarmah, 2012). Further, ground vegetation, what is existed here, also prevents sediment production. This study identifies four gullies of the Mora Dhansiri River which are named as Gully-1, Gully-2, Gully-3, and Gully-4 and located at Siddhakhowa village, BorgoraKhuti village, Baruagaon village, and Kawpati T. E. of the study area respectively. These are the outlets through which basin sediments are transported to the Mora Dhansiri River. Besides, there are direct contributions from overbanks, banks, and bed.

Material and methods

Estimation of sediment yield is considered to be an essential task while adopting any soil conservation measures. Though, of late, scientific literature including models on estimation of sediment yield became bulky from researches across the globeyet no universal model at micro scale with little physiographic and high climatic variations is found to be existed and what is existed are based on remote sensing data. This study isbased on field based data and thus not uses remote sensing data.It adopts conventional method for estimation of suspended sediment yield from catchments.

*Conventional method:*Conventional method, here, refers to the method of estimation of sediment yield rates by measurement of discharge and sediment concentration at confluences of floodplain gullies. Direct and indirect methods to measure suspended sediment concentration (SSC) include collecting daily, weekly, or monthly SSC samples, or developing sediment rating curves that predict SSC from continuously recorded variables such as water discharge, turbidity, air temperature, or precipitation (Menounos et al., 2006). However, direct measurement of SSC is expensive and sediment yields can be heavily biased if sampling strategies do not adequately sample high flows (e.g. Walling and Webb, 1982; Thomas, 1985). This study addopts direct method of SSC and adaquate sediment samples (320 samples) are taken. Goswami (1985) estimated sediment yield of river basins of the Brahmaputra system of rivers through measurement of sediment concentration and multiplying by the volume of water discharge. To estimate rate of sediment yield (t/km^2/y) of the present study area gully basins are delineated examining topographical maps, satellite data, and google earth data. These gully basins are shown in Fig.1. Basin areas of Gully basin 1, 2, 3, and 4 are 8.74 km^2, 29.42 km^2, 2.58 km^2, and 5.37 km^2 respectively. Photographs showing confluences of gully-1, gully-2, gully-3, and gully-4 where discharge measurement and sediment sampling was carried out are presented in Fig.2. (See page No.38).

In this study, the following formula is used for estimation of rate of sediment yield.

$SY_1=Q_1C_1/A_1$

Where, SY_1 is rate of suspended sediment yield at gully basin-1 in t/km^2/y, Q_1 is discharges (m^{3}s^{-1}) measured at gully mouth 1; and A_1 is catchment area (km^2) of gully-1.

Accordingly, the formula for sediment yield from all gully basins in one year will be

$SY_i = \sum Q_i C_i / \sum A_i$

where, SY*i* is rate of suspended sediment yield from all four gully basins in t/km^2/y; Q_i is discharges (m^{3}s^{-1}) measured at gully mouth 1, 2, 3, and 4 respectively; and A*i* is catchment area (km^2) of gully basins of 1, 2, 3, and 4 respectively.

For calculation of total sediment load (in ton), average discharge and average sediment concentration is find out from the observed data and multiplied by the calculated time (explained in following paras). Moreover, for calculation of sediment yield from other parts of the basin excluding the gully basins average discharge and average sediment concentration of gully basins are used.

For measurement of velocity, current meter is used. Average wetted depth and width are measured manually. Discharges (Q) are calculated for the months July, August, September, and October. In other months, discharge is found to be insignificant. However, little discharge cannot be denied in the laterhalf of June during rainy days which is immediately absorbed on account of recharging the ground; and early Novemberwhich does not carry much sediment.

Suspended sediment concentration (C) in t/m^3, of samples collected from four gully confluences, is estimated following the filtering-drying-weighting method for 100 ml of sample in the laboratory. The value of 'C' is estimated for all samples collected from four confluences. The mean value of 'C' of all samples (C_m) is used for estimating sediment yield for the dates (time) for which sample could not be collected and from other parts of the basin excluding the gully basins.

