NATIONAL BUILDING RESEARCH ORGANISATION

2021 ANNUAL REPORT

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Auditor General’s Report is attached to the Sinhala Version

The Annual Report 2021 was approved by the NBRO Interim Management Committee (IMC) on its meeting held on 22nd February 2022

About NBRO

National Building Research Organisation (NBRO) was formed on 5th March 1984 following a Cabinet Decision taken on 29th September 1983. Today, after nearly 38 years in existence, the NBRO stands out as a leading R & D institution, a reputed technical service provider and the national focal point for landslide risk management.

NBRO is a multi-disciplinary institution, having six technical divisions namely in the alphabetical order, Building Materials Research & Testing Division, Environmental Studies & Services Division, Geotechnical Engineering & Testing Division, Human Settlements Planning & Training Division, Landslide Research & Risk Management Division and Project Management Division, supported by the Administration Division, Finance Division, ICT & Program Unit and Internal Audit Unit.

As a reputed research institution, NBRO conducts research related to its scope of work and also as requested by stakeholder institutions. The General Treasury provides sufficient funds for this research work and the research outcome is published annually. Being the national focal point for landslide risk management in Sri Lanka NBRO carries out activities of identification of slope instability, assessment of associated risk, mapping of hazardous zones, monitoring of ground movement in landslides and rainfall in landslide-prone areas, issuance of landslide early warning, mitigation of landslides and unstable slopes and building of awareness of landslide hazard. In addition, NBRO issues Landslide Risk Assessment Reports (LRAR) for all construction and development activities in landslide-prone areas in the country as the mandated institution.

NBRO as a self-funded institution meets its recurrent expenditure, by earning revenue by the provision of testing and technical consultancy services to the general public, public sector institutions, private companies and international institutions. With its ISO accredited and best-equipped soil-testing laboratory in the country, NBRO performs as the leading institution for geotechnical engineering investigations and conducts investigations of most large infrastructure development and landslide mitigation projects in the country. NBRO also carries out as fee-based services: the testing of building materials for suitability in construction, assessment of landslide & disaster risk, planning of human settlements & developing cost-effective disaster-resilient housing; testing of water, wastewater, soil, sediment, air and stack emissions; assessment of building condition & structural integrity, and various other related studies as technical consultancy services that bring in NBRO its much needed revenue.

People seek NBRO assistance when confronted with a diversity of problems in their living environment, be that due to rumbling mountains, soft grounds, polluted air, contaminated water, poor construction and substandard building materials etc. NBRO as a dutiful service provider together with technical experts from various disciplines is always geared up to provide suitable solutions to maintain and improve the quality of life of all citizens.

Executive Report

NBRO in the preceding year of 2021, continued fulfilling its duties and responsibilities to the best of its ability in spite of obstacles posed by the COVID-19 pandemic and its related issues in the country. These obstacles adversely impacted both on the physical engagement of staff on duty and also on the financial earnings through its provision of consultancy services. However, NBRO performed sufficiently well as a responsible government institution duly accomplishing assigned tasks and in consideration, I take great privilege to compile and present this Annual Report and the Financial Statement of NBRO for the year ended on 31st December 2021.

In this year 2021, several incidents of landslides and slope failures were reported during May – June and in November, the notable landslide, rockfall, slope and retaining wall failure incidents were in Ratnapura, Kegalle, Kalutara, Kandy and Kurunegala districts. In this, NBRO took preassigned roles of monitoring, early warning for evacuation and implementation of corrective and preventive mitigation measures.

NBRO continued the implementation of on-going Disaster Risk Reduction projects, with funds coming from the General Treasury and other financial institutions. Importantly, in the Asian Infrastructure Investment Bank (AIIB) financed "Reduction of Landslide Vulnerability by Mitigation Measures Project" NBRO already commenced mitigation works in 24 sites and their work is in progress and in 32 other sites are now under procurement stage. NBRO expects completing all the mitigation work in the selected 147 sites by 2025 that were identified as threatening the functioning of schools, hospitals and important buildings, major roads and railway lines.

NBRO continued to provide technical consultancy and laboratory testing services to customers while maintaining high standards and assuring the quality and timely delivery. In support, the accreditation of all the three laboratories to ISO 17025 was maintained and all the due internal and external audits were conducted on time. The total income from provision of testing & consultancy work in 2021 was Rs. 523.4 Mn whereas a turnover of Rs. 860.2 Mn and a profit of Rs. 70.4 Mn were recorded. This contributed to its financial performance and institutional stability. NBRO has been able to earn a net profit each year since 2010.

Approved cadre of NBRO was maintained whereas recruitment and retrenchment of staff were done as per requirements of projects undertaken. By the end of December 2021, the staff strength was 346.

Usually, NBRO holds in the beginning of the year the Annual Industry Consultation Meeting with its stakeholders to learn the research needs in industry for incorporating them in the Research and Development programme. This meeting was not held in the year 2021 because of the pandemic situation. NBRO developed a R & D Programme based on previous experience and then accordingly, utilized the annual government allocation of LKR 14.6 Mn. for research work in 2021. Further, NBRO invested the allocation of Rs. 3.8 Mn for procuring laboratory and field equipment effectively for research purposes. The R&D studies in 2021 covered a wide range of subject areas and the list of these

studies is given under the Research & Development Programme in this report.

CONTRIBUTION TOWARDS NATIONAL DEVELOPMENT

NBRO as the national focal point for landslide risk management conducts investigation & risk assessment studies and produces hazard and risk maps. These maps are used in physical planning and development activities in the country. NBRO further monitors landslide areas and issues early warning as a very important assigned duty.

NBRO issues Landslide Risk Assessment Reports (LRAR) with technical recommendations to local government bodies for granting approval for construction or development activities in landslide hazard-prone areas in 14 districts. In 2021, 6763 reports were issued after conducting necessary investigations.

