

Operational Highlights - 2018



National Building Research Organisation (NBRO) in 2018 carried out its duties well and made a sturdy progress. The highlight was the evacuation of 23 residents in Norwood in the district of Nuwara Eliya to safety in the wake of the impending landslide in September 2018. R & D work progressed well leading to a two-day NBRO Annual Research Symposium. The NBRO maintained its position as a leading technical service provider in the country, earning over Rs. 1048 Mn as consultancy revenue in 2018.

NBRO is the research arm and the only technical agency in the line ministry. NBRO was able to provide solutions to many issues in the country especially utilizing combine capacities of multi-disciplined technical divisions backed by their modern facilities. NBRO's expertise is now offered as technical services mainly in the fields of geotechnical engineering, building materials technology, human settlements planning, environmental management & project management. NBRO specializes now in emerging fields to address many other issues in the country, especially in landslide mitigation technology, detecting ground subsidence, creating disaster resilience and promoting drought adaptation, which other institutions do not have the technical expertise and equipment capacity.

During the year under review NBRO carried out the following specific tasks in line with its designated functions, Corporate Plan and Annual Action Plan.

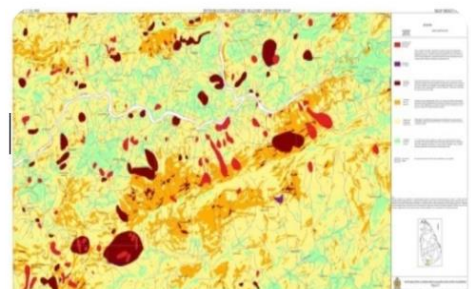
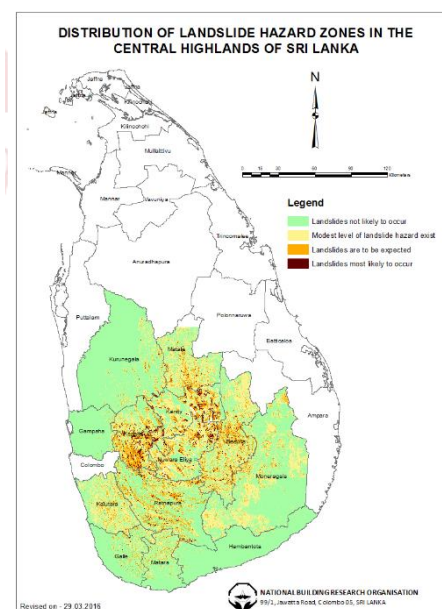
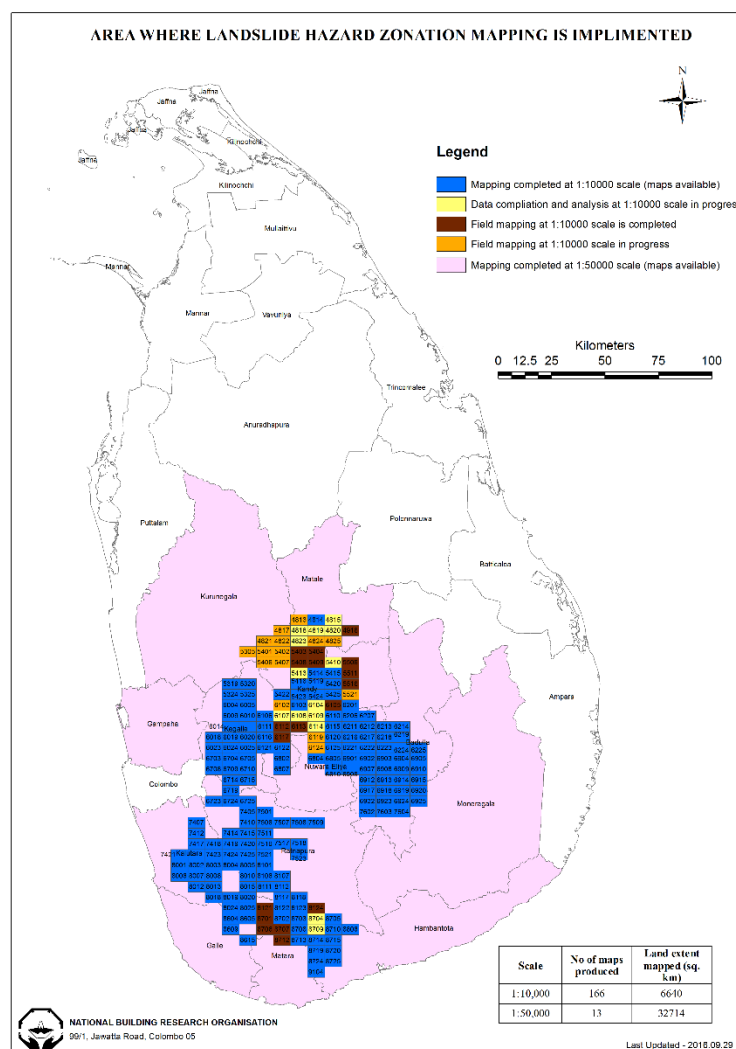
GOSL Funded Projects

Landslide Hazard Zonation Mapping Programme (LHMP)

Landslide Hazard Zonation Mapping Project (LHMP) is a project funded by the government and continuing since 1992. It identifies spatial distribution of landslide hazard and as an outcome, produces landslide hazard maps. Thus far under this project, landslide hazard zonation maps to the scale 1:50,000 have been prepared to cover a total of 32,593.1 sq. km in 13 districts identified as having the landslide hazard risk. In addition, maps to the scale 1:10,000 have been prepared to cover prioritized areas covering a total of 6,840 sq. km.

In 2018, the project received a Government grant of Rs. 20.0 Mn. and as the outcome, 12 map sheets each covering 40 sq. km in 1:10,000 scale were prepared in the districts of Ratnapura, Kalutara and Nuwara Eliya. Total area covered under 1:10,000 scale was 480 sq. km. In addition, 27 sq. km was mapped covering Ratnapura MC area in 1:5,000 scale.

The maps produced by this project are used in the issuance of landslide early warning, and in landslide investigation work leading to hazard risk assessment, issuance of Landslide Risk Assessment Reports (LRAR), and identification and prioritization of potentially dangerous sites for mitigation. The maps are also used in national and regional level planning by various institutions. Most of these maps are available for downloading free of cost in the NBRO website (www.nbro.gov.lk).



Hazard Zonation Map 1: 50,000 Scale

Landslide Risk Assessment Reporting Process (LRAR)

NBRO issues Landslide Risk Assessment Reports to local governmental authorities recommending whether to grant or not approval to a building permit or approval of a development project when sites are in landslide-prone areas. By 31st December 2018 the NBRO has received 73,304 applications since the issuance first started in March 2011. The number of applications received in 2018 was 9325, the number of approvals issued was 9200 and the number of applications rejected was 125. The NBRO charges a nominal fee to process an application, carry out necessary investigations and issue a report. The General Treasury provided Rs. 27.5 Mn in the year 2018 to cover the recurrent expenditure of this process and balance expenditure was borne by NBRO revenue as CSR.

Table : LRAR details since the process inception in March 2011

	(district) දිස්ත්‍රික්කය	1	2			3=1-(2a+2b+2c)	Pending Application Details (අතිරේක)		
		Total Applications Received (ලැබූ ඉල්ලුම්පත් සංඛ්‍යාව)	Total Applications work			Total applications pending (අතිරේක ඉල්ලුම්පත් සංඛ්‍යාව)	Pending For initial Investigation (මූලික පරීක්ෂණ සඳහා)	Referred to revisit/detail investigation (විස්තරාත්මක අධ්‍යයනයට යොමු කිරීම)	Documents Pending from Client (ඉල්ලුම්කරුගෙන් අදාළ ලියකියවිලි ලැබෙන තෙක්)
			2a Permission granted (අනුමැතිය ලබා දුන් ඉල්ලුම්පත්)	2b Permission not granted (අනුමැතිය ලබා නොදුන්)	2c Applications rejected due to other reasons (වෙනත් හේතූන් මත)				
1	Kandy - මහනුවර	17467	15693	216	1384	174	21	8	145
2	Matale- මාතලේ	7231	7142	16	33	40	26	0	14
3	Nuwaraeliya - නුවරඑළිය	6276	6042	43	50	141	58	40	43
4	Badulla - බදුල්ල	9339	8844	142	236	117	56	30	31
5	Kagalle - කෑගල්ල	9849	9393	29	360	67	1	1	65
6	Rathnapura - රත්නපුර	8455	7189	31	1171	64	46	0	18
7	Kaluthara - කළුතර	834	797	5	26	6	4	0	2
8	Galle - ගාල්ල	11857	11792	5	23	37	35	2	0
9	Matara - මාතර	1953	1935	5	7	6	0	0	6
10	Hambanthota - හම්බන්තොට	36	36	0	0	0	0	0	0
11	Kurunagala - කුරුණෑගල	7	7	0	0	0	0	0	0
	Total	73304	68870	492	3290	652	247	81	324

Landslide Special Investigations (SPI)

District and Divisional Secretaries, and officials of governmental institutions often request NBRO to conduct landslide special investigations for the purpose of identifying risks in particular sites in relation to the safety of neighbouring human settlements, infrastructure and plantations and to provide immediate recommendations. A total of 2820 landslide special investigations were performed in 2018. The General Treasury has provided Rs. 36.81 Mn. for this work.

Landslide Mitigation Program (GOSL Funded)

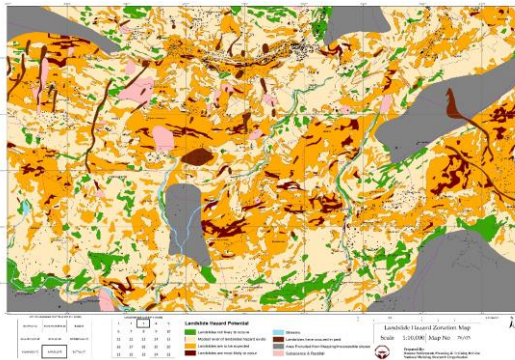
The landslide and slope instabilities needing mitigation have been identified by LHMP and SPI, and six prioritised sites were mitigated during 2018 as indicated by the following.

- 🚧 Stabilization of unstable slopes near Lankagama Maha Widyalyaya (Rs. 42.40 million)
- 🚧 Stabilization of unstable slopes near Kadugannawa Tamil School (Rs.34.30 million)
- 🚧 Stabilization of unstable slopes and landslides near Ayagama hospital (Rs. 31.50 million)
- 🚧 Landslide mitigation near Kandy Nursing school (Rs. 23.30 million)
- 🚧 Stabilization of unstable slopes near Atale Maha Vidyalaya (Rs. 43.0 million)
- 🚧 Stabilization of unstable slopes on either-side of Maha Oya , Kochchikade river bank (Rs. 10.5 million)

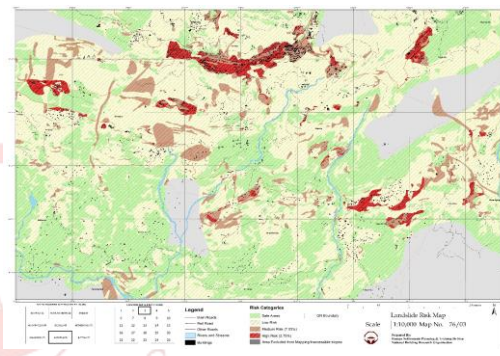
Development of Risk Profile for landslide prone areas

This project was initiated to meet the outcome -1: National and sub-national level agencies are capable of assessing disaster risk and making decisions for short-, medium- and long-term disaster management of the Sri Lanka Comprehensive Disaster Management Programme (SLCDMP) 2014-2018. Adhering to this outcome, risk profiles have been developed to enhance the capacity of national and sub-national level agencies in assessing the disaster risk and formulate short, medium- and long-term disaster risk reduction decisions. Tasks achieved under the Landslide Risk Profile Development Project in the year 2018 are;

- I. Formulation of landslide exposure map in 1:10,000 scale
- II. Data collection on buildings expose to landslide hazard
- III. Training and awareness
- IV. Establish community-based disaster management committees
- V. Identification of potential safer lands for development
- VI. Development of a spatial database on buildings expose to landslide hazard



Landslide Hazard Map (76/03)



Landslide Risk Map (76/03)

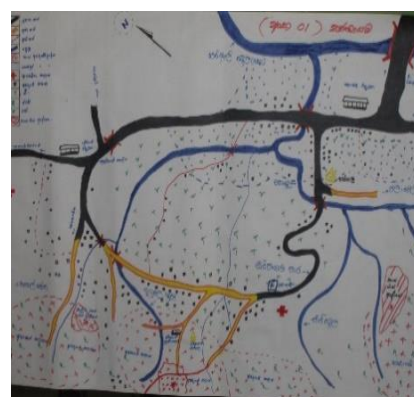
Installation of community-based landslide early warning systems – Phase I (cont'd from 2017)

Landslides occur due to heavy rainfall and hence, NBRO issues landslide early warning to areas indicating heavy rainfall. But some communities living in isolation do not readily receive such warnings sent. This project addresses the requirements of communities living in isolation and empowers them by making them aware of how to monitor rainfall and evacuate if necessary. This is important because such communities can be prepared and take precautionary actions on time, even before receiving early warnings sent by authorities.

So far, the project is in effect at 96 selected sites belonging to Nuwara Eliya, Badulla and Kegalle districts. As per the objectives of the project, site-wise community awareness creation, community vigilance group creation, manual rain gauges distribution, manual sirens distribution, introduction of simple extensometer instrumentation to monitor ground movement and community involved risk map and preparedness plan formulation have been already completed in each of these sites. Additionally, a "landslide early warning preparedness plan map" i.e. a printed map showing verified landslide susceptible areas and safe areas in the village, locations of houses, locations of rain gauges, safe evacuation routes and evacuation centres, has been set up at a suitable public and open location in selected sites so that it will be displayed to the community at all times.

Exchange of contact information between the NBRO and community vigilance group leaders and rain gauge data recorders within these communities has enabled NBRO to alert the communities in advance about adverse weather forecasts issued from Meteorological Department. Monthly rainfall records of all the manual rain gauges are sent to NBRO by the community rainfall data

recorders at the end of each month which helps to maintain an active link between these communities and the NBRO. Furthermore, before the onset of the last monsoon, special workshops were conducted in all three districts gathering the community vigilance group leaders and manual rain gauge data recorders from all the sites in order to enhance attentiveness of the communities. Moreover, it is planned to conduct such community leader workshops on a quarterly basis in the years ahead with the aim of sustaining a dynamic relation between the communities and NBRO. Currently under the project, manual rain gauges are being set up adjoining automated rain gauges in the NBRO's automated rain gauge system. This allows communities to get better observations of rainfall and allows NBRO to verify the records of automated rain gauges as well.

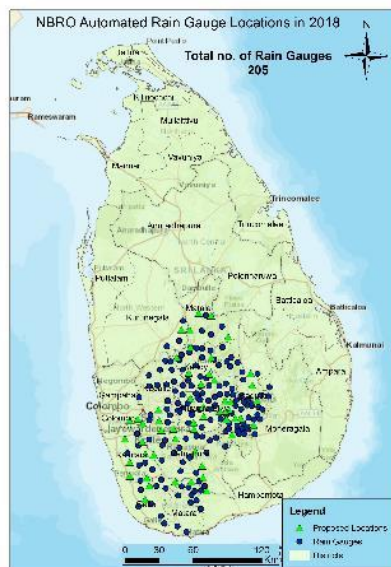


Enhance real time landslide forecasting & early warning capacity by expanding automated rain gauge network.

This project covers installation of 130 Nos automated rain gauges into the existing rainfall monitoring system to issue landslide early warning to the locations identified as high risk. NBRO established a Landslide Early Warning Centre at NBRO Head Office for issuing timely early warning and evacuation orders to Disaster Management Centre (DMC) and this Early Warning Centre is now working around the clock during rainy weather.

The project will also Identify gaps and introduce additional automated rain gauges and cutting-edge technologies to improve methods and accuracy of landslide early warning issued. In the year 2018,

66 numbers automated rain gauges have been added to the system, that now provides data from 216 rain gauges. Total number of rain gauges in the system would be 292 by the end of 2019.



Automated rain gauges locations



Data retrieval in Early Warning Center

Stabilising Meethotamulla Wastefill for Development

After the garbage mound located at Meethotamulla, Kolonnawa collapsed on 14th April 2017, National Building Research Organisation (NBRO) staff together with a team of experts from Japan investigated and reported on the situation existed, probable causes of failure, demarcation of evacuation zones and remedial actions to prevent further failures. Later, Japanese experts helped NBRO staff to assess relevant geotechnical parameters applicable to this waste fill.

NBRO later assisted in the designing of long-term countermeasures for stabilization of the waste fill. A trial embankment with 50 m in length, 30 m in width and 5 m in height was compacted with the Army extending assistance in construction works. At present, the settlement of this trail section, shear failures and compaction are being monitored.

Research & Development Program

NBRO received Rs. 15.0 Mn as the annual government grant for research and development in 2018. The primary focus of the R & D programme was set on creating disaster resilience. Outcomes of this work were presented and published at the 9th Annual Research Symposium of NBRO 'Innovation for Build Back Better' held on 18th and 19th of December 2018 in Colombo. Altogether 38 technical papers were published in the Symposium Proceedings.

R & D projects in 2018

Continuation of developing resilient construction manuals:

NBRO revised the previous document (නායයැම් ආපදා ප්‍රත්‍යාස්ථිතික ඉදිකිරීම් පිළිබඳ තාක්ෂණික මාර්ගෝපදේශය) by adding more information related to utilities etc. in 2018 and published for distribution among resettled families, technical officers in local government authorities, home builders and construction professionals. This document provides guidance to the resettlement project presently in progress to resettle over 14000 families over the next 2 years.



Constructing disaster resilient model houses:



NBRO designed and constructed a model house with flood-resilient features for public display at the 202 Milepost in Tangalle. In addition this model house exhibits special features such as low thermal transmittance in walls. Alternative building materials such as Bottom Ash Blocks, Expanded Poly Styrene and rammed earth panels that were developed as NBRO R & D work were used in construction work. Thermal performance was tested and found to be superior and the results were published at the Symposium.



Determination of regional and local rainfall thresholds for landslides in Sri Lanka

This study was carried out to investigate the relationship between occurred date/time of landslides and antecedent rainfall characteristics. Landslides in some districts logically are connected with a shorter time period of rainfall, whereas some others are not. To determine the effective antecedent rainfall threshold values, 1-day, 2-day, 3-day, 5-day, 10-day, 15-day and 20-day cumulative rainfall were considered. In certain circumstances, the crucial soil moisture to trigger a landslide in central highland districts is related to more than 15-20 days antecedent rainfall (lower intensities over long time period) and in South-Western districts the crucial soil moisture to trigger a landslide is related to less than 3-5 days antecedent rainfall (high intensities over long time period). Studies proved that not only the daily rainfall affects for the initiation of a landslide but also, the antecedent rainfalls are a necessity. As a result of these different features in different scale, more research is needed to investigate the relation between rainfall and other physical characteristics to trigger a landslide event.

Development of geotechnical guidelines for high-rise buildings

Recent increase in the construction of high-rise buildings and large building complexes in urban areas are often found to be affecting stability of adjacent buildings and sometimes, damaging them. As poor designs and construction practices during excavation and subsurface construction contribute vastly, it is necessary to develop mechanisms to guide design and construction personnel to follow proper and systematic work procedures. This research will probe into pros and cons in present design and construction work and prescribe correct procedures to follow and it has been proposed that using such developed procedures and guidelines be made mandatory in future.

Designing a transitional shelter for disaster-affected communities

The frequency of landslide and flood occurrence has increased significantly in the recent past as a result of which the need for transitional shelters to shelter disaster affected persons has also risen. Tents are used for this purpose at present but contemporarily, improved transitional shelters are a necessity. This research will lead to the development of transitional shelters that can be transported to selected sites quickly and erected and at the same time, stored in compact stores when not in use. Benefit of such development is that prefabricated shelters can be made and kept in store beforehand and deployed quickly after emergencies and further, this can prevent using schools as transitional shelters.

Analysing the effect of meteorological, environmental and anthropogenic factors attributed to drought severity and sector-based water stress in Anuradhapura District

Drought and water stress occur as a consequence of rainfall deficiency and projections for Sri Lanka are severe. The study focused onto the effect of rainfall variability on drought related water stress in a particular area in the dry zone for a period of 9 years from 2008 onwards. The results show a strong rainfall variability seasonally. There is no variability in the annual rainfall, but a large fraction of annual rainfall has been delivered by extreme rainfalls. An increasing trend of extreme rainfall events was apparent during this period.

Preparation of Technical Guidelines for Building Demolition work in Sri Lanka

Increasing number of buildings are being demolished especially in urban areas for various reasons like creating land space for gardens or constructing newer and larger buildings, or because of being unfit for occupancy or lack of structural integrity. In the absence of controlling mechanisms or procedures such demolitions take place in an ad-hoc and unsafe manner. With the need for preparing and introducing a suitable guideline being felt, this project was launched as a research first to study the current demolition procedures and identify strengths and weaknesses, and then to compile and introduce a suitable guideline for demolition work.

Development of cost-effective green masonry products using textile waste

The apparel industry generates vast quantities of fabric offcuts as waste resulting in a waste disposal problem and of these, disposal of offcuts of rubber-mixed fabrics like polyester spandex is found to be a difficult issue. This research is expected to develop polyester spandex embedded masonry products that can be produced with desired strength and other properties and used in construction work. Accordingly, paving blocks were developed incorporating shredded form of polyester spandex, which shows superior energy absorption capability.



Development of guideline for selection of materials and products for construction industry

Presently a large number of different construction materials and products are available in the market and construction persons are often unaware of their properties, how to design with such materials and how to correctly use them in construction work. This research will develop a guideline giving such information, as a valuable future reference.

Development of alternative fibres to asbestos fibres for roofing materials

This research project is expected to develop roofing materials using natural fibres as viable alternative to asbestos fibres. Many different natural fibres have been tested and roofing sheets samples have been fabricated and tested.



Systematic diagnostic assessment of select chemical disasters in Sri Lanka

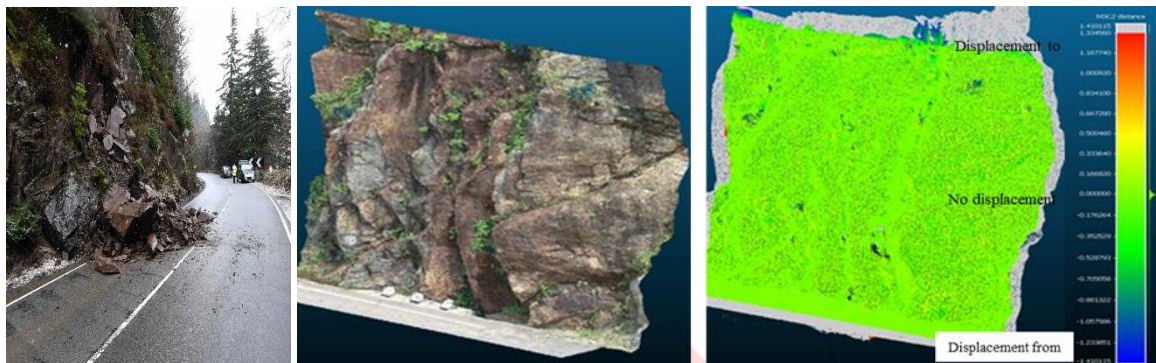
Occurrence of accidents in chemical industries is showing an increasing tendency and exposure of vulnerable elements in the neighbourhood to this hazard could lead to man-made disasters. A systematic procedure for risk assessment is absent, and poor transparency on information to the public on overall situation makes the situation worse. Past incidents highlighted gaps in current DM process and while understanding the potential for chemical disaster, the need has been strongly felt for introducing a chemical hazard mitigation frame work and a sound legal framework on management of disasters associated with chemical accidents. Preparatory work of this research study has been already started and a literature review has been conducted. Professional engineer from Norway who is an expert in this field was invited to NBRO as a guest lecturer to deliver an extended lecture on the subject to NBRO staff.

Application of ecosystem resilience approach to analyse water resource health of Pinga Oya watershed

Pinga Oya watershed is a sub-watershed in the Polgolla watershed and its water quality is subject to heavy degradation due to numerous anthropogenic influences. Using Watershed Metaphor Model developed based on Metaphorical analysis was used to assess the system resilience with respect to flux of constituents in various phases of ecosystem under diverse anthropogenic influence and the response of water resource healthiness in terms of water quality and biological integrity was also studied. This research project now continues into the third successive year and samples were extracted and analysed adding data into a comprehensive database.

Application of UAVs & fast image processing techniques in rockfall monitoring

Rockfall is a hazard in hilly areas. When such site is close to a main road, monitoring becomes a sheer necessity. It is usually required to continuously monitor fractured rock surface to identify rockfall events and traditional approach of monitoring rocky surfaces is time consuming and costly. Hence, advancement in the UAV based photogrammetry technology along with structure-from-motion in combination with multi-view-stereo (SFM – MVS) technology-based 3D model was used as a precise technology. NBRO researched into rockfall monitoring by using image processing techniques where camera drones and super computers at NBRO were used to create three dimensional images. A vertical rock cliff located at 18th bend of Kandy – Mahiyanganya Road (7.343754° , 80.913108°) was taken as a case-study and height of the rock surface ranged from 680m to 740m and the length was about 100 m. Senior staff at the Norwegian Geotechnical Institute advised NBRO scientists in this research work.



Short-Term Research Projects

Establishment of heat index values for the identification of hotspots (A case study in Colombo urban area)

This research was for establishing heat index values in the hot humid city of Colombo, Sri Lanka and conducting a questionnaire survey to assess the subjective thermal comfort. Calculation of thermal comfort is based on field measurements of air temperature and relative humidity. Main objective of this research was to compare the heat index in different urban designs in Colombo. Other specific objectives were to assess the public perception about outdoor thermal comfort in Colombo urban area based on questionnaire and to develop heat index distribution map for Colombo by using ArcGIS software.

Short-Term Research Project: Comparative assessment of particulate matter concentration and air quality index in selected urban areas (A case study in Colombo)

A research study was conducted to identify the ambient air quality level in different urban areas that represent commercial and construction areas by using air quality index values. Survey was conducted to evaluate the public perception and awareness about the particulate matter related ambient air pollution and air quality index concept. Appropriate statistical approaches (one sample t-test and tukey pairwise comparison) and statistical software (Minitab18.0 version and SPSS16.3 version) were used for the data analysis of this research. The research outcomes (8 articles) were published in "Air that we breathe" conference, Sri Lanka and "Better Air Quality" conference at Kuching, Malaysia.

NBRO Annual Research Symposium



NBRO held its 9th Annual Research Symposium under the theme “Innovation for Build Back Better” in Colombo on 18th and 19th December 2018 where outcomes of research by NBRO and collaborative work with local and international stakeholders were presented and published as the Symposium Proceedings. The symposium recorded a high level of attendance of participants coming from a wide-spectrum of stakeholders.



Dr. Farrokh Nadim, Technical Director of Norwegian Geotechnical Institute delivered the key note address on “Managing landslide and other natural hazard risks: Lessons from the European Safe Land Project”. Afterwards the symposium proceeded, holding six structured technical sessions chaired respectively by Dr. U. P. Nawagamuwa, Dr. J. S. M. Fowze, Prof. S. U. Adikary, Dr. Prasanna Ratnaweera, Dr. (Mrs.) B. C. Liyanage Athapattu, and Prof. Tilak Hewawasam, on the following themes.

- Emerging technologies for safer built environment
- Preparedness for effective response
- Innovations for sustainable building materials
- Engineering approaches for resilience
- Environmental adaptation for sustainable development
- Recovery, rehabilitation & reconstruction



There were two panel discussions and the first panel discussion on “Nature Based Solutions for Landslide Risk Management” was held on 18th chaired by Mr. N.M.S.I. Arambepola as the Moderator and with Dr. U.P. Nawagamuwa, Mr. H.M.U. Chularathne, Dr. Pathmakumara Jayasinghe and Ms. Priyanka Dissanayake as panellists. The second panel discussion was held on 19th on “Sri Lanka’s approach towards resilient built environment: Are we on the right path towards Building Back Better?”, chaired by Ms. Florita Gunasekara as the Moderator, and with Eng. (Dr). Asiri Karunawardena, Dr. William Cheang, Dr. Farrokh Nadim, Prof. C. Jayasinghe, Col. Sudath Madugalle, and Dr. Athula Senaratne as panellists. Prof. of University of Melbourne visiting the event made a brief and very attractive address on high rise structures.



The symposium attracted researchers, disaster management practitioners, policy makers and eminent experts from local and international institutions and it provided an excellent platform to have discussions, exchange ideas and share experience. The symposium was very successful. All the presentations were interesting and informative, the published papers were of high standard and the attendance on both the days was fairly high. Symposium Proceedings containing 38 technical papers was published.

Seminars and Workshops - 2018

1. Workshop on “Introduction of real time air quality monitoring sensor system for ambient air quality in Sri Lanka”

A workshop was organised by Environmental Studies and Services Division on “Introduction of real time air quality monitoring sensor system for ambient air quality in Sri Lanka” on 19th July 2018 at the auditorium of Meteorology Department, Sri Lanka. Dr. Ajith Kaduwela presented the keynote speech on “Importance of air quality monitoring and use of real-time air quality sensors” and other presentations were made by Mr. S. Premalal, Director General of Meteorology Department and Mr. H.D.S. Premasiri, Senior Scientist in-charge of air quality studies at NBRO. After, a panel discussion was held on the theme “The way forward to future of air quality monitoring and management in Sri Lanka”. Many participants invited from governmental organizations, industries, universities & various parties relevant to air quality monitoring participated in the workshop, and actively discussed and shared their views.



2. Nature-Based Landslide Risk Management Project in Sri Lanka

- (a) This project implemented by NBRO is facilitated by Asian Disaster Preparedness Center (ADPC) of Thailand and funded by the World Bank and has participation of experts from the University of Peradeniya. It aims at raising the awareness on the subject and deepen the knowledge within country on the role of nature-based solutions for landslide risk management. A national workshop was organized by NBRO and Asian Disaster Preparedness Center to validate the findings and recommendations of this project on 28th September 2018 at Colombo.



- (b) As a part of this project, a training programme was conducted from 1st to 4th October 2018 on Application of Google Earth Engine (GEE) Platform for Land Cover Monitoring and Satellite-Based Rainfall Estimation.



- (c) Nature-Based Landslide Disaster Risk Management project – Training Part 1 was held on 12th & 13th November 2018.

Major Consultancy Projects

Clearing geotechnical issues in construction projects

When requested, NBRO conducts investigations and issues reports to authorities such as UDA and Tourist Board prior to granting permits for construction projects involving high-rise buildings and large building complexes where extensive excavation and foundation works are carried out and have a potential to impact on neighbouring buildings. This process has been carried out since 2017.

Year	2017	2018
No. Reports	32	38

Issuing condition reports on buildings

As per a client request or a court order, NBRO conducts investigations including crack surveys and carry out associated computations to decide on the condition of a building and its structural integrity and then issues relevant reports as a fee-based service. Often such services are required to assess condition of buildings in export-oriented industries and sometimes, to decide damage to buildings caused by construction activities in adjacent properties. This process has been carried out for considerably long period by NBRO and the following table gives the details.

Year	2011	2012	2013	2014	2015	2016	2017	2018
No. Reports	47	29	28	47	42	60	148	116

Laboratory Testing Demonstration Sessions for Construction Professionals

Building Materials Research and Testing Division of NBRO conducted Laboratory Testing Demonstration Sessions for professionals from construction industry, planned to impart them exposure to laboratory work. The four-week weekend course titled "Testing of cement and concrete for the professionals in the construction industry" was conducted twice in 2018. Participants mainly from PRDA and other construction industries attended these programmes. The sessions covered theoretical and practical aspects of testing of cement and concrete and related quality control and each session was attended by over 20 professionals.



Project on ambient air quality in main urban cities in Sri Lanka

The Ministry of Environment and Mahaweli Development awarded a grant to extend the current study of Ambient Air Quality in Main Urban Cities in Sri Lanka by using passive air quality monitoring technique funded by VETT program. The monitoring network was extended to Puttalam city and new strategic sampling locations were introduced to the Kandy city. The project was started in late 2017 and NO₂ and SO₂ data have been collected since then.

Study of Ambient Air Quality in Main Urban Cities in Sri Lanka by Using Passive Air Quality Monitoring Technique

Study of Ambient Air Quality in main urban cities in Sri Lanka by using passive air quality monitoring technique was continued. The project was started in Colombo, Gampaha, Horana, Rathnapura, Galle and Kalutara in 2012 and SO₂ and NO₂ data have been collected since then. The monitoring network will be extended to Kandy, Kurunegala, Anuradhapura and Puttalam cities. A PM 2.5 sampling program was introduced to the project additionally in late 2017 to enhance the Air Quality database.

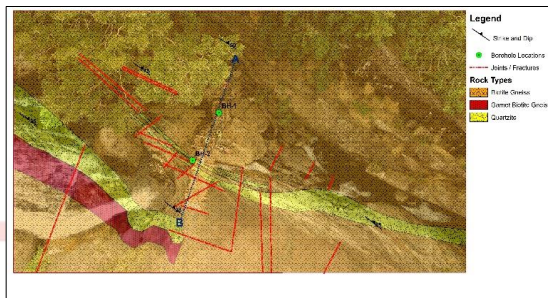
Major geotechnical consultancy projects

1. Restoration Transport Continuity of Hatton – Maskeliya – Delhouse (B-149) Road damaged due to the Norwood Landslide at Culvert 10/2 (30/25793)
2. Geotechnical Investigation for Design Review to Evaluation Undue Settlement of Gabion Wall, Moragoda Ela, Galle (30/26211)
3. Preliminary Geotechnical Investigation Work Of Both the Banks of the Kelani River from Kaduwela to Hanwella (30/26168)



Norwood Landslide

4. Geotechnical Investigation for Proposed Greater Matale Water Supply Scheme 30/26177



5. Reduction of Landslide Vulnerability by Mitigation Measures Project – Phase I-30/26215

Projects with Foreign / Donor Collaboration

NBRO-JICA technical collaboration projects (Foreign Aid and Technical Cooperation)

➤ **Technical Cooperation for Landslide mitigation Project (TCLMP-Phase I)**

The mitigation works of three landslide locations (Alagumale, Udamadura and Badulusirigama) prioritized by Integrated Landslide Mitigation Project under the TCLMP Phase I were officially completed in 2017. Japan International Cooperation Agency provided technical and financial assistance for project implementation. Post-mitigation monitoring work of the three sites continued in 2018. (TCLMP-Phase II is expected to commence from February 2019).

➤ **Landslide mitigation at Nurses Training School in Kandy District**

Mitigation work of landslide / unstable slopes in and around the premises of Nurses Training School in Kandy was carried out with the assistance of JICA as a joint venture by Koiwa Corporation and Earth System Science Limited with Nippon Koei working as the consultant. Design work of this mitigation work was done by the TCLMP Phase I. NBRO completed certain project components of this project and it is presently near completion.



Alagumale rock falling site



Badulusirigama site



Udamadura site



Kandy training School site



➤ **Ground Movement Detection Instrumentation**

There are isolated communities living in landslide-prone areas whom cannot be contacted easily for landslide early warning dissemination from Colombo. With the assistance from the Government of Japan and JICA, a project was launched by Earth System Science & Osasi Limited to install monitoring instrumentation in such areas for the benefit of respective communities. An instrumentation system was installed first in Diyanilla to demonstrate capabilities, and later as a pilot project, instrumentation systems including dip meters, rain gauges and inclinometers were installed in Galaboda. Presently these two systems are in operation and signals from instruments are received by NBRO Early Warning Center and by mobile phones of the officers concerned with early warning.



Instruments at Diyanilla in Nuwara Eliya



Instruments at Galaboda in Ratnapura

➤ **Landslide research with NILIM**

NBRO and National Institute for Land and Infrastructure Management (NILIM) of Ministry of Land, Infrastructure, Transport and Tourism (MLIT), Tsukuba City, Ibaraki, Japan joined in hands by signing a memorandum of understanding at the last NBRO Research Symposium held on 24th January 2018. Teams from NILIM visited NBRO & sites, and held discussions on conducting research on landslides. A team of three scientists from NBRO went to NILIM for training on sediment disaster.



Training NBRO staff in Japan



Field work in Sri Lanka

UNDP assistance on resilience building in flood and landslide recovery

NBRO implemented “Resilience Building Program in Flood and Landslide Recovery” in collaboration with the UNDP to ensure safer built environment in landslide disaster-prone districts in Sri Lanka. This programme was formulated to enhance relevant awareness of main 4 stakeholder groups namely Awareness for District Senior Government Officers (District Secretary & Divisional Secretaries) (4 programmes), Training Workshop for Technical officers & National Disaster Relief and Service Centre (NDRSC) officers (9 programmes), Awareness for the Beneficiaries of the National Resettlement Programme - 2017 (12 programmes) and Training Workshop for the Masons (11 programmes) in this effort. NBRO presently has a memorandum of understanding with the UNDP to this effect.

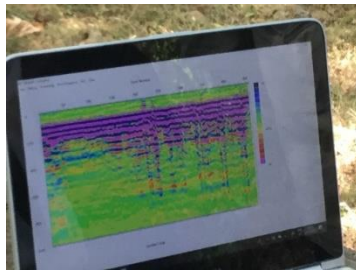
Deliverables achieved can be listed as related knowledge sharing for District level administrative decision makers in creating an arena to bring forward the problems and challenges faced in the resettlement framework; keeping everything on track, towards the ultimate target of disaster resilient and sustainable human settlements; a benchmark particularly on changing mindset of the stakeholders about the importance of NBRO recommendations for a safer built environment, in contrary with their traditional ways of land selection, housing construction, land development; in distributing required technical knowledge on land use management significantly in disaster-prone areas, able to make the masons aware on disaster resilient housing construction methods as recommended by NBRO and their importance as a sustainable measure in achieving the future goals of disaster resilient and sustainable human settlements; in distributing this knowledge to who has no professional training on construction was quite beneficial in order to change their mindset significantly on housing construction in disaster-prone areas to deviate from traditional practices in Sri Lanka.

NBRO –NGI Technical Cooperation Project



NBRO and Norwegian Geotechnical Institute (NGI) have conducted various studies since 20xx and an agreement on cooperation was signed to continue the project "Institutional Cooperation on Mitigation of Natural Disasters due to Climate Change" for the five years from 2018 to 2022.

In 2018, NGI experts together with NBRO staff, conducted a GPR survey in Anuradhapura to map the subsurface to located the inner citadel for the Sacred Cities Development Project.



Dr. Farrok Nadim the Technical Director of Norwegian Geotechnical Institute visited NBRO in December 2018 and expressed interest to conduct nature-based landslide mitigation projects, venturing into more diversified areas in association with Asian Disaster Preparedness Centre.

Royal Norwegian Embassy (RNE) in Colombo provided financial assistance to this project.

Nature Based Landslide Risk Management Project with Asian Disaster Preparedness Centre in Sri Lanka

In the past Sri Lanka has largely relied on engineering solutions on landslide risk management. The application of nature-based and hybrid (engineering and nature based) approaches for landslide risk management is still limited. It has been demonstrated in many countries in Asia that the risk-informed nature-based solutions can be effective in reducing the occurrence and impact of landslides.

Recognizing the importance of application of nature-based solutions for landslide risk management in mitigating the landslide risk in Sri Lanka, National Building Research Organisation (NBRO) has taken an initiative to implement the project on "Nature Based Landslide Risk Management", with the technical assistance from Asian Disaster Preparedness Center (ADPC), Thailand. This Analytics and Advisory Services project is funded by the World Bank and aims at raising the awareness on the subject and deepen the knowledge within country on the role of nature-based solutions for landslide risk management. It is also expected to apply this knowledge in a number of pilot demonstration sites under the ongoing Climate Resilience Improvement Project (CRIP) funded by the World Bank.

Reduction of Landslide Vulnerability by Mitigation Measures Project

NBRO devised the Reduction of Landslide Vulnerability by Mitigation Measures Project (referred now shortly as the RLVMMMP) following the Cabinet approval for implementation of Integrated Landslide Mitigation Programme. In this project, prioritized mitigation sites requiring immediate attention have been listed for mitigation and these include roadside unstable slopes as well as unstable slopes along the railway lines in the hill country for mitigation jointly with Road Development Authority and Sri Lanka Railway.

The project components of the proposed project are:

- Civil work and associated design and construction supervision / management activities
- Policy and Regulation Enhancement
- Institutional Capacity Building
- Technical Support and Project Management

In 2018, NBRO conducted ground investigation and social & environmental studies related to 27 sites selected for urgent mitigation and later, carried out design of the mitigation measures. Selection of contractors will be done in early 2019. Further, works related other 120 sites in altogether 8 districts have been started by NBRO.

Developing of Real-time Air Quality Monitoring Sensors

The staff of Environmental Studies and Services Division, AQ section with the guidance of Dr. Ajith Kaduwela, an expert from California Air Quality Research Board developed a real-time Particulate Matter Monitoring sampler to measure ambient air quality. Dr. Kaduwela with his aides for two weeks conducted a series of lectures and practical sessions for NBRO staff on this subject. The division initiated the development of this air quality monitoring sensor with the intention of achieving real-time online air quality data. The Division is currently engaged in monitoring ambient air quality in major urban cities of the country and to assess the ambient air pollution levels. Due to recent concerns on air pollution in cities and associated impacts, the division has decided to install air quality monitoring equipment in suitable locations in the city of Colombo.

With that intent, the premises of Meteorology Department in Colombo with the permission of the higher management was selected to install the Real-time Air Quality monitoring sensor. The on-line air quality data (SO₂, NO₂, PM₁₀) are being recorded in monitoring sensors and displayed in all three languages (via digital display) in front of the said premises and data are also disseminated to the public through NBRO web site, so that, the public can be aware of levels of the real time ambient Particulate Matter in air that they breathe. This data is made available to the research community in coordination with the Air Quality Studies Unit. NBRO expects signing a memorandum to continue this research in collaboration with the University of California, Davies.



Air Quality measurement unit installed in Dept. of Meteorology premises

Safer Communities with Hydro-Meteorological Disaster Resilient Houses

Initial workshop on the collaborative research between Bath University, UK; University of Moratuwa, Sri Lanka and National Building Research Organisation was held in May 2018. The overall aim of this project is to build resilience of vulnerable communities in Sri Lanka by developing strategies that will improve the resilience of low-rise masonry structures to withstand flood events. The project will employ inter-disciplinary approaches to address the questions posed by post-disaster reconstruction, while working with social scientists and economists in Sri Lanka.