Time (T) is obviously a pertinent factor of sediment yield. While, all other controlling factors of sediment yield remain constant, the sediment yield is directly proportional to time. More the span of time more is the amount of sediment yield. In this study, sediment yield is estimated for three years (2009, 2010, 2011, and 2014) in yearly basis. As mentioned above, four months in a year viz. July, August, September, and October (ground saturated period) are accounted for study of all sediment yield parameters. Discharge at any gully confluence is a 24 hours process and calculated in seconds. Thus, total time (T) taken for estimation of sediment yield in one day is 24 x 60 x 60 = 86400 seconds. Accordingly, the total time (T) for estimation of sediment yield in one year is 122 days in four months x 24 hours x 60 minutes x 60 seconds = 10540800 seconds.

Results And Discussion

Magnitude and rates of sediment yield in the Mora Dhansiri River catchments have been estimated following proposed field based conventional method and using data generated through field measurement and sampling at the confluences of floodplain gully basins and presented in table-1. This study evident that rate of sediment yield is in highest magnitude at gully-3 followed by gully-4, gully-2 and gully-1 in the year 2009. Same order of spatial variation in rates of sediment yield is evident in all gully basins for the years 2010, 2011, and 2014. The average rate of sediment yield is estimated to be 417 t/km^2/y at gully-1, 451 t/km^2/y at gully-2, 865 t/km^2/y at gully-3, and 742 t/km^2/y at gully-4 with an average of 618 t/km^2/y for all gullies (table-1) during 2009-14. Sarmah (2001) in his study on JiaDhansiri River estimated a slightly lower rate of 435 t/km^2/y of sediment yield with a much larger basin size (1161 km^2) than the basin size of the present river (152 km^2). The high rate of sediment yield in the Mora Dhansiri River is basically because of floodplain character of the basin with high anthropogenic interventions by tillaging the agricultural lands during the high runoff period. A study made by Goswami (1985) noticed in his study that other two rivers of the Brahmaputra system of rivers viz. Deosila River and Dudhnoi River with slightly larger basin size of 270 km^2 and 360 km^2 respectively than the present river yields comparatively low sediment of 135 t/km^2/y and 167 t/km^2/y primarily because of existence of coarse soil texture in the basin. Existence of course soil texture in these two river basins, probably in some other basin of the same Brahmaputra system of rivers, is because of diverse physiographic settings comprising high hills and mountains, dissected foothills, large piedmont area. As against this, the present river basin is cpmprised by piedmont area and large floodplain zone which contribute huge quantities of sediment through gully basins. But, these rates are simirar with the present estimation when compared with the drainage area, topographic characteristics, and soil texture. Though there are little variation in topography, slope, vegetation, etcin the study area which have not being playing much role yet variation in hydrogeomorphological conditions particularly texture of soil played significant role in sediment yield. Data on downstream distance of gully confluencesfrom the source of the Mora Dhansiri River and sediment yield of gully basins presented in table-1 demonstrate that rate of sediment yield is increasing in downstrean distance. This rate is calculated to be 8 t/km^2/y/km. Similar observation is also made by Singh (2002) in a study on gully erosion and management. Singh (2002) opined that sediment yield increases with increase of gully basin order. Study made by Sinha (2005) in Gangetic Rivers also finds similar rate of sediment yield. Data on sediment yield of different rivers of the Eastern Gangetic Plains (EGP) and Western Gangetic Plains (WGP) also indicate that the sediment supply from the upstream Himalayan catchment is variable from west (UP plains) to east (Bihar plains) (Sinha, 2005) in India. The WGP rivers such asthe Ganga (at Haridwar) and Yamuna (Allahabad) are characterized by low sediment yield of 150–350 t/km^2/yr, while the EGP rivers such as the Kosi (at Barakshetra) and Gandak (at Triveni) rivers are characterized by much highersediment yield of 1500–2000 t/km^2/yr (Sinha, 2005). Even the smaller rivers show a similar trend, for example, the Ramganga river in the WGP has much less sediment yield (~300 t/km^2/yr) in comparison to the Baghmati (~ 2700 t/km^2/yr) and Kamla-Balan (~ 4600 t/km^2/yr) rivers in the EGP (Sinha, 2005). These rates of sediment yield are similar with the present river with exception in some rivers of EGP because of mountain character of the catchment.

Sarmah (2003) made a study on downstream changes in channel form and grain size in the JiaDhansiri River, the parent river of the Mora Dhansiri River, and found that bed grains and pebble diameters are fining downstream (Table-2). Since, Mora Dhansiri River is an adjacent tributary river of the JiaDhansiri River (Fig.1) and flowing in the similar direction, this downstream fining of the grains and pebbles implies to be similar in case of later. Thus, downward fining of soil texture is found to be the determining factor of this order of sediment yield in the gully basins as the fine sediments constitute more suspended sediment than the course sediments. Field observations reveal that soils of the gully-1 are more course and porous than the gully-2 followed by gully-3 and gully-4 indicating the recorded order of sediment yield with little exception in gully-3. As shown in Fig.1, gully-3 is located near the mainstream and observed to be characterised by dissected, low and saturated ground compared to gully-4 and others consisting silt and clay resisting rainwater to percolate fast and allowing rapid sediment yield than other gullies. These facts are found to be attributable to more sediment yield in gully-3 than gully-4 and others. Thus it may be concluded that there is a trend of downstream increase of sediment yieldin the order of 8 t/km^2/y/km in the study area. Similar conclusion is also made by Milliman and Syvitski (1992). Across the globe, Milliman and Syvitski (1992) distinguished seven coherent sets of sediment yield from catchments ranging in size from 10 to 10^{6}km^2 (Milliman and Syvitski, 1992). In all but one case, sediment yields from catchments it is also high downstream (Milliman and Syvitski, 1992). Field observation reveals that sediment yield is, by and large, controlled by the hydrogeomorphological condition and soil texture. Dissected topography, saturated soil, and fine soil texture are key players of high sediment yield (861 t/km^2/y and 747 t/km^2/y in gully-3 and gully-4 respectively) during the entire period of study. Gully-1 is located in the downstream part of the piedmont zone in the study area which is characterised by coarse sand, high rate of water seepage, and comparatively high surface gradient. These characters of the ground except high surface gradient do not allow high sediment yield and delivery and thus gully-1 ranks forth in sediment yield.

To examine the role of discharge on sediment yield, four scatter plots of daily discharges vs. daily sediment yield (SY) for the years 2009, 2010, 2011 and 2014 are constructed and presented in Fig.3, Fig.4, Fig.5 and Fig.6 respectively.

Scatter plots on discharge vs. sediment yield presented in Fig.3, Fig.4, Fig.5 and Fig.6 demonstrates that discharge played significant role in sediment yield. Slopes of the trendlines representing different gullies shown in Fig.3 indicate that gully-3 rank first (b≈17.90) followed by gully-4 (b≈7.84), gully-2 (b≈4.73), and gully-1 (b≈3.89) in sediment yield in the year 2009. Rank of gullies in 2010 as shown in Fig.4 in respect of slope of sediment yield trendlines are first gully-3 (b≈11.86) followed by gully-4 (b≈7.92), gully-1 (b≈3.65), and gully-2 (b≈1.33). Rank of gullies in 2011 as shown in Fig.5in respect of slope of sediment yield trendlines are first gully-3 (b≈8.40) followed by gully-4 (b≈6.55), gully-1 (b≈2.10), and gully-2 (b≈0.55). Similar ranking of gullies as shown in Fig.6 also evident in 2014 placing gully-3 in the first (b≈7.47) followed by gully-4 (b≈6.43), gully-1 (b≈2.11), and gully-2 (b≈0.44). It is evident in all four scatter plots constructed for the rears 2009, 2010, 2011, and 2014 that individual gullies are maintaining their respective ranks in sediment yield during the three years study period except at gully-2 in 2009. Non-consistancy of temporal distribution of rainfall in 2009 as shown in Fig.7, extensive areal coverage of catchment area, and large size of gully channel are examined to be the principal causes of this exception. It is already mentioned that variations in ranks in sediment yield of different gullies and during the years 2009, 2010, 2011 and 2014 are primarily determined by the hydrogeomorphological conditions particularly soil texture. It is mentioned

Table-1 Sediment yield from gully catchments of Mora Dhansiri River

Gully Nos.	Gully-1	Gully -2	Gully -3	Gully -4	Average rate of sediment yield ($t/km^2/y$)
Drainage area (km^2) →	8.74	29.42	2.58	5.37	
Distance (km) from source to gully confluences →	33	67	69	73	
1	**2**	**3**	**4**	**5**	**6**
Year ↓	Rate of sediment yield ($t/km^2/y$)				**---**
2009	342	386	831	675	558
2010	454	504	905	877	685
2011	430	434	846	688	600
2014	440	480	878	730	632
Average of three years	417	451	865	742	618

Table-2 Average size distribution of bed grains and pebbles of the Jia Dhansiri River (the parent river of Mora Dhansiri River)

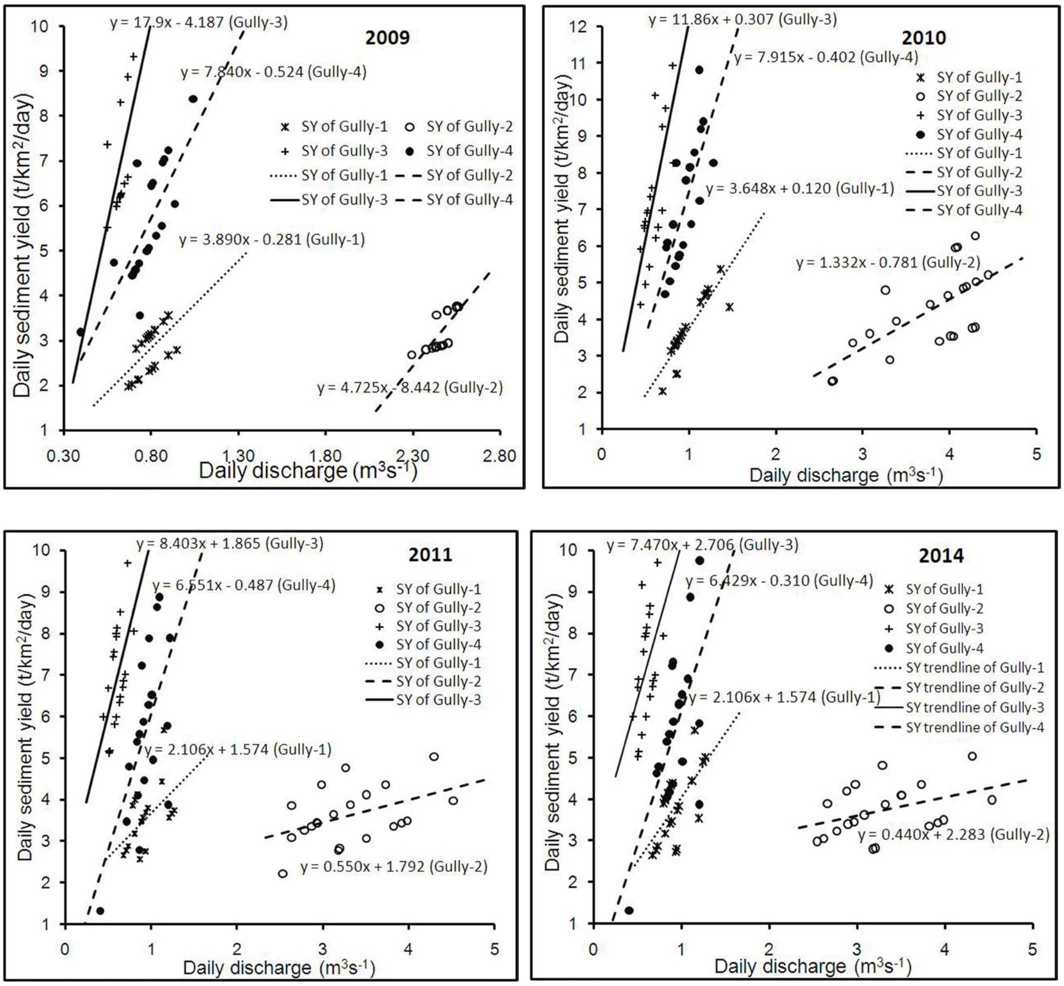
Sample site in downstream order with distance (km) from Bhairabkunda	Mean size of bed grains		Size class name of grains	Bed pebble diameter (cm)	
	In ϕ scale	In mm scale		Mean	Median
1	**2**	**3**	**4**	**5**	**6**
Bhairabkunda 0	1.973	0.255	Medium sand	4.62	4.75
Tarajuli village 14	2.153	0.225	Fine sand	2.95	2.30
Rowta Railway station 21	---	---	---	2.27	2.10
Dhansirighat 30	3.040	0.123	Very fine sand	1.03	0.88
Barigaon village 35	3.093	0.117	Very fine sand	No pebble	No pebble
Bagishakask village 41	3.780	0.073	Very fine sand	No pebble	No pebble
Thalthali village 46	4.067	0.060	Coarse silt	No pebble	No pebble
Thalthali beel village 47	4.117	0.055	Coarse silt	No pebble	No pebble

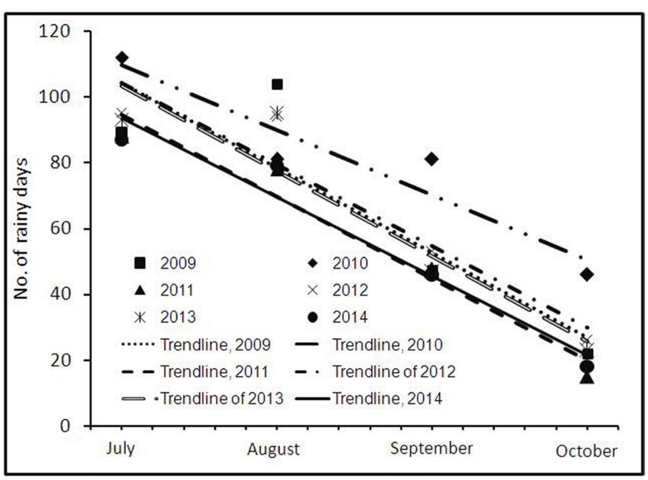
Source: Compiled from Sarmah (2003)

above that a study made by Sarmah (2001, 2003, 2008) also made a simillar conclusion in case of river bank materials, bed materials, and floodplain materials in the JiaDhansiri River basin which is the parent river of the present river under study. Thus study reveal that the variation in the rate of sediment yield during the years 2009, 2010, 2011 and 2014 are mostly attributable to temporal variation in rainfall and hydrogeomorphological conditions particularly soil texture. Goswami's (1985) estimation of rate of sediment yield of the rivers of Brahmaputra system of rivers shows a similar rate of yields if it is compared with the drainage area. Table-3 represents sediment yield rates of some of the small rivers of the Brahmaputra system of rivers compared with the drainage area. It is evident in table-3 that the rates of sediment yield of four gullies of the Mora Dhansiri River and the Mora Dhansiri River are 618 t/km^2/y and 696 t/km^2/y respectively. These data evident similar if compared with drainage area of rivers of the present environmental setting (table-3). Locations of points at the upper part of the graphs presented in Fig.6, Fig.7, Fig.8 and Fig.9 with similar discharges indicate sudden increase in sediment concentration. Observation during discharge measurement and sediment sampling evident that land tillage during high runoff period in the croplands particularly in paddy fields contrubuted more suspended sediment. Thus, land use is found to be a determining anthropogenic factor of sediment yield. Another study made by Klaghofer et al. (2002) on trends in soil erosion and sediment yield in the alpine basin of the Austrian Danube indicated an increasing trend of the sediment yield because of changes in land use as well as agricultural management practices.

This study also estimates that sediment yieldrate from the area (106 km^2) of the Mora Dhansiri River catchments excluding the area covered by gully basins and channel fabrics is 55 t/km^2/y in 2009, 68 t/km^2/y in 2010, 72 t/km^2/y in 2011 and 70 t/km^2/y in 2014. Major part of this area is covered by the piedmont zone which does not yield more sediment because of coarse soil texture and thus magnitude of sediment yield is much less compared to gully basins. Besides, as observed in field work, in major parts of this area exhibits reverse gradient on account of existence of many natural levees. This study finds no significant anthropogenic activity except regular land tillage during high runoff period which can bring about changes in sediment yield in the years 2009-14. Thus, inferences drawn here are considered to be justified.

However, there are temporal variations in sediment yield. The average rate of sediment yield from four gully basins were 558 t/km^2/y in 2009, 685 t/km^2/y in 2010, 600 t/km^2/y in 2011 and 632 t/km^2/y in 2014 respectively with the average of 618 t/km^2/y for all gullies (table-1) during 2009-14. This study finds that temporal variation in the occurrence of rainfall is the root cause behind the temporal variations in sediment yield. When other conditions remain constant, sediment yield in the catchment is strongly determined by the occurrence of rainfall more particularly rainfall of ground saturated period (July to October) in the study area. It is found that average rainfall of July to October has increased by 318mm (49%) during 2009-2010 which yielded an


2009
y = 17.9x - 4.187 (Gully-3)
y = 7.840x - 0.524 (Gully-4)
y = 3.890x - 0.281 (Gully-1)
y = 4.725x - 8.442 (Gully-2)
SY of Gully-1
SY of Gully-2
SY of Gully-3
SY of Gully-4
Daily sediment yield (t/km²/day)
Daily discharge (m³s⁻¹)
2010
y = 11.86x + 0.307 (Gully-3)
y = 7.915x - 0.402 (Gully-4)
y = 3.648x + 0.120 (Gully-1)
y = 1.332x - 0.781 (Gully-2)
2011
y = 8.403x + 1.865 (Gully-3)
y = 6.551x - 0.487 (Gully-4)
y = 2.106x + 1.574 (Gully-1)
y = 0.550x + 1.792 (Gully-2)
2014
y = 7.470x + 2.706 (Gully-3)
y = 6.429x - 0.310 (Gully-4)
y = 2.106x + 1.574 (Gully-1)
y = 0.440x + 2.283 (Gully-2)
SY trendline of Gully-1
SY trendline of Gully-2
SY trendline of Gully-3
SY trendline of Gully-4


No. of rainy days
July
August
September
October
2009
2010
2011
2012
2013
2014
Trendline, 2009
Trendline, 2010
Trendline, 2011
Trendline of 2012
Trendline of 2013
Trendline, 2014

increase of sediment yield of 127 t/km^2/y (23%) during the same period. This relation in 2010-2011 became 266mm (27%) to 85 t/km^2/y (12%) and in 2011-2014 became 36mm (3%) to 32 t/km^2/y (5%). Thus it is concluded that sediment yield rate is strongly determined by rainfall of ground saturated period**.** Here, two components of occurrence of rainfall are considered. *First*, total rainfall occurred in a particular period and, *second*, temporal distribution of occurrence of rainfall in that particular period. Keeping other conditions constant, if total rainfall in two consecutive years is nearly same but temporal distribution of occurrence of rainfall is consistant in one year and nonconsistant in the other, then sediment yield will be more in the year where temporal distribution of rainfall is consistant and less where nonconsistant because consistantrailfall yields more sediment due to more detachment of soil particles, less percolation of water, continuous surface runoff, etc on account of prolong saturated ground. This study reveals that in the year 2009, the total rainfall of July to October period of four stations situated in and around the study area was 2588 mm while in 2010 it was 2894 mm. Considering the variable character of Indian monsoon rainfall, occurring in this far distant region from its origin, these two data are similar. But, if we look at temporal distribution of rainfall in terms of month wise total number of rainy days during the same period (July to October) for both the years the picture is quite opposite. Distribution of rainfall in four months in terms of total number of rainy days in 2009, 2010, 2011, and 2014 is shown in Fig.7. It is evident in Fig.7 that trendlines of distribution of rainfall shows low negative trend in 2010, lower in 2011 and 2014, and lowest in 2009 and 2013. Low negative trend of temporal distribution of rainfall in 2010 demonstrates fairly uniform rainfall compared to other years signifying fairly high soil erosion vis-a-vis sediment yield and sediment delivery. The lower and low negative trend of temporal distribution of rainfall in 2009, 2011, 2013, and 2014 respectively demonstrate quite uniform and hafazard rainfall signifying comparatively lower and low soil erosion vis-a-vis sediment yield and sediment delivery which are evident in table-1. Thus, temporal distribution of rainfall is found to

Table-4 Rate of sediment yield of some rivers of the Brahmaputra system of rivers

River	Drainage area	Sediment yield (t/km^2/y)	Source of data
Borgang River	409	1749	Goswami, 1985
Pagladiya River	383	1883	Goswami, 1985
Deosila River	270	135	Goswami, 1985
Nanoi River	520	228	Goswami, 1985
Dudhnoi River	360	167	Goswami, 1985
Jia Dhansiri River	1611	435	Sarmah, 2001
Mora Dhansiri River	152	696	This study
Gullies of Mora Dhansiri River	46	614	This study

be powerful determinant in sediment yield and delivery in the study area which have been triggering occurrence of infrequent fluvial hazards in the study area. High monsoonal rainfall in the upper catchments of the Brahmaputra system of rivers and the steep gradient of the rivers are considered to be the major factors responsible for the high rates of unit discharge which in turn help to generate the high sediment yield from the basins and contribute drainage congestion in the valley (Goswami, 1998).

Conclusion

This study estimated that average rates of sediment yield in the Mora Dhansiri River catchment is618 t/km^2/y. The rates of sediment yield in the study area increases downstream by 8 t/km^2/y/km mostly because of fining of soil texture, and favourable hydrogeomorphological condition of the ground.The average rate of sediment yield is estimated to be 417 t/km^2/y at gully-1, 451 t/km^2/y at gully-2, 865 t/km^2/y at gully-3, and 742 t/km^2/y at gully-4 with an average of 618 t/km^2/y for all gullies during 2009-14.This study also estimates that sediment yield rate from the area of the Mora Dhansiri River catchments (106 km^2) excluding the area covered by gully basins and channel fabrics is 55 t/km^2/y in 2009, 68 t/km^2/y in 2010, 72 t/km^2/y in 2011 and 70 t/km^2/y in 2014. The average rates of sediment yield from gully basins in 2009, 2010, 2011, and 2014 are 558 t/km^2/y, 685 t/km^2/y, 600 t/km^2/y and 632 t/km^2/y respectively. It is found that average rainfall of July to October has increased by 318mm (49%) during 2009-10 which yielded an increase of sediment yield of 127 t/km^2/y (23%) during the same period. This relation in 2010-11 became 266mm (27%) to 85 t/km^2/y (12%) and in 2011-2014 became 36mm (3%) to 32 t/km^2/y (5%). Thus it is concluded that sediment yield rate is strongly determined by rainfall of ground saturated period and frequent tillage of the agricultural lands during the high runoff period.Study area is intensively cultivated, and thus continuation of this high sediment yield rate will invite hazards like drainage congestion, channel shifting, flood, etc affecting agricultural practices in recent future.

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Rana Sarmah
Pandu College, Pandu,
Guwahati-781012, Assam, INDIA,
ranasarmah2@gmail.com,
rana_sarmah@rediffmail.com