International donor agencies and institutions often extend their assistance to NBRO. In the year 2021, Japan International Cooperation Agency (JICA), the World Bank, Asian Disaster Preparedness Centre (ADPC), Norwegian Geotechnical Institute (NGI), and Asian Infrastructure Investment Bank (AIIB) continued to provide their assistance to NBRO. In addition, United States Geological Society, Bath University, University of Salford and Huddersfield University too assisted NBRO.

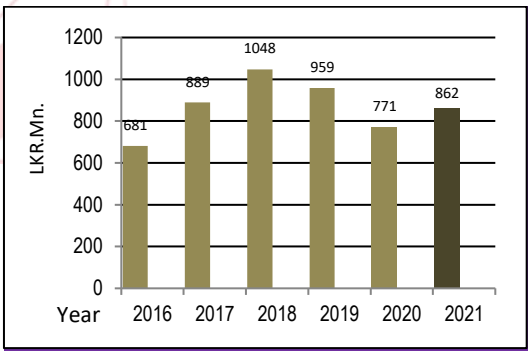
In 2021, NBRO continued to implement landslide mitigation work. This work included mitigation of identified potentially hazardous landslides that threaten settlements, and the stabilization of roadside slopes, identified unstable slopes close to rail tracks and slopes around schools and vulnerable public buildings.

NBRO continued in 2021 to extend technical services to governmental development programmes. NBRO provided technical expertise in stabilizing several slope stabilization projects in Central Expressway development and in other major road networks where some projects in Kandy-Mahiyangana Road were implemented under Climate Resilience Improvement Program (CRIP) of the World Bank. Provision of technical services for investigation, risk assessment and monitoring of unstable slopes on the Kandy-Colombo main road at Kadugannawa was highly acclaimed.

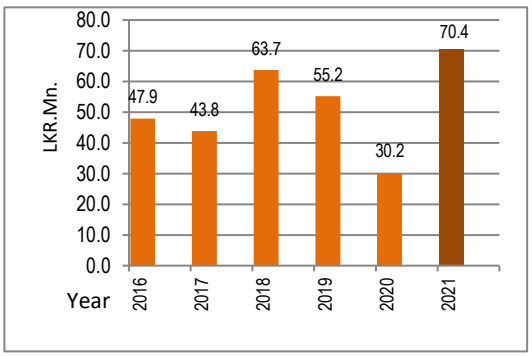
NBRO further continued in 2021 to provide its technical support to the Government programme to resettle victims of recent landslide and flood disasters, and the persons living in areas with high risk in disaster-resilient settlements in safer areas.

REVENUE

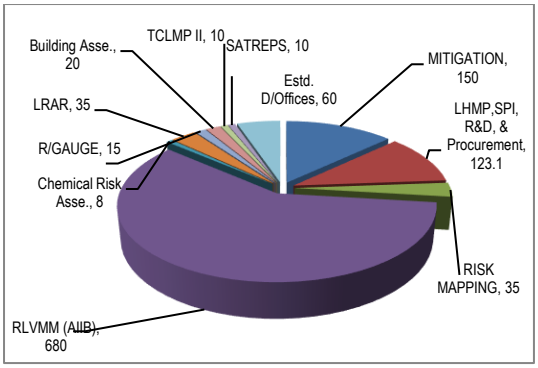
NBRO meets its recurrent expenditure with the revenue it generates by the provision of consultancy & testing services offered to state and private sectors and general public. Landslide risk assessments are done by NBRO as a fee-based service as well. NBRO also receives funds for implementing mitigation projects, mapping, special landslide investigations, other govt. funded projects and donor-funded projects.



Total Operating revenue for last 6 years



Profit & loss record for last 6 years



Govt. Grant for projects & programs – 2021

CONSTRAINTS

- NBRO is yet to be established by a bill
- Difficulty in bidding for consultancies being a government organization
- Restrictions on extended working hours
- Difficulties in retaining experienced staff and in recruiting qualified technical staff as other employers offer higher benefits

INITIATIVES FOR PRODUCTIVITY IMPROVEMENT

- ✓ Maintain all 3 laboratories accredited
- ✓ Strengthen institutional capacity through technical cooperation projects
- ✓ Strengthen Design unit of NBRO
- ✓ Enhance capacity for geotechnical risk assessments of high-rise and large building complexes

FUTURE PLANS

- ➢ Continuing landslide mitigation & related capacity enhancement
- ➢ Preparing hazard maps / risk profiles
- ➢ Assessing condition of buildings as a disaster reduction measure
- ➢ Continuing studies on chemical hazard management
- ➢ Constructing district offices now functioning in rented buildings

APPRECIATION

I take this opportunity to thank Hon. Chamal Rajapaksa the State Minister of National Security and Disaster Management and General Kamal Gunaratna (Retd.), Secretary of the State Ministry of National Security and Disaster Management, and also the Chairperson of Interim Management Committee (IMC) of NBRO, and Addl. Secretary, Major General Sudantha Ranasinghe whose direction and guidance have paved NBRO the way to this success.

I also wish to thank members of the IMC and Audit & Management Committee, the Director Generals of Department of Budget, Department of General Treasury, National Planning Department, External Resources Department (ERD), Disaster Management Centre, Department of Meteorology, Geological Survey & Mines Bureau and Director National Disaster Relief Services Centre (NDRSC) who deserve great appreciation.

At this juncture our gratitude is also extended to our international stakeholders, the World Bank, UNDP, JICA, ADPC, NGI, AIIB, USGS, ICL, SATREPS of Japan, THINKlab of University of Salford UK, Huddersfield University and Bath University and all the local collaborating institutions and universities for providing technical and financial assistance for various projects and programs. In addition, I express my sincere thanks to our local stakeholders and valued customers for their continued confidence on us.

I am grateful to the dedicated employees of NBRO, without the help of whom we will not be able to perform during trying conditions prevailed in the country due to Covid-19 pandemic. Our appreciation is gratefully extended to this remarkably competent team, whose knowledge, skills and professionalism make the backbone of NBRO.

We will continue working cooperatively to improve the NBRO performance further in the coming years and accomplish the mission and objectives set by our Annual Action Plan. We are sure that our team members will be very supportive of each other and collaborate across teams in sharing ideas and achieving great outcomes.

Eng. (Dr.) Asiri Karunawardena
Director General

Vision, Mission & Goals

VISION

A nation living in a safer, sustainable & disaster resilient built environment

MISSION

Reduce disaster risks through building resilience to ensure safer & sustainable built environment for all

GOALS

- Goal 1: Achieve technical excellence in disaster risk assessment in related disciplines & subject areas
- Goal 2: Achieve legal status, statutory powers and the recognition in DRR in related disciplines and subject areas.
- Goal 3: Be an apex national entity in providing quality accredited testing & technical consultancy services in environmental, geotechnical engineering, building materials, resilient built environmental planning and resilient construction technology.
- Goal 4: Achieve excellence in Research and Development in DRR and in disaster resilient development technology & innovation.
- Goal 5: Establish national and regional cooperation and connectivity to promote and sustain DRR and resilient development science and technology
- Goal 6: Strengthen institutional capacity for effective disaster risk reduction in related disciplines & subject areas
- Goal 7: Achieve financial sustainability of NBRO for effective performance in DRR.
- Goal 8: Become the centre of excellence for landslide disaster risk management as the national focal point.
- Goal 9: Build disaster resilience through Climate Smart early warning technology
- Goal 10: Build disaster resilience through ecosystem-based risk mitigation technology
- Goal 11: Build disaster resilience through community science-based risk mitigation process
- Goal 12: Build disaster resilience through rehabilitation and reconstruction technology

Management of NBRO

MINISTER IN CHARGE OF THE SUBJECT

Hon. Chamal Rajapaksa
State Minister of National Security, Home Affairs & Disaster Mangement

Presently a Cabinet approved Interim Management Committee (IMC) with Secretary of the line ministry as the Chairman guides and directs the administrative, financial and management functions of NBRO.

INTERIM MANAGEMENT COMMITTEE (IMC)

Gen. (Retd) Kamal Gunaratna (Chairman) Secretary, State Ministry of National Security, Home Affairs & Disaster Management	**Mrs. M. A. Nandani** Addl. Director General, Department of National Budget
Major General Sudantha Ranasinghe Director General, Disaster Management Centre	**Eng. Anura Gamage** Director, Consulting Engineers & Architects Associated (Pvt) Ltd
Dr. Sugath Yalegama Addl. Secretary (Policy & Admin), Ministry of Urban Development & Housing	**Mr. H U R Fonseka,** Chief Accountant, State Ministry of National Security & Disaster Management
Mr. A K Karunanayake Director General, Department of Meteorology	**Eng. (Dr.) Asiri Karunawardena** Director General National Building Research Organisation

AUDIT & MANAGEMENT COMMITTEE

Committee

Mrs. M. A. Nandani (Chairperson) Addl. Director General, Department of National Budget	**Mr. H U R Fonseka** (Member) Chief Accountant, State Ministry of National Security & Disaster Management	**Eng. Anura Gamage** (Member) Director, Consulting Engineers & Architects Associated (Pvt) Ltd

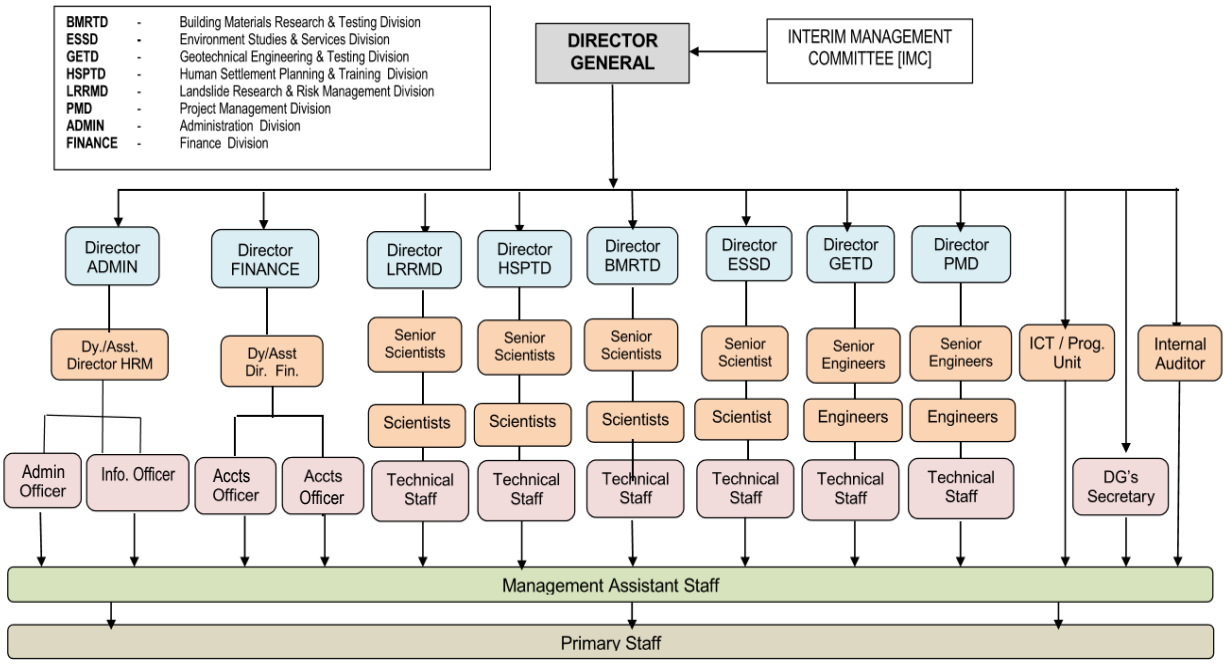
Observer

Mrs. L B G Sandamali Act. Audit Superintendent	**Mrs. R A N D Ranatunge** Chief Internal Auditor Ministry of Disaster Management

In participation

Eng. (Dr.) Asiri Karunawardena Director General National Building Research Organisation	**Mrs. Kumudu Randeny** Director (Finance) National Building Research Organisation	**Mr. H. L. Ruwanthilaka** Internal Auditor National Building Research Organisation

Organisation Structure



SENIOR MANAGEMENT OF NBRO

Eng. (Dr.) Asiri Karunawardena	Director General
Mr. Kishan Sugathapala	Director, Human Settlements Planning & Training Division
Mr. Sarath Premasiri	Director, Environmental Studies & Services Division
Mr. Kithsiri N Bandara	Director, Geotechnical Engineering & Testing Division
Mrs. Sunethra Muthurathna	Director, Building Materials Research & Testing Division
Ms. Dammika Kahahengoda	Director, Project Management Division
Dr. Gamini Jayatissa	Actg. Director, Landslide Research & Risk Management Division
Mrs. Kumudu Randeny	Director, Finance
Mr. Sarath Cooray	Actg. Director, Administration
Mr. Senerath Bandara	Project Director (PMU), RLVMM Project

Operational Highlights

In 2021, National Building Research Organisation (NBRO) together with International Landslide Consortium and with many important stakeholder involvements continued the five-year major research study 'Development of Early Warning Technology of Rain-Induced Rapid and Long Travelling Landslides in Sri Lanka' supported by both Sri Lankan and Japanese governments. NBRO continued implementation of the mega scale 'Reduction of Landslide Vulnerability by Mitigation Measures Project' (RLVMMP) that was started in 2019. Other projects started with international stakeholder institutions (NILIM, SABO, USGS & ThinkLab etc.,) in view of strengthening institutional capacity made considerable progress in spite of the adverse conditions prevailed due to COVID-19 pandemic.

NBRO further strengthened both the automated rain gauge network in landslide-prone areas and ground movement detection instrument network on moving landslides enabling effective operation of Landslide Early Warning Centre set at NBRO Head Office in disseminating of early warnings. Development of local manufacture of automated rain gauges and related instrumentation was continued as an effort to expand and maintain these networks at a low cost.

Research and Development Programme continued with the guidance of the NBRO Research Committee. The 11th NBRO Annual Research Symposium was held in December 2021 where many researchers presented their research outcomes. All the papers were published in Symposium Proceedings.

NBRO is the research arm and an important technical agency in Disaster Management Division of the line ministry. NBRO was able to provide solutions to many contemporary issues in the country especially utilizing combined 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, landslide risk assessment & project management. NBRO continues to specialize in new technical fields to address emerging issues in the country, especially in landslide mitigation technologies, detecting ground subsidence, creating disaster resilience and promoting drought adaptation.

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

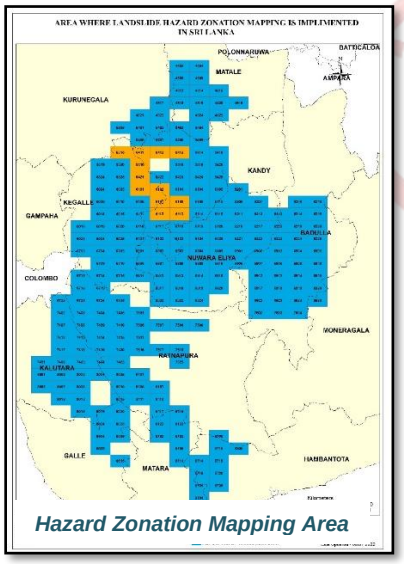
Projects under Public Investment Program

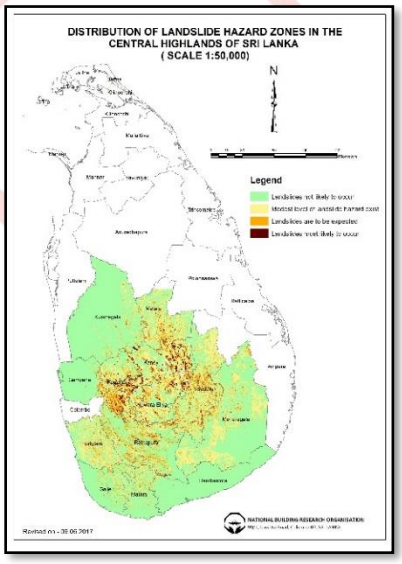
Landslide Hazard Zonation Mapping Programme (LHMP)

The government following severe landslides in 1985 assigned the NBRO to carry out landslide investigations and relevant studies. Thereafter, NBRO started landslide identification and mapping work and as a consequence, Landslide Hazard Zonation Mapping Project (LHMP) was launched in 1992 with the assistance of the United Nations Development Program. This project continued to this date with government funds and as the main outcome, (i) maps to the scale 1:50,000 were prepared to cover a total of 32,593.1 sq. km in 13 districts, and (ii) maps to the scale 1:10,000 were prepared to cover prioritized areas covering a total of 8,960 sq. km.

In 2021, the project received Government grant of Rs. 26.6 Mn. and as the project outcome, 14 map sheets each covering 40 sq. km in 1:10,000 scale, were prepared in the districts of Nuwara Eliya and Kandy. The total area covered under 1:10,000 scale is now in the excess of 560 sq. km.

The maps produced by this project are being 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).





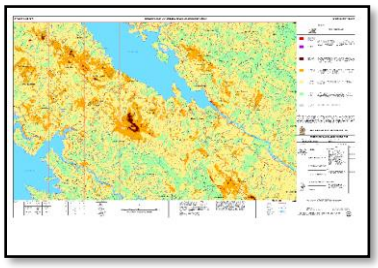


Fig.1 Area where Landslide Hazard Zonation is implemented in Sri Lanka
Fig.2 Distribution of Landslide Hazard Zonation in Sri Lanka, Scale 1:50,000
Fig.2 Sample of Landslide Hazard Zonation map, Scale 1:50,000

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 5783 landslide special investigations were performed in 2021. The General Treasury has provided Rs. 78.0 Mn for this work.

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 2021 the NBRO has received over 98,000 applications since the issuance first started in March 2011. The number of approvals issued in 2021 was 8685 and the number of applications rejected for the entire period was 61. The NBRO charges a nominal fee to process an application, carry out necessary investigations and issue a report. The General Treasury provided Rs. 35.0 Mn in the year 2021 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

Progress of the Issuance of Landslide Risk Assesment Certificates for Construction and Development Activities in Landslide Prone Areas (LRAB & LRAD)

නායයෑම් අවදානම් සහිත ප්‍රදේශ වල ඉදිකිරීම් හා සංවර්ධන කටයුතු සඳහා නායයෑම් යෝග්‍යතා

(01.03.2011 - 31.12.2021)

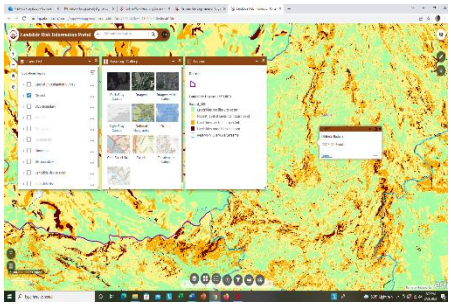
අනු අංකය Item No.	District දිස්ත්‍රික්කය	01.03.2011 - 31.12.2021				01.01.2021 - 31.12.2021				Total applications pending (අතිරික්ත ඉල්ලුම්පත් සංඛ්‍යාව) {1-(2+3+4)}	Pending Application Details (අතිරික්ත ඉල්ලුම්පත් පිළිබඳ විස්තර)		
		Applications Received (ලැබූ ඉල්ලුම් පත්) (1)	Permission granted (අනුමැතිය ලබාදුන්) (2)	Permission not granted (අනුමැතිය ලබා නොදුන්) (3)	Applications Cancelled due to other reasons (වෙනත් හේතූන් මත අවලංගු කරන ලද ඉල්ලුම්පත්) (4)	Applications Received (ලැබූ ඉල්ලුම් පත්)	Permission granted (අනුමැතිය ලබාදුන්)	Permission not granted (අනුමැතිය ලබා නොදුන්)	Applications Cancelled due to other reasons (වෙනත් හේතූන් මත අවලංගු කරන ලද ඉල්ලුම්පත්)		Pending For initial Investigation / report preparation (මූලික පරීක්ෂණ සඳහා/වාර්තා සැකැසීම)	Referred to revisit / detailed inspection (වැඩිදුර අධ්‍යයන යට යොමු කිරීම සඳහා)	Details Pending from Client (ඉල්ලුම්කරුගෙන් අදාල ලියකියවිලි ලැබෙන තෙක්)
1	Kandy	21,537	19,321	316	1,667	1,535	1,707	3	275	233	71	2	160
2	Matale	9,224	9,166	17	32	719	841	0	0	9	9		
3	Nuwaraeliya	8,224	7,802	83	181	750	597	19	130	158	51	0	107
4	Badulla/Monaragala	13,364	12,726	221	320	1,388	1,398	21	10	97	87	4	6
5	Kagalle	12,231	11,589	67	440	895	809	5	8	135	98	0	37
6	Rathnapura	12,748	11,105	46	1,513	1,361	1,276	8	113	84	84		
7	Kalutara	1,273	1,221	11	30	168	167	4	1	11	11	0	0
8	Galle	17,195	17,144	9	24	1,655	1,700	1	1	18	18		
9	Matara/H'tota	2,338	2,327	5	6	116	121	0	0	0	0		
10	Kurunagala	44	43	0	1	18	18	0	1	0	0	0	0
11	Colombo/Gampaha	51	51	0	0	51	51	0	0	0	0	0	0
එකතුව/Total		**98,229**	**92,495**	**775**	**4,214**	**8,656**	**8,685**	**61**	**539**	**745**	**429**	**6**	**310**

Landslide Mitigation Program (GOSL Funded)

Among the landslide and slope instabilities needing mitigation that were identified by the LHMP and the SPI, mitigation of prioritised 2 major landslides and 9 other slope improvement work were carried out using funds from the Treasury as indicated below.

Se. No	Landslide Mitigation, Slope Stabilization Project	Total Cost (Rs. Mn.)
1	Rectification of Unstable Slope at Malapattawa, Nuwaraeliya District	76.90
2	Landslide mitigation at Kotaharakanda, Avissawella.	52.04
3	Geotechnical Investigation, Engineering Design and rectification works of landslides and unstable slopes in Sri Dalada Maligawa, Asgiriya temple, Vardana Kumbura on Thalawakele Nawalapitiya Road, Shakthi Tea Factory- Passara, Bewerian Lion's club tsunami village, Ambalangoda, Sri Darmavijaya Piriwena, Kalutara, Sri Anandaramaya Temple, Kalutara & at No 129, Wellakka, Weligama.	9.26
	Total	**138.20**

Development of Risk Profile for landslide prone areas



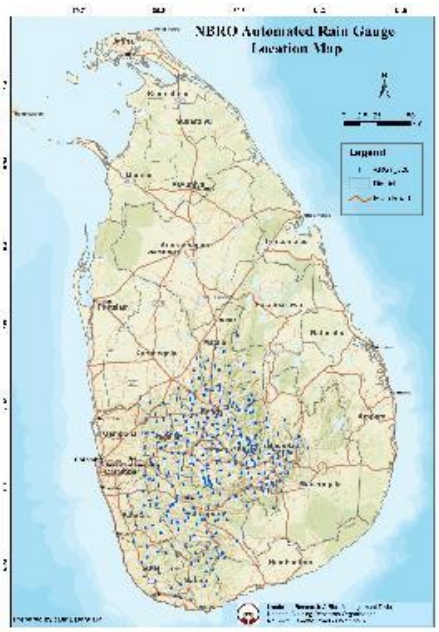
Landslide risk maps show the landslide potential together with the expected losses in terms of casualties, in the event of a landslide occurrence. Landslide risk maps are being developed by combining human settlements maps and landslide hazard zonation maps. These maps will serve as a tool to guide investments in development and utilization of lands susceptible to landslides. Following activities were carried out in 2021 out of the 5-year planned work.

- Identify priority landslide mitigation locations in 100 GN Divisions
- Establish 30 community disaster management committees in Kalutara district
- Development of DSD level risk profiles (Galle, Matara, Kandy, Matale, Ratnapura Districts)
- Preparation of Grama Niladari Division level Landslide Exposure maps for 205 hazard maps
- Data publishing in Landslide Risk Information Portal, training and awareness on relevant authorities and stakeholders for use of the portal (DMC, NDRSC, District Secretariats in 10 landslide prone districts – (Nuwara Eliya and Kalutara work fully completed.)

Developing a system for building assessment and condition reporting

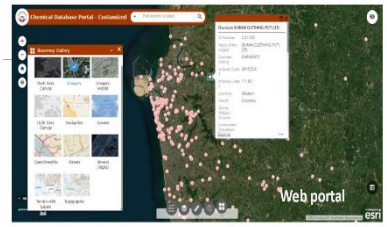
A system is in place for state owned public buildings and owners of other buildings commonly used by the general public having conditions such as older than design life, showing evidence of deterioration due to advanced age, having inferior structural integrity, suffered physical damage during a disaster, because of poor maintenance or resulted by impact of construction activities in the surroundings that could be considered for the investigation to obtain a technical/structural assessment report from NBRO and implement technical recommendations contained therein. NBRO carried out structural assessment and investigation of 116 buildings in 2021.

Enhancing real time landslide forecasting & early warning capacity



NBRO maintains a network of automated rain gauges for monitoring rainfall in landslide-prone areas for effective issuance of landslide early warnings, as triggering of landslides mostly occurs due to increase in soil moisture by high intensity rainfall. Scientists of Landslide Early Warning Centre at the NBRO study weather forecasts issued by the Department of Meteorology and analyze rainfall data acquired from the automated rain gauges for issuing early warnings combinedly with Emergency Operation Centre of Disaster Management Center. In 2021, 29 automated rain gauges were added to this network thus increasing the total number of automated rain gauges now to 329.

Systematic assessment of chemical disaster risk in Sri Lanka



Realizing the need of a disaster management plans for industries (especially for the industries using hazardous chemicals), NBRO formulated “Systematic assessment of chemical disaster risk in Sri Lanka” Project. This project aimed to study chemical disasters/hazardous situations, determine the triggering factors, and propose corrective and preventive actions. With this study, NBRO intends to develop a policy framework to prevent or minimize occurrence of chemical disasters and raise awareness on safer industrial environment in Sri Lanka.

Under this project, NBRO developed a systematic method of assessing chemical disaster risk in Sri Lanka. This method can be used island-wide and it is also applicable to many industries. It assesses the risk from the initial storage of a specific chemical to the disposal of the generated hazardous waste. As a part of the program, a chemical data platform and an industrial data platform were developed and updated with available data. The chemical data platform includes physical and chemical characteristics of the hazardous chemical and its incompatible conditions. It also contains data needed to identify and model basic evacuation zones during an undesirable event. The industry data platform stores industrial data. The industries are prioritized by the hazardousness of the chemicals used in each industry. An industrial database will be helpful to predict consequences and to take immediate actions during a chemical disaster. Required data will be collected through a mobile application.

“Chemical Disaster Management Taskforce” to be established under National Building Research Organisation with the necessary infrastructure to assist assessment of any chemical disaster risk in Sri Lanka.

Research & Development Program

NBRO received Rs. 14.6 Mn in 2021 as the annual government research grant. The Industrial Consultation to learn research needs of stakeholder institutions and construction industry was not held in 2021 due to COVID 19 pandemic situation. Based on previous experience, a suitable R & D programme was devised for 2021. The NBRO Research Committee continued to provide guidance to scientists to conduct their research projects and NBRO provided necessary assistance and facilities. In house monitoring of research progress continued though the circumstances did not permit gathering of usual audience at the research progress meetings. The 11th Annual Research Symposium of NBRO was held in December 2021 with all recommended heath safety precautions. The following table gives information of the R & D Projects of 2021.

Principal Researcher	Division	Research Topic
S.A.D.A.S.Suraweera	BMRTD	Suitability of offshore sand sludge for value added building products
S.R.Randika		Development of test method & specification of coir fiber geotextiles
M.Gannoruwa		Development of cost-effective green masonry products using waste materials
D.R.Ratnasinghe		Parameter retrodiction towards durability assessments of hardened concrete
R.Ruhunuge	ESSD	Development of provincial based harvested rainwater quality Index and Independent surveillance of RWHS in Anuradhapura district
Harshini Kumarapeli		Assessing ventilation conditions and use of indoor plants to improve the indoor air quality of urban residences
N.D.C Lakmal		Development of real-time air quality monitoring network in urban areas in Sri Lanka for air quality prediction and preparedness system
SAMS Dissanayake		Preparation of guidance document on environmental, social, health and safety (ESHS) traffic management on Landslide Mitigation projects
M.P.Amarathunga	LRRMD	Strengthening the prediction power of landslide hazard zonation maps by incorporating zone-based rainfall threshold through infiltration modelling
D.Rajapaksha		Determination of regional and local rainfall thresholds for landslides in Sri Lanka
Ranil Weerasinghe	HSPTD	Retrofitting of community centre at Makaldeniya estate for Meeriyabedda landslide victims
Dayan Munasinghe		Building of hazard resilient model house in Polonnaruwa
Chinthaka Rathnasiri		Hazard identification structural assessment of damaged houses situated in the Hingurakoda DSD and provide recommendations for resilient house construction

A Design Manual for Rooftop Rainwater Harvesting Systems for Sri Lanka

Access to safe water is a fundamental human right and it is recognized as one of the UN-SDG Sustainable Development Goals (SDGs), SDG 6: "Clean Water and Sanitation". However, there are inequalities in access to safe water in the globe. Human-induced water pollution, increased frequency and intensity of extreme weather events drive communities towards water stress.

Due to a wide range of factors related to the system reliability, roof-based rainwater harvesting is not much popular as a sustainable option among the water-stressed communities. Yet, properly designed and operated rooftop rainwater harvesting systems can be a sustainable solution for managing domestic water stress in communities suffering from long-term water stress. A study conducted by NBRO revealed that existing Rain Water Harvesting (RWH) systems in many parts of Sri Lanka are not functioning satisfactorily due to inappropriate designs and inaccurate installations.

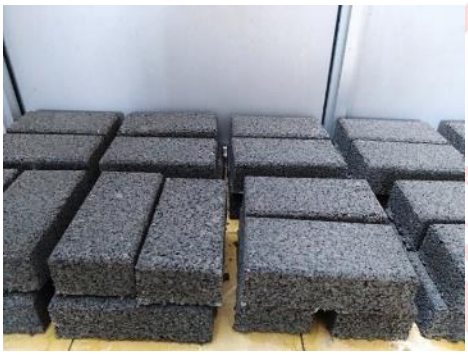
Identifying the importance of establishing rainwater harvesting systems, their drawbacks and existing knowledge gaps, NBRO devised a project titled "Sustainable roof top-based rainwater harvesting systems to overcome domestic water deficit conditions in the Anuradhapura" in 2019, under the R & D programme. Under this project**, "**A Design Manual for Rooftop Rainwater Harvesting Systems for Sri Lanka" was developed as a self-guided technical reference and a guide to design, construct and operate sustainable Rooftop RWH systems. It is a timely and much-needed technical tool for water sector professionals, Community Based Organizations, and stakeholders. The manual is available in English, Sinhala and Tamil languages.

Simultaneously, an easy-to-use freely accessible on-line rainwater harvesting potential calculator was developed with the collaboration of Lanka Rainwater Harvesting Forum. This online calculator is created under three different tiers including estimation of up-to-date bill of quantities. It is embedded with monthly rainfall values from 2000 to 2019, relevant field-verified average domestic water requirements, a complete user-guide and a simulation model of monthly water distribution based on water requirement, harvestable volume and storage capacity.

Development of cost-effective green masonry products using waste materials

Synthetic fiber blended textile (polyester spandex) offcuts generated from apparel industry is considered as waste: currently it is incinerated as fuel in the cement manufacturing process and remainder ends up in illegal dumps. Use of textile waste as a raw material in construction industry was studied while focusing on environmental preservation. Accordingly, this research focused on developing fabric embedded paving blocks applicable for foot paths and outdoor sports surfaces with improved shock absorption and water permeable characteristics. Developed paving bocks complied with the requirements specified in BS EN 1338: 2003, Concrete paving blocks – Requirements and test methods. As additional features, the developed paving block has the ability to reduce impact force by 20% which is satisfying the requirement for outdoor sports surfaces for better foot comfort. Therefore, developed fabric embedded paving blocks can be recommended for outdoor sports surfaces. Furthermore, water infiltration capability of developed fabric embedded paving blocks is 100 times higher than that of conventional concrete paving blocks that can significantly lower the surface runoff during heavy rains.

As joint pilot project with Bitumix (Pvt) Ltd, MAS Holdings (Pvt) Ltd and the NBRO, developed paving blocks were laid on a jogging track in Panagoda Regimental Center. Based on the comments received from its users this block surface facilitates better foot comfort when compared to conventional concrete paving block surfaces.



Symposia

11th NBRO Annual Research Symposium 2021

INNOVATION GEARED
BUILDING RESILIENCE

Inauguration of 11thAnnual Research Symposium - 2021on **"Innovation Geared Building Resilience"** organized by National Building Research Organisation was successfully held on14th December 2021at the Waters Edge Hotel, Colombo. This graceful event was hosted as a hybrid form event with limited physical participation of researchers, disaster management practitioners, policy makers and eminent experts from local and international institutions and many other participants witnessed the event through the online form. The event provided an excellent platform to have discussions, exchange ideas and share experience.

Gen. Kamal Gunaratne (Retd), Secretary to the Ministry of Defence participated as the chief guest of this event. During the Inaugural Session, Eng. (Dr.) Asiri Karunawardena, Director General of NBRO delivered the welcome address. Thereafter, Mr. Abdur Rahim Siddiqui, Country Director, World Food Program (WFP) addressed the audience. Afterwards, a special launching event was held to launch the following items;

- NBRO Symposium Proceedings Book titled "Technical Guidelines for Disaster Resilient Construction"
- Manual for Roof Top Rain Water Harvesting and web-based Calculator
- Living lab concept, pilot for Kalutara District using Mobilize Platform
- Demarcation of Landslide impact zone using Red and yellow zone concept – Pilot project, Kegalle district
- Mobile application on real time landslide early warnings dissemination

The keynote speaker Eng. Mike Stannard, Specialist in Building Codes, New Zealand, delivered an eye-opening keynote address on "Building Codes for Resilient Built Environment". Afterwards, the symposium proceeded with a panel discussion on "Building Resilience" moderated by the Prof. Chintha Jayasinghe, Senior Professor, University of Moratuwa with the participation of panelists Prof. Tilak Hewawasam, Professor in Geology, University of Peradeniya, Dr. Kushan Wijesundara, Senior Lecturer, University of Peradeniya, Mrs. Kanthi De Silva, Former Deputy Director General, Central Environment Authority, and Mr. Toru Koike, Team Leader, Project SABO, JICA.

The first day of the symposium was structured with a technical session titled “Investing on Resilient Environment” and chaired by Prof. Udeni Nawagamuwa, Professor, University of Moratuwa. NBRO wishes to thank the resource persons, the distinguished invitees and the physical and online participants who made this event so successful to the end.

The second day of the symposium was on 15th December 2021 at the Auditorium of State Ministry of National Security and Disaster Management (Disaster Management Division), Vidya Mawatha Colombo 07. Proceedings of the second day included a Keynote speech, a panel discussion and two technical sessions.

On Day (2), Major General Sudantha Ranasinghe, Additional Secretary, DM Division, State Ministry of National Security and Disaster Management addressed the gathering and then, the Keynote Address ‘Climate Change and Sediment Disasters’ was delivered by Dr. Uchida Taro, Associate Professor, Faculty of Life and Environmental Science, University of Tsukuba. This was followed by a panel discussion on Sendai Framework to achieve sustainable development goals with Mr. Firzan Hashim as the moderator and Mr. Rohan Samarakkodi, Additional Director General, DMC, Ms. Yasangi Muditha Randeni, General Manager, Group Business Development and Sustainability, Aitken Spence PLC, Dr. Buddika Hapuarachchi, Policy Specialist & Team Lead (Climate and Environment), UNDP, and Dr. Vishka Hiddelage, Freelance Consultant as panelists. A technical session on Technological advancements in building research followed that was chaired by Dr. H.M.Y.C. Mallikarachchi, Senior Lecturer, University of Moratuwa where four authors presented their papers.

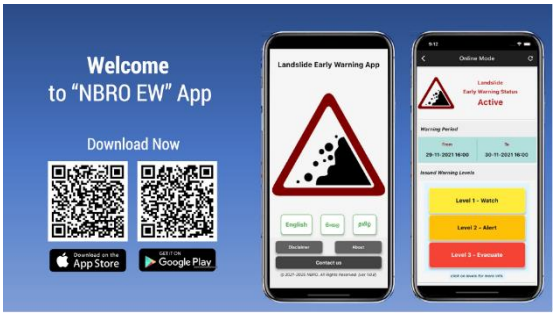
In the afternoon, Mr. Takayoshi Hirose of Furuno Electric first presented on Application of X-band weather radar in Landslide Early Warning as a special session that was later followed by the technical session on Non-structural measures for landslide risk reduction with Mr. Toru Koike, Team Leader, Project SABO, JICA as the session chairman where for more authors presented their papers. The last technical session was on Application of digital technologies for risk management with Prof. Terrence Fernando, Director, THINKlab, University of Salford, UK at the chair where four more authors presented their research papers.

The symposium attracted researchers, disaster management practitioners, policymakers, and eminent experts from local and international institutions and provided an excellent platform to have discussions, exchange ideas, and share experiences. Printed version of Symposium proceedings was made available to participants.

Panel discussion on “Building Resilience”

Technical sessions

Mobile Application "NBRO EW" for Dissemination of Landslide Early Warnings



National Building Research Organisation unveiled its mobile application "NBRO EW '' at its 11th Annual Research Symposium 2021 held on 14th December 2021 at Water's Edge Buttaramulla. The state-of-the-art app has a plethora of interesting features such as allow its users to instantly receive official landslide early warnings and visualize effective warnings overlain on a live location map making it easier for the user to track if the user is within a warning effective area.

This application enables smooth and speedy dissemination of landslide early warnings to the general public, especially people living in landslide prone areas.

Some key features of the app include:

- Delivery of landslide early warnings to users instantly
- A detailed view of all issued warnings on Divisional Secretariat Divisional level
- Landslide early warnings effective areas displayed on topographic and satellite maps with user's live location
- Available in online and offline modes.
- Direct dialing facility to Disaster Management Call Center Hotline

The application was developed by Mr. M. S. M. Aroos, Senior Scientist of National' Building Research Organisation. The app is available to download from both the Google Play Store and Apple app-store. Get "NBRO EW" app from here: Appstore / Google Play

Handing over Mobile air quality monitoring unit

The high tech automated mobile air quality monitoring unit was handed over to the NBRO by Vehicular Emission Testing (VET) office for air quality monitoring work in urban areas of Sri Lanka. The monitoring unit has facilities to measure real-time levels of all criteria air pollutants such as Particulate Matter (PM10 & PM2.5), Sulphur Dioxide (SO_2), Oxides of Nitrogen (NO_2 & NO), Carbon Monoxide (CO), Ozone (O_3) and Hydrocarbons (HC). In addition meteorological parameters such as wind direction, wind speed, temperature, relative humidity, rainfall and solar radiation etc can be measured. Since the system uses highly accurate standard techniques and periodically calibrated with primary standard calibration gases, this system is very important in the validation of data from other techniques in air quality monitoring frequently used by the NBRO. The average cost of the system is about Rs. 40.0 Mn.

Training Programmes, Seminars and Workshops

Two online workshops on “landslide flow path simulations”, organized and coordinated under OFDA/USAID support by the USGS, with resource persons participating from USