Proceedings of Seminar on "Soil Erosion in North Eastern Region" Held at Assam Administrative Staff College, Guwahati on 15th February, 2019

Brahmaputra Board
Government of India
Ministry of Water Resources,
River Development & Ganga Rejuvenatio

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1. Introduction:

North Eastern region of India is prone to Natural Disaster like earthquake, flood, landslide, erosions. etc. These natural phenomenons have great bearing on the lives of people living in the region and often cause misery to a large section of its population along with loss of property etc. Of these, erosion is a more serious problem as it causes permanent loss of land and other properties to the valley's agro-based people, turning them into paupers.

The seminar, organized by Brahmaputra Board on "Soil Erosion in North Eastern Region" at Assam Administrative Staff College, Guwahati on 15th February, 2019, is an attempt to bring domain knowledge in the field together and to deliberate possible remedies so as to evolve a cost effective and sustainable solution to the problem of soil erosion in the region. Dr. Pramod Kumar Mishra, Additional Principal Secretary to the Hon'ble Prime Minister of India and a noted expert on disaster management graced inaugural session of the seminar as the Chief Guest. Apart from Shri Rajiv Yadav, Chairman, Brahmaputra Board and Shri P. M. Scott, Vice-Chairman, Brahmaputra Board, other distinguished guests present during inaugural of the seminar were Shri Alok Kumar, Chief Secretary, Government of Assam, Shri Ranjit Kumar Pachnanda, Security Adviser to the Hon'ble Chief Minister of Assam, Shri A. M. Singh, PCCF, Department of Forest and Environment, Government of Assam, Shri Jadab Payeng, Padmashri and noted environmentalist. A host of other guests including resource persons and experts on the subject were also present on the occasion.

2. Inaugural Session:

2.1 The Chairman, Brahmaputra Board extended a warm welcome to the distinguished guests and delegates to the seminar, highlighted the issues of soil erosion encountered in the North Eastern Region in the form of erosion of river bank in the valley region as well as the soil erosion in the hills. He pointed that although flood is one major natural calamity faced in the region, the severity of soil erosion affects more as it leads to permanent loss of land and livelihood.

He stated that, steeper gradient in the tributaries and soil erosion in the hill slopes contributed to aggradations of river bed in the plains and causing the miseries of river bank erosion. To have a feel of the miseries of the people in affected areas, two families from the affected areas of Majuli Island and Mikirgaon area of Morigaon District were invited to the seminar. He hoped that the issue involving soil erosion which are going to be deliberated in the 3 (three) Technical Sessions, would help in evolving sustainable solution for managing the problem of soil erosion.

Highlighting the various anti-erosion works implemented by Brahmaputra Board, he mentioned that these schemes have been able to contain erosion in the affected reaches to a reasonable extent.

2.2 The two erosion affected families also described how the bank erosion affected their lives like many of them living in the river bank. Sri Jugal Hazarika from Majuli stated that flood had been a regular phenomenon in Majuli from the early days and people considered it as a boon instead of a curse as floods benefitted the people in many ways. It is the river bank erosion that has brought miseries to the people living in the river banks as their agricultural fields and dwelling houses have been eroded away almost every year bit by bit which made many of them landless. He stated that after Brahmaputra Board taken up implementation of anti-erosion measures in the island, erosion has been contained in majority of the bank line of Majuli. He hoped that in coming days, Brahmaputra Board will be able to instill confidence

among the affected people of the island through their works for protection of the island.

Sri Naba Kanta Deka of Mikirgaon area, another severely erosion affected area of this region, described how they have lost their entire farm land due to erosion of Brahmaputra. He stated that even after efforts to contain erosion by the Government of Assam, erosion is still unabated and everyday fertile lands are engulfed by the mighty river. He requested the gathering that Government of India through Brahmaputra Board will evolve some scientific method to combat the problem of erosion in Mikirgaon area.

2.3 Sri A.M. Singh, Principal Chief Conservator of Forest, Government of Assam stressed on the need of adoption of suitable forest cover to contain the menace of soil erosion. He stated that there are various model tools available for assessment of forest cover and verification of the ground truth for the same. He hoped that river experts and researchers would discuss the challenges and come into conclusion for some sustainable practical solution.

2.4 Noted environmentalist and globally known 'Forest man of India', Padmashree Sri Jadab Payeng spoke at length about importance and need for increased plantation in river catchments. He attributed deforestation in upper catchment as the main culprit for excess silt carried by the rivers and their aggradations causing devastating floods and braiding of rivers leading to bank erosion. Elaborating as to how he created a forest on a barren sand bar on the river bank at Kokilamukh near Jorhat town of Assam, he emphasized on the fact that with sincere and dedicated efforts, degraded forests could be recreated and fury of floods and erosion could be minimized.

2.5 Sri Ranjit Kumar Pachnanda, Security Adviser to the Hon'ble Chief Minister of Assam gave a general talk on disaster management and response. He highlighted events that led to formulation of 'Disaster Management Act' and constitution of the NDMA in India. Sharing his experience in the field of disaster management, he pointed to the fact that nearly 12% of the landmass of the country prone to disaster of

floods and erosion. He emphasized that for any country to become disaster resilient, early warning system of impending disaster, proper vulnerability mapping and sensitization of communities to disaster preparedness is of utmost importance. He is confident that with the efforts that have been taken by the State and Central governments, the country will be able to efficiently manage any disaster related issues.

2.6 Shri Alok Kumar, Chief Secretary to the Government of Assam, speaking on the occasion underlined various facets of soil erosion, particularly river bank erosion and termed it as a very critical issue faced by the region. He opined that such issues should be dealt as a community problem. Brahmaputra Board with its resources and insight should provide support in finding solution to this existential issue. He hoped that deliberations in the technical sessions of the seminar would concentrate on various aspects of erosion issues and evolve a concrete way forward to address this critical issue of soil erosion in the region.

2.7 Dr. P. K. Mishra, Additional Principal Secretary to the Hon'ble Prime Minister of India pointed out that soil and river bank erosion in this region is a vital issue and probably so far it had not received as much importance as it should have. He congratulated Brahmaputra Board for organizing the seminar on this vital issue. Dr. Mishra stated that surprisingly river bank erosion is not included in the list of principal hazards by the High Powered Committee constituted in 2001 by the Government of India to look into disaster management issues. He agreed that soil erosion is a critical problem in the N E region which has catastrophic effect due high seasonal variation of rainfall and discharge. Sediment load carried by Brahmaputra river is one of the highest among world's large rivers. He highlighted enormous erosion that had taken away large chunks of famous Majuli Island by the Brahmaputra since 1950 till 2005. He expressed happiness that erosion in the Island has been contained to a reasonable extent and the Island has gained its landmass since Brahmaputra Board took over the task of erosion control. Dr. Mishra hoped that deliberation in technical sessions would evolve sustainable solutions to diverse problems of soil erosion in the region. He raised five principles to the gathering which he felt could be

considered in search for solution to the problem of soil erosion, if found appropriate –

i) In search for solution, from sophisticated technology to indigenous technology, all possible alternatives should be explored. Given the diverse topography of the region, no single technical solution will suffice for a suitable solution. Aim should be to generate a compendium of solutions to mitigate the problem.

ii) In our endeavor to evolve a solution, the search should not be confined amongst technocrats and other experts. The communities which are exposed to hazards of soil erosion should also be involved and their experience are to be considered in the process for finding solutions.

iii) Given the scale of the problem, consideration of alternatives to engineering solution is important. Possibility of promoting hydroponic cultivation can be explored.

iv) Problem of soil and river bank erosion should be looked in the wider context of environment and water resources management. Government of India formed a panel lead by NITY Ayog to prepare strategy to address the problem of soil erosion and water resources development in NE region. The work of the seminar needs to be connected to this broader efforts and perspectives.

v) Problem of soil and river bank erosion needs to be looked at as a multi-hazard problem. The problem should be seen in the wider hazard risk profile context and hazard vulnerability profile of disaster management

Concluding his speech, Dr. Mishra wished that deliberations in the technical session of the seminar would be fruitful and would come up with specific recommendation that would fit the policies of the State governments of the region as well as Central government.

2.8 Shri P. M. Scott, Vice-Chairman, Brahmaputra Board and Chief Engineer, B&BBO, Central Water Commission offered vote of thanks in the inaugural session.

3. Technical Session:

Landslides and soil erosion in the hill catchment, and floods and river bank erosion in the valley areas of the rivers of the North Eastern region of India are the major natural deterrents to socio-economic development of the region. Problem of soil erosion is considered to be more disastrous as it leads to permanent loss of mostly agricultural land. The seminar is an attempt to bring together the domain knowledge experts in this field and to deliberate on possible remedies for evolving a sustainable solution to the problem of soil erosion in the region. With a view to achieve the desired objective, technical session of the seminar is held in three sessions – "Soil Erosion and Dynamics of River Brahmaputra", "Dynamics of Soil Erosion" and "Inputs for Soil Erosion Study and its Control".

3.1 Technical Session - I: "Soil Erosion and Dynamics of River Brahmaputra"

Four resource persons, who are domain experts – Dr. Nayan Sarma, former Professor, IIT Roorkee; Professor Dr. Subashisa Dutta, Department of Civil Engineering, IIT Guwahati; Dr. G. Venkatappa Rao, former Professor, IIT Delhi and Mr. Olivier Drieu, Senior Water Resources Specialist, Asian Development Bank – presented their papers on the theme.

3.1.1 Dr. Nayan Sarma, former Professor, IIT Roorkee presented his paper on 'Control of Sediment Ingress from Watersheds for River Management and Flood Mitigation'.

Study area considered in his paper is Jiadhal river, a northern tributary of the Brahmaputra river, which transports high sediments load from its catchment and causes catastrophe during floods by breaching of

embankment system and deposition of sediments in vast agricultural land and human settlements. Objectives of the study was to assess the soil erosion rate of the catchment. Analyzing data for the study area, Dr. Sarma observed that average annual soil loss of the catchment of Jiadhal is very high as compared to other catchments in the region. He also noted that study of vegetative/forest cover in the catchment from 2000 to 2014 indicated a sharp increase under bare soil cover class from 3.86 Km2 in the year 2003 to 97.60 Km2 in the year 2014. Dr. Sarma attributed the cause of susceptibility of the catchment to landslide & erosion mainly to complicated structure and geological setting of the region and tectonic movement resulting from movements of the earth's crust.

Elaborating on the loss of land due to erosion in main stem and major tributaries of Brahmaputra river system, Dr. Nayan Sarma portrayed a grim scenario of loss of land in a study period of 1990 to 2008 during which 1054 sqkm area lost due to erosion by the main-stem Brahmaputra while 639 sqkm lost due to its major tributaries.

Taking a cue from the key strategy adopted to manage flooding and sedimentation in Yellow River, Dr. Sarma stressed on the need for measures for soil erosion control in the higher catchment by improved Land use practices and resorting to geomorphology analysis to identify hotspots of erosion.

3.1.2 Professor Dr. Subashisa Dutta, IIT Guwahati presented his paper on 'Bank Erosion and Morphological Processes of the Brahmaputra River'.

Presenting his paper, Dr. Dutta eloaborated on the findings of his study in two specific reaches of Brahmaputra – Jamuguri reach and Dolgobinda reach. He observed that process of bank erosion in composite river banks, which is predominant in the Brahmaputra river, is attributable to excess shear stress developed at the toe causing toe scour; sediment transport capacity of the river near the bank; high variation in the river stage level causing the pore water pressure of the bank materials which lead to collapse the bank and seepage erosion of the bank during the receding phase of the river stage. Through their

study and in-situ experiments on erodibility variation in the banks of middle reach of the Brahmaputra, it was found that majority of bank soil belongs to very erodible class and erodibility varies from site to site. However, their laboratory tests indicates that higher the slope higher the time to collapse; effect of bank height is insignificant to the collapse time and more silt/clay layer increases the time of collapse and lesser seepage erosion.

Dr. Dutta described their study on morphological variability of Brahmaputra River at Ganeshpahar reach of Brahmaputra from 2013 to 2015 as well as physical modeling of Brahmaputra River at that reach. Concluding his presentation Dr Dutta pointed out processes of bank erosion and way forward on the issue as under -

- The river Brahmaputra is characterized by mobile braided loop morphology with intra and inter year variability.
- Understanding bank erosion processes (seepage and fluvial) and their relation with soil properties (critical shear stress and particle size), bend geometry (deflection angle and bank height) and flood characteristics (return period) leads to conclusion that -
  - The magnitude of the bank erosion increases from dry to wet monsoon years, with larger flood wave return period and longitudinal bed slope.
  - Seepage erosion prevails over fluvial erosion for soils with high critical shear stress.
  - The particle size of the river bed does not significantly affect the magnitude of annual bank erosion.
- Morphological response to river training works is complex. The river re-configures to form a braided loop in response to local placement of permeable spur.
- Long term decadal morphological analysis and entropy based morphological analysis showed decreasing trend in morphological

activity of the river and increase in morphological stability of the river in the recent years.

3.1.3 Professor Dr. G. Venkatappa Rao, former Professor, IIT Delhi presented his paper on 'Geosynthetic systems in mitigating river bank erosion'. Dr. Rao described uses of various types of geosynthetics in mitigating river bank erosion by depicting visuals on works executed in protection of the bank of Sarada river, Pilibhit, UP, Brahmaputra river banks protection measures at Majuli Island and Rohmoria, Assam.

Speaking on role of geosynthetics in sediment and erosion control, he mentioned that erosion control is a means of keeping a soil in place or catching a soil after it has been displaced but before it moves into surface waters. Types of geosynthetics for different purposes are different. Composite products are required for special applications - woven for strength and non-woven for filtering or surface protection. geosynthetics pays the role as separator, reinforcement to soil, as drainage, filter, energy absorber and a barrier between water and soil surface. It is suitable for various uses of protection like revetments, filter, toe protection (launching apron), etc. He impressed upon his point that geotextiles are more advantageous over granular materials for erosion protection due their assured quality, easy installation and durability. various benefits of using geotextile systems are mainly reduction in work volume, reduction in execution time, reduction in construction cost, the use of local materials, low skilled labor and locally available equipment. To top it all, the elements can be tailor made.

3.1.3 Olivier Drieu, Senior Water Resources Specialist, Asian Development Bank presented a paper on Measures to Mitigate Flood and Riverbank Erosion Disasters along the Brahmaputra in Assam and Bangladesh.

His thrust was on ADB's aim and interventions along the braided Brahmaputra river. Its overall aim is to mitigate flood and riverbank erosion risks with an integrated structural and non-structural approach (including safeguards) to reduce economic and social vulnerability and increase resilience in selected flood-prone areas. Besides various

schemes in Bangladesh, ADB' programme in the region includes 3 sites under Assam Integrated Flood and Riverbank Erosion Risk Management Investment Program, 2010-2020.

Key Technological Developments (structural) under ADB are new types of riverbank protection with long-guiding revetments maximizing local resources and resulting in cost-effective works, use of sand-filled geotextile bags coupled with CC blocs / boulders on filters, pro-siltation measure (porcupines) and use of jute mattress and nature based solutions (vetiver). Its endeavor is for construction of modern flood embankments incorporating high quality construction and future anticipated changes.

Summarizing his paper, Mr. Olivier Drieu stated that ADB interventions have proven benefits due to robust, proven, and cost-effective riverbank solution with minimal maintenance. They have been able to save substantial infrastructure from erosion in Bangladesh and Assam and secure livelihoods and increased economic activities in protected areas.

3.2 Technical Session 2: "Dynamic of Soil Erosion"

Four resource persons, who are domain experts – Dr. Arup Kr Sarma, Professor, Civil Engineering Department, Indian Institute of Technology, IIT Guwahati; Prof. Bibhash Sarma, Assam Engineering College, Jalukbari, Assam; Dr. P.L.N. Raju, Director, North Eastern Space Applications Centre (NESAC), Department of Space, Government of India, Umiam and Sri P.M. Scott, Chief Engineer, B&BBO, Central Water Commission & Vice-Chairman, Brahmaputra Board – presented their papers on the theme.

3.2.1 Dr. Arup Kr Sarma, Professor, Civil Engineering Department, Indian Institute of Technology, IIT Guwahati presented his paper on 'Need and Scope of Sediment Management in Brahmaputra Basin.

Dr. Sarma said that Brahmaputra river has a vast watershed and receives highest rainfall. The river has sudden drop of gradient from hills to plains, narrow basin in plains and has high drainage density with 35 Tributaries. Earthquakes in the basin inflict massive landslides to disturb the sediment regime of the river. Trans-boundary nature adds additional complexities. He stressed on the need for sediment management and control of sediment influx as it reduces flow carrying capacity activates near-bank channel leading to erosion. Top humus-rich soil is the fertile soil and progressive anthropogenic erosion can leads to disastrous landslide.

Catchment degradation and sediment deposition in the river reduces its carrying capacity causing formation and removal of sand bars, changing bathymetry of the river, activating near bank channel resulting in floods and river bank erosion.

He stressed that knowing sediment yield from the tributaries, their characteristics and sediment transport process for different reaches of Brahmaputra is essential. Change in precipitation characteristic under climate change is another key aspect to be reconed with.

Some Possible Ways of Controlling Sediment and Water Yield mentioned are -

- Soil and water conservation through watershed management with Optimal Ecological Management Practices (EMP). This can be achieved through high value native plantation with high carbon sequestration; rainwater harvesting with enhanced pond economy and coordinated effort of all countries sharing the basin, and coordination among states within each of the countries with mutually beneficial program (solving flood, bank erosion, landslide and improving economy)
- Storage Reservoir for augmenting seasonal flow and for deriving multiple benefit.
- Adoption of a concept of River-Regulator-Canal System for flood moderation sediment control and to achieve other benefits.

- Adoption of eco-friendly system bioengineering approach for controlling bank erosion.

3.2.2 Prof. Bibhash Sarma, Assam Engineering College, Jalukbari, Assam presented his paper on 'Action Plan for Brahmaputra River Bank Protection'.

Prof. Sarma stressed on the need for proper action plan on issues of erosion management for the Brahmaputra basin. Speaking on the current status of erosion management he stated till now no 'Erosion Management Program' exist and permanent "Bank line" is not defined. He pointed that for erosion control only patch works are done as per field requirements. As a result, in many cases, problem is shifted from one place to another and many embankments are realigned due to erosion. It has become a social issue. Bedsides, documentation of success and failure are few Dr. Sarma emphasized that apart from common practices adopted for erosion control for Brahmaputra, measures like Articulated Concrete Mattresses, Retaining Walls, Sheet piles and Windrows and Trenches shall also be adopted. He advocated for the ideas of dredging of river Brahmaputra, biological measures (vegetative control), channelization using porcupines and dam on river Brahmaputra main stream with diversion of water. He attributed poor bank soil properties, excessive sediment load and very high fluctuations of discharge and sediment load as the root cause of sandbar formation and erosion. He advocated for aggressive watershed management practices and construction of flood mitigation reservoirs at major tributaries for reduction of silt load and flood peaks of the river.

Dr. Sarma proposed for phasewise action plan for this purpose.

Phase-I

- Identify suitable points on the river course to be used as nodal points at an approximate distance of 50-60 km.
- Make the banks firm (zero erosion) and permanent at these points.

- Identify the desired bank line between two control points and plot them in map with absolute locations.
- With respect to erosion hazard, classify the river reach as most vulnerable, vulnerable, moderately vulnerable and stable

Phase-II

- Estimation of sediment load for river reaches between two nodal points;
- Model study for each river reaches;
- Identification of tributaries contributing maximum sediment load
- Reduction of sediment load by detention reservoirs and Watershed management practices.

Phase-III

- Use pro-siltation measures to actually obtain the bank line defined in Phase-I on priority basis.
- Permanent bank protection measures and corrective channelization(dredging) may be required at critical reaches.
- Timing of installation of pro-siltation measures is very important.
- Urgent erosion situations have to be attained, but the actions should be in accordance to the overall plan.
- Large land spurs should be avoided without detailed study. In unavoidable situations, closely spaced submergible bull heads may be preferred.
- Dredging at points near to the bank may attract the river towards the bank. Such dredging should be avoided. Objective should be to make the river flow along the centre line.

3.2.3 Dr. P.L.N. Raju, Director, North Eastern Space Applications Centre (NESAC), Department of Space, Government of India, Umiam – 793103, Meghalaya presented his paper on 'A study of Brahmaputra River: Dynamics of soil erosion and deposition for the last 30 years in main channel'.

Dr. Raju presented his paper based on inputs obtained through Landsat 5 (30 m resolution); Landsat 8 (30 m resolution); Sentinel-1 SAR (20 m) and Sentinel-2 multispectral (10 m). Decadal analysis Brahmaputra river islands near Dhubri, Bilasipara and Dibrugarh from 1988 to 2018 showed a trend that total area of river island is increasing. Around 1000 islands increased in thirty years with an increase in area of approximately 50,000 ha. There are only 17 islands bigger than 500 hectare which are stable and most of them are in upper Assam region. 50 islands are in range of 100 to 500 hectares which are stable from 3 decades. Identification of the char settlement and vegetation were made from the satellite imagery during lean period. Char monitoring during monsoon season were made using Microwave SAR data.

He also presented a study of the Catchments of the Ranganadi Hydro Electric Plant (RHEP) through Remote Sensing to assess the status of soil erosion with reference to upcoming Projects in the area and silt deposition in the reservoir. The objective of the study was to prepare land use land cover map and assessment of silt generation and predict its future trend under the emerging changes in the area.

Another assessment of silt generation to identify critical sub-watersheds in the catchment area of Kopili Hydro Electric Plant was also presented. The objectives were to prepare Land use Land cover and other thematic maps of the study area using 6 m spatial resolution and multi-spectral satellite imagery at 1:25,000 scales, estimation of soil loss, using different runoff and soil Loss Models and thematic maps and prioritization of the sub-watersheds and identify the critical areas in the catchment.

3.2.4 Sri P.M. Scott, Chief Engineer, B&BBO, Central Water Commission & Vice-Chairman, Brahmaputra Board presented his paper on 'Sedimentation in River System of North Eastern Region'.

Mr. Scott cited examples of sediment contributed by the tributaries of the NE region and highlighted the cause enormous silt load in the tributaries even though discharge in the river is not substantial. Annual sediment load carried by the Digaru, a sub-tributary of the Kopili river, with catchment mostly in Meghalaya, is as high as 572.3 thousand MT. He attributed the cause mainly to the development taking place in the drainage area of the sub-basin. He cited another tributary of Brahmaputra originating from Meghalaya, the Kopili, which carries a maximum silt load of 2652.4 thousand MT. Silt load carried by rivers of Tripura like Manu, Khowai and Gumti are also enormous compared to the discharge carried by the rivers. He has displayed ranking of silt load in some rivers in Barhmaputra Basin. Highest load carried by Subansiri at Chowndhowaghat followed in the order by Digaru at Sonapur, Brahmaputra at Pandu, Brahmaputra at Bhomoraguri, Dhansiri at Golaghat and Kopili at Jagibhakatgaon. However, it is the rivers of Tripura which are worst as far as silt load in the river is concerned. He noted that predictably, rate of siltation in reservoirs is highest in the basins of Himalayan region.

Mr. Scott indicated some ways to move forward with the issue which are as follows –

- River managers like CWC, WRD should give regular attention in silt observation and flood forecast
- Project owners should religiously survey capacity changes in the reservoirs and share data with compilers
- Inland Water Transport handler should regularly resort to dredging and river training issues
- River valley projects should generously resort to CAT and make periodical evaluation

- Infrastructure development should be in a smart way so that spoils do not get flown to the rivers
- Project planners should make proper estimation for loss storage at the time of design of the project
- Relentless R&D should be there in place
- Reservoir regulators should update AC curves for reallocation of storage capacity
- CWC should be kept updated with silt data by all project authority as they update countrywide data silt in silt compedium

3.3 Technical Session 3: "Inputs for Soil Erosion Study and its Control"

Four resource persons, who are domain experts – Dr. S.K. Srivastav, Dean (Academics), Indian Institute of Remote Sensing, Dehradun; Sri D. J. Borgohain, Retired Chief Engineer, Brahmaputra Board; Professor Parag Phukan, Centre for Brahmaputra Studies, Gauhati University and Dr. Prasenjit Ray, Soil Scientist, ICR National Bureau of Soil Survey and Land Use Planning, Jorhat – presented their papers on the theme.

3.3.1 Dr. S.K. Srivastav, Dean (Academics), Indian Institute of Remote Sensing, Dehradun presented his paper on 'Remote Sensing Inputs for Soil Erosion Studies : Some Examples from North-Eastern & Western Himalayan Region'.

Dr. Srivastav narrated different physical processes & factors affecting soil erosion. Notable factors affecting soil erosion are rainfall & surface runoff, fluvial processes, Floods, wind, soil erodibility, nature of topography, vegetation cover/LULC, conservation measures, LULC change and climate change. He stated however that major drivers of erosion in Brahmaputra & Barak valley are floods and LULC change. Hence, understanding fluvial geomorphic processes and LULC change

is critical to address soil erosion issues in Brahmaputra and Barak Valley of NE Region.

Dr. Srivastav elaborated study of Subansiri River in Assam with GIS-Based approach to assess changes in river channel & identification of high erosion zones assessment of river bank erosion probability using Graf's model. The study mapped high erosion zones using RS Data and estimation of river bank erosion considering river geometry & hydrology. Highlighting findings of the studies in Naula Watershed (Uttarakhand) and part of Satluj Basin (H.P.) Dr. Srivastav concluded that Remote Sensing data provide a number of inputs that can be effectively utilized in soil erosion studies. Integrating information derived from Remote Sensing and ground-based data and modeling approach in a geospatial framework are required for addressing soil erosion problem.

3.3.2 Sri D. J. Borgohain, Retired Chief Engineer, Brahmaputra Board presented his paper on "Bank Erosion in Brahmaputra river".

Sri Borgohain spoke on the erosion aspects of Brahmaputra river, various measures taken and outcome so far. He referred to the master plans prepared by Brahmaputra Board and stated that erosion tends to be active in limited areas in the valley portion which already under tremendous pressure due to population growth. Erosion makes many farmer to paupers. People in most rural areas do not bother about floods as most farmers consider it as boon. Whereas, erosion is a curse for them. With every passing year, riverine area is increasing due to erosion.

Describing common anti-erosion measures undertaken in the erosion protection of Brahmaputra are solid spurs, permeable screens made of bamboo and RCC, bank revetment with apron with boulders as well as geo-bags, tie-bunds for closure of spill channels, underground drainage to counter sloughing, Adoption of a specific method depends on river morphology, bank material, finance available and modes of bank erosion. Sri Borgohain discussed each methods used for erosion protection. He also discussed majors works undertaken by Assam

government since 1954. Due to paucity of funds, works could be taken in piecemeal manner. From 10th Plan onwards, after introduction of FMP programme of Government of India, works could be taken up extensively. He highlighted anti-erosion works undertaken by Brahmaputra Board in different reaches of Brahmaputra. He highlighted the efficacy of RCC porcupines as pro-siltation measure for deflecting bank channel away and thereby containing erosion. He talked about new thinking in erosion protection like, submerged veins, sheet piles, jacketing, dredging, grouting, articulated concrete blocks, vegetative measures. Permanent protection from erosion cannot be guaranteed. However, protection for 50 -0100 years can well be considered as long term solution. Since Brahmaputra is a highly dynamic river, our approach for a sustainable solution to the problem shall also be dynamic

3.3.3 Professor Parag Phukan, Centre for Brahmaputra Studies, Gauhati University presented his paper on "Erosion and Aggradation and associated fluvial Dynamics of Brahmaputra river".

Dr. Phukan informed that the Centre for Brahmaputra Studies, Gauhati University is taking up research work which will help in providing sustainable engineering solutions with support from DoNER Ministry through North Eastern Council. He opined that flood, erosion and sedimentation are not only engineering issues, these are socio-economic and political issues as well. He advocated for highlighting the socio economic issues and bring up the policy research and build the bridge between the policy makers and the researchers.

Dr.Phukan mentioned that Brahmaputra has a very narrow flood plain area. A case study carried out covering a stretch of 650 km from Pasighat to Dhubri and taking a range of data sets from 1911 to 2018 as well as satellite images showing minimal deposition compared to the active erosion in that reach. Erosion is not prevalent in crystalline rock outcroppings in places like Numaligarh, Dhubri, Golpara, Guwahati, Tezpur, Burapahar area. In case of Majuli, the soil is clay plug type in Salmara area and at opposite side at Neematighat thick clay zone is observed. Due to presence of this clay zone in between Salmara and

Neematighat, the river width is about 5 km. But beyond , this reach the river width is about 10 km. He observed that river erosion is controlled by the types bank material. He also observed that types of erosion / failures depends on different types of soil / bank materials. Silt and Sand dominant bank – slumping is observed, cohesive bank material with predominance of clay – vertical failure is observed and top part comprising silt % clay and bottom part sand – toppling effect.

In the north bank of river Brahmaputra, the ground water table is at a very shallow depth of about 5m, and in this reach the river acts as an affluent in the low flow stage and contributes to seepage called piping seepage. This is predominant is Majuli Island and western part of Biswanath Chariali.

In order to counter the erosion in an effective manner, the geology of the soil and bank material needs to be taken in to consideration.

Bringing reference to notorious sediment behavior of the rivers in Tripura, Dr. Phukan felt the problem lies with the geological nature of the sediments in the river. He summed up that the sediment input in the Brahmaputra river is increasing and at the same time the total water input into the river is not changing. This has lead to widening of the river to make way for the sediments resulting in erosion and channel multiplicity developing more sediment bars.

He advocated that like Bangladesh, where a is sand bar stable for 10 or 15 years becomes patta land, newly formed stable sediment bars in Brahmaputra should be utilized for greater interest of the region. Flood Plain Zoning needs to be introduced in Assam in order to regulate the land use in the flood plain region. He expressed that it is now time to revalidate the role of embankments and focus should be on erosion rather than on floods.

3.3.4 Dr. Prasenjit Ray, Soil Scientist, ICR National Bureau of Soil Survey and Land Use Planning, Jorhat presented his paper on ‘Land Resource Inventory for soil erosion assessment and control’.

He stated that Regional Centre, Jorhat is looking after the soil resources studies in 8 NER states. It is mandated for soil survey for soil resources, soil profile study, mapping of soil resources, and conducting and promoting research in the field of pedology, land evaluation and land use planning. It is also mandated to generate soil and land resource information in India.

Importance of LRI is to -

i. Generation of land resource information

ii. Assessing soil erosion at site specific level

iii. For developing a suitable land use plan

iv. Based on LRI information identification of different priority zones, venerable zones on various factor like fertility. Soil erosion, etc.

Landscape Ecological Unit mapping is done by using GIS. High resolution satellite data from ISRO used for preparing land use and land cover map. Digital Elevation Model used for slope information, land form information and chemical analysis at laboratories used for knowing soil properties. Landscape Ecological Unit Map is used as a base map for soil survey.

Citing a case study of Majuli Island, Dr. Ray stated that char areas acts as a buffer between river and the island. So there is need to protect the char land areas and provide a very good land use plan for the char areas as well as for the main island of Majuli. It is important to generate the land and soil resource information of Majuli Island for assessment of soil erosion loss in Majuli. NBSSLUP will be willing to generate the soil and land resource information and mapping of the island and would also like to provide suitable land use plan for the island to protect the area from river erosion.

4.0 Concluding Speech:

i) Shri P. M. Scott, Chief Engineer B&BBO, CWC, Shillong and Vice-Chairman, Brahmaputra Board gave concluding speech of the technical

session on behalf of the Chairman, Brahmaputra Board. He said that all good things have to come to an end and so as the seminar. He expressed happiness that after a grueling day and hard work, the seminar had been able to reap the harvest through the recommendations and way forward presented by the various research/resource persons. He was confident that recommendations of the seminar would be able to help planners and project managers in addressing the problem of soil erosion and water resources development in NE region in line with the broader efforts and perspectives envisaged by the Government of India for this region.

He liked to assure that having learned from this seminar, our future approach will be to look at the problem of soil and river bank erosion as a multi-hazard, multi-disciplinary and inclusive.

5.0 Recommendations made in the seminar:

1. In search for solution, from sophisticated technology to indigenous technology, all possible alternatives need to be explored. Aim should be to generate a compendium of solutions to mitigate the problem.
2. In our endeavor to evolve a solution, the search should not be confined amongst technocrats and other experts. The communities which are exposed to hazards of soil erosion should also be involved and their experience are to be considered in the process for finding solutions.
3. Given the scale of the problem, consideration of alternatives to engineering solution is important. Possibility of promoting hydroponic cultivation can be explored.
4. Problem of soil and river bank erosion should be looked in the wider context of environment and water resources management. Government of India formed a panel lead by NITY Ayog to prepare strategy to address the problem of soil erosion and water resources development in NE region. Approach of the seminar needs to be connected to the broader efforts and perspectives.

5. Problem of soil and river bank erosion needs to be looked at as a multi-hazard problem. The problem should be seen in the wider hazard risk profile context and hazard vulnerability profile of disaster management.

6. There is need for measures for soil erosion control in the higher catchment by improved Land use practices and resorting to geomorphology analysis to identify hotspots of erosion.

7. There is need for sediment management and control of sediment influx as it reduces flow carrying capacity and activates near-bank channel leading to erosion. Study of sediment yield from the tributaries, their characteristics and sediment transport process for different reaches of Brahmaputra is essential.

8. Controlling Sediment and Water Yield can be attained through –

   - Soil and water conservation through watershed management with Optimal Ecological Management Practices (EMP) which can be achieved through high value native plantation with high carbon sequestration; rainwater harvesting with enhanced pond economy and coordination among states within each of the countries with mutually beneficial program.

   - Storage Reservoir for augmenting seasonal flow and for deriving multiple benefit is important. Reservoir regulation needs to be adopted as complementary measures.

   - Adoption of a concept of River-Regulator-Canal System for flood moderation, sediment control and to achieve other benefits can be considered.

   - Eco-friendly system and bioengineering approach for controlling bank erosion can be adopted. Polygon Foundation (NGO) has taken vegetative measures for control of erosion in Dikrong river which has been performing well. Similar environmental friendly measures can be tried elsewhere.

9. There is need for proper action plan and 'Erosion Management Program' on issues of erosion management for the Brahmaputra basin. For this a permanent "Bank line" is to be defined.

10. Adequate documentation of success and failure stories of erosion management activities is important. Apart from common practices adopted for erosion control for Brahmaputra, measures like Articulated Concrete Mattresses, Retaining Walls, Sheet piles and Windrows and Trenches shall also be adopted.

11. For riverbank erosion control, ideas of dredging of river Brahmaputra, biological measures (vegetative control), channelization using porcupines and dam on river Brahmaputra main stream with diversion of water to be given importance.

12. Aggressive watershed management practices and construction of flood mitigation reservoirs at major tributaries for reduction of silt load and flood peaks of the river to be adopted.

13. Phasewise action plan is needed for erosion management and following can be considered -.

    - There are a number of natural nodal points in Brahmaputra river. New nodal points in between existing ones need to be created. Measures to be adopted to make the banks firm and permanent at these points. Desired bank line between two control points to be identified and to classify the river reach as most vulnerable, vulnerable, moderately vulnerable and stable.

    - Sediment load for river reaches between two nodal points to be estimated, model study for each river reaches to be carried out. Identification of tributaries contributing maximum sediment load and reduction of sediment load by detention reservoirs and Watershed management practices to be adopted.

    - Use pro-siltation measures to actually obtain the bank line between each nodes, permanent bank protection measures and corrective channelization (dredging) at critical reaches necessary. Dredging at

points near to the bank should be avoided. Objective should be to make the river flow along the centre line.

14. Reservoir capacity reduces due to siltation of reservoir. For increasing the life of a reservoir, prioritization of the sub-watersheds and identifying the critical areas in the catchment for taking measures to reduce inflow of sediment into reservoir need to be undertaken. Preparation of Land use Land cover and other thematic maps of the identified critical sub-watersheds / study area is necessary for estimation of soil loss. Different technology for runoff and soil Loss Models can be adopted.

15. An inclusive Reservoir operation policy needs to be adopted so that multiple benefits can be derived in different situation. Reservoir operation should also be shared with authority in lower riparian areas.

16. River managers like CWC, WRD should give regular attention in silt observation and flood forecast.

17. Project owners should religiously survey capacity changes in the reservoirs and share data with compilers.

18. Inland Water Transport handler should regularly resort to dredging with due consideration to river training issues.

19. River valley projects should generously resort to Catchment Area Treatment and make periodical evaluation.

20. Infrastructure development should be in a smart way so that spoils do not get drained to the rivers aggravating silt load.

21. Project planners should make proper estimation for loss of storage at the time of design of the project. Reservoir regulators should update Area-Capacity curves for reallocation of storage capacity.

22. Relentless R&D should be there in place for evolving soil and erosion control technology.

23. CWC should be kept updated with silt data by all project authorities as they update countrywide data silt in silt compendium.

24. Integrating information derived from Remote Sensing and ground-based data and modeling approach in a geospatial framework are required for addressing soil erosion problem.

25. Flood, erosion and sedimentation are not only engineering issues, these are socio-economic and political issues as well. Hence, the socio economic issues need to be highlighted and the gap between the policy makers and the researchers should be bridged. Policy for development and utilization of newly formed stable sand bars in Brahmaputra may be contemplated for greater interest of the region.

26. There is need to protect the char land areas and provide a very good land use plan for the char areas. Important to be given to generate the land and soil resource information inventory.

27. Flood Plain Zoning needs to be introduced in order to regulate the land use in the flood plain region.

28. Revalidation of the role of embankments to be looked into and focus should be more on erosion.

29. Role of geosynthetics for different types of uses in soil erosion may be extensively explored as an engineering approach. Geo-synthetic/ Textile which is available in various customized forms like filter, gabion, bags, mattress etc. can be optimally used along with local materials after giving due consideration to experiences of their uses in similar condition.

30. ADB has successfully intervened through various structural and non-structural measures for flood risk mitigation in Brahmaputra in India (Assam) and Bangladesh. Integrated approach adopted by ADB involving community should be adopted to minimize miseries due to erosion.

31. A Centre of Excellence for erosion & flood management need to be established which will provide road map and guidance for erosion & flood management in holistic manner

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