भारतीय भूवैज्ञानिक सर्वेक्षण
GEOLOGICAL SURVEY OF INDIA
मिशन –IV / Mission-IV
केंद्रीय मुख्यालय, कोलकाता / Central Headquarter, Kolkata

MINUTES OF BRAIN STORMING SESSION

ON

MESO-SCALE LANDSLIDE SUSCEPTIBILITY MAPPING PROGRAMME OF GEOLOGICAL SURVEY OF INDIA

November 12, 2018
Geological Survey of India, Kolkata

The Addl. Director General and Head: Mission-IV, Geological Survey of India, organized a Brain Storming Session (BSS) on Meso-scale Landslide Susceptibility Mapping Programme at GSI, Central Headquarters, Kolkata on 12th November, 2018 between 11:00 and 18:00 hrs.

The event, organized under the Chairmanship of Dr. S. Raju, ADG and NMH-IV, GSI, was aimed at focused discussions and generating ideas/ solutions on methodology to be adopted for meso-scale (1:5000-1:10,000) landslide susceptibility mapping (LSM) in GSI to meet the end user's demand for providing user friendly susceptibility maps. Meso-scale LS maps are required for town planning purposes (hill area infrastructure and settlement development). The ADG and HOD of NER; DDG and RMHs-IV of NR, SR, NER; DDG, M-IVA, DDG of State Units of P&HP, and officers of Landslide Divisions of NER, SUs: Assam, Sikkim, Pune, K&G, P&HP, J&K, UK, GHRM Centre, DGCO and PSS, CHQ attended the BSS through video conference. The programme schedule is given Annexure-1.

Highlights of the proceedings of Brain-storming Session (BSS)

1.0. Welcome Address	The programme started with a welcome address by Dr. K. Jayabalan, DDG, Mission IV-A, GSI, CHQ, Kolkata. In his address, Dr. K. Jayabalan highlighted the need of holding BSS as no standard methodology is available in the country. BSS provides opportunity to learn from the landslide domain experts within GSI to evolve standards for meso-scale LS mapping.

2.0. Chairman's Address	Dr. S. Raju, Addl. Director General and Head, Mission-IV and the Chairman of the BSS started his address by mentioning that the Brain Storming Session is necessary to unleash the ideas so that best solutions for meso-scale LSM can be brought out. He added that the purpose of the BSS is to have focused discussions on the formulated guidelines so that the meso-scale LSM work can be taken up without technical hindrance and the evolution of the guidelines/SOP can take place as the work proceeds. He also suggested having Landslide Division in Arunachal Pradesh as the state is highly prone to landslide hazard. He requested DDG and RMH-IV, NER to submit proposal for the same.
3.0. Objective of BSS	Dr. Pankaj Jaiswal, Director, LnSD, GHRM Centre elaborated the main objective of the BSS in the line of decision taken in IPR of FS 2019-20. He highlighted the urgent need of evolving methodology on meso-scale LSM so that a user friendly map can be generated, which can categorise landslide susceptibility based on landslide/geomorphic processes.
4.0 ISSUES AND CHALLENGES IN THE EXISTING METHODOLOGY OF MESO-SCALE (1:10K) LSM	
4.1 Presentation on Chibo case study, West Bengal	Dr. Timir B. Ghoshal, Director, EG and Landslide division, ER presented on the issue and challenges in carrying out 1:10k LSM in Chibo area. He adapted the methodology published in IJGS (which is also included in the draft SOP of GSI on meso-scale LSM). The following suggestions were made: 1. Different criteria were used for mapping susceptibility in rock and overburden covered slopes. Overburden <1 m was included within rocky slopes. 2. For rock mass analysis, SMR may be replaced by RMR_{basic} as the former is good for cut slopes but not for natural slopes. 3. Structural data such as relation of bedding/foliation and joints with slope should be used separately as suggested in macro-scale guidelines of BIS (1998). 4. Requires revision of slope and relative relief matrix and rating as suggested in draft SOP of GSI on meso-scale. 5. The need for considering shear parameters (cohesion and angle of internal friction) of overburden as a separate thematic factor. 6. The area of study should be small and accessible so that data can be collected physically. 7. The need for exploring robust techniques in

	interpolation of point data to adjacent slopes. 8. The need for rationalizing knowledge-based weightage using established methods like AHP, ANN etc. 9. Suggestion for use of remote sensing techniques for preparation of land cover and hydrology maps. 10. Identification of safe shelter and escape route in case of landslide. 11. Preliminary mitigation measures.
4.2 Presentation on Mangan case study, Sikkim	Shri Jagdish Nandan Hindayar, Senior Geologist, SU: Maharashtra, Pune presented on the issue and challenges in carrying out 1:10k LSM in Mangan area. He adapted the methodology published in IJGS (which is also included in the draft SOP of GSI on meso-scale LSM). The following suggestions were made: 1. Scale of mapping should be 1:5000 so that smaller important features can be plotted. 2. Grid-based sampling and collection of undisturbed samples at all desired locations not possible. Judicious collection of representative samples to be explored. 3. Suggested the need to have methodology for collection of samples for geotechnical analysis. 4. Facet drawn manually from CartoDEM was not true to the ground condition. 5. Assigning centroid-based rating for overlapping thematic maps in facet-based study can produce unsatisfactory maps. Care should be taken through manual checking of all such facets for assigning appropriate ratings. 6. Need to explore possibility to include sub-surface moisture condition as one of the input parameters. 7. Relative relief classes need to be changed depending on the terrain condition. 8. Need to explore use of geophysical survey for estimation of overburden thickness.
4.3 Presentation on way forward on meso-scale LSM	Dr. Pankaj Jaiswal, Director, LnSD, GHRM Centre gave a brief presentation on the constraints in the draft BIS guidelines on meso-scale landslide studies and suggestions for the way forward. The need for preparing correct thematic maps based on the characteristics and factors causing landslides in a particular terrain was stressed. Further, considering the need of end users, the output map indicating their susceptibility to the expected type of landslides i.e., a landslide domain-based susceptibility map was projected as a possible alternative. This was followed by a brief discussion led by Dr. Saibal Ghosh, Director, DGCO, New Delhi on the nature of the work, required orientation of the workers,

	expectation of the stakeholders from meso-scale landslide studies, importance of dense field-data collection, understanding the uncertainties involved and efforts for minimizing such uncertainties through field work, etc.
5.0 DISCUSSION	
The brain storming session, moderated by Dr. K. Jayabalan, DDG, M-IVA, commenced with the inputs from the participating officers on all issues and constraints for outlining their solutions. Some of the pertinent issues discussed and decision taken include:	
5.1 Modalities for taking up meso-scale LSM in GSI	Towards disaster preparedness, GSI will take up meso-scale landslide studies sou-moto. However, requests from State Governments and other Stakeholders will be prioritized. Certain criteria for taking up sou-moto meso-scale landslide studies were outlined as follows: 1. Consult the Ministry of Road Transport and Highways (MoRTH) pertaining to their work plan for the next 10 years in the hilly terrains of the country. 2. Consult the state governments of hilly states for existing road network, reservoirs, and upcoming work plans on infrastructure development, etc. for prioritizing the study areas. 3. Compulsory presence of High Susceptible zones and some parts of Moderate Susceptible zones from the available 50k landslide susceptibility map prepared under NLSM programme in the proposed study areas. 4. The declared Smart Cities of the Govt. of India and falling within hilly region can be taken up. 5. Elements at risk in the proposed study areas. 6. Every Region of GSI falling in Hilly terrains to take up at least one pilot project on meso-scale landslide studies during FS: 2019-20. For developing a robust methodology pertinent to the region and the terrain, the proposed pilot project in all Regions to consider choosing an area where maximum landslides types expected in that region are represented.
5.2 Scale for taking up meso-scale LSM in GSI and area coverage for defining NQT	Considering the importance of run-out of landslides, particularly in the case of debris flows, and the occurrence of rock falls and topples from inaccessible steep slopes, the proposed study areas will necessarily be carried out from the crest of the hillslope down to the valley bottom. However, in the difficult Himalayan terrain where accessibility is severely restricted, the study will be confined to 100 m on both sides of the road or whichever is visible along road. Such cases of special studies will consider landslide susceptibility mapping

	from the crest of the hillslope down to the valley bottom. Studies carried out along road corridors should be judiciously selected covering 50 line km/10 sq. km for one field season for two officers. For meso-scale study of settlement areas/townships, a minimum of 3 sq. km in the Himalayan terrain with rugged topography and a minimum of 5 sq. km for hilly terrains with subdued topography in a field season are proposed.
5.3 Choice of a base map for meso-scale LSM	Preparation of base maps on 1:10 k following conventional methods using Total Station is time consuming as well as difficult. Considering the low cost, ready availability, possibility of preparing base maps as well as contours and taking into confidence the input given by NRSC scientists during CGPB meeting on the suitability of CartoDEM for 1:10k studies, GSI will make use of the 10 m resolution CartoDEM and 2.5 m Cartosat images for meso-scale landslide studies till such time better options or sources are developed.
5.4 Thematic maps/parameters for input in meso-scale LSM	The parameters and thematic maps required for the preparation of meso-scale landslide susceptibility map can broadly be categorised under the Geological, Geomorphological, Geotechnical and Geophysical domains. 1. Geological- slope forming material map showing the rock and overburden slopes along with the various possible sub-classes will be prepared. Colluvium should be mapped based on its character as different lithologies can generate colluvium of different shear properties. The guiding principle for mapping slopes with thin overburden (>0.5m) should be the type of failure expected on that slope for assigning the correct slope forming material. 2. A land use-land cover (LULC) map will be prepared from the CartoPAN and field validated. The classes should be based on type of vegetation such as tea, rubber, pine, bamboo, mix vegetation, paddy etc. This will help to assess the root cohesion effect in slope instability. 3. CartoDEM-derived drainage map considering drainage order will be used as a distance buffer map.

	4. Considering the subjectivity of overburden thickness maps as well as the uncertainty of their role in causing landslides, the overburden thickness map shall be avoided unless if the accuracy is acceptable. Similarly, the hydrology map also may not be required. 5. Geomorphological- A landform map derived from CartoDEM will be prepared and used. Landslide Studies Division, GHRM Centre will provide services to working officers from Regions/state units in preparing the landform map. However, procurement and supply of the required CartoDEM to GHRM Centre for preparation of the same shall be the responsibility of the Regions/state units. 6. Geotechnical- A separate geotechnical map incorporating the shear parameters of overburden and rockmass characterization of slopes will be prepared. 7. Geophysical- Considering the difficulty of geophysical surveys in Himalayan terrain as well as the subtraction of overburden thickness maps in the study area, the requirement of geophysical input in meso-scale landslide susceptibility mapping is to be judiciously decided by the field officer/s. If required geophysical component may be incorporated in NQT. 8. Landslide inventory- a detail assessment of landslides to be carried out to understand the failure mechanism and control of geofactors. If required, the study can include areas adjacent to the study area. This will help to understand the role of thematic factors on initiation of landslide or type of landslide process being active in the area.
5.5 Sampling method	Procedure for samples locations will be judiciously chosen by the field officer/s considering the representation of the different types of slope forming materials (at different elevation to capture effect of kinematic sieving) present in the study area. The quantum of samples to be collected and tested for an item in a field season may be projected as 20-30 samples. Since, discontinuity wall strength is known to be important for assessing rockmass condition, rather than the strength of intact rock, sampling of rocks, if any, may be judiciously

	decided by the field officer/s. For estimating the discontinuity wall strength of rock slopes, use of Schmidt hammer may be adopted. Collection of undisturbed soil samples (UDS) may be difficult in the Himalayan terrain. In such cases, bulk samples of 2 kg will be collected for estimating the shear parameters through Direct Shear Test.
5.6 Methodology vis-à-vis Output Map	For arriving at a concrete methodology on meso-scale landslide susceptibility mapping, a similar session to be conducted after the completion of the ongoing items in FS 2018-19. For optimal output, efforts to be made in all the projects for the preparation of user friendly susceptibility maps. For continuing items under FS 2018-19, the existing methodology may be followed with necessary adaptation as suggested/discussed in the BSS. For new items, the concept of landslide domain based factor analysis for susceptibility mapping may also be explored vis-a-vis the innovative input in refining the issues in the already available method.
6.0 CONCLUDING REMARKS BY THE CHAIRMAN	
Dr. S. Raju, Addl. Director General and Head, Mission-IV and the Chairman of the BSS concluded by highlighting the need for finalising the Standard Operating Procedure (SOP) for meso-scale LSM and getting it vetted by other experts including BIS, NDMA. He also opined for the preparation and submission of the perspective plan on meso-scale landslide studies vis-à-vis engagement of officers in GSI to the Ministry. The BSS ended with a vote of thanks.	

Annexure-1

Brain Storming Session on formalizing the methodology for meso-scale Landslide Susceptibility Mapping

15 A&B, Kyd street, Geological Survey of India

11:00 hrs to 16:30 hrs on 12-11-2018

Programme

Time	Title	Speaker
11.00-11.05 hrs	Welcome address	Dr. K. Jayabalan, DDG, M-IVA
11.05-11.10 hrs	Opening Remarks	Dr. S. Raju, ADG and NMH-IV
11.10-11.15 hrs	Objective of BSS	Dr. Pankaj Jaiswal, Director, LnSD
Presentations		
11:15-11:30 hrs	Issues and constraints of the existing methodology of meso-scale LSM- Chibo case study	Dr. Timir B. Ghoshal, Director, EGD, ER
11:30-11:45 hrs	Issues and constraints of the existing methodology of meso-scale LSM- case study from Sikkim	Shri Jagdish Nandan Hindayar, Senior Geologist, SU: Maharashtra, Pune
11:45-12:00 hrs	Issues of mesoscale LSM in Western Ghats/Konkan area	Dr. M.S.Bodas, Director, SU Maharashtra and Shri K. Aravind, Director, SU:TNP
12:00 -12:15hrs	Issues related to preparation of thematic maps on 1:10k	Dr. Pankaj Jaiswal, Director, LnSD
12:15-12:30 hrs	User friendly meso scale LSM	Dr. Saibal Ghosh, Director, DGCO
Discussions		
12:30-13:30 hrs	Discussion on 1. Basemap 2. Thematic maps 3. Methodology on Meso-scale LSM for different terrain conditions	Moderator: Dr. K.Jayabalan, DDG, MIVA
13:30-14:30	Lunch break	
14:30-16:30	Finalization of approach for meso-scale LSM for different terrain condition	
16:30	Vote of thanks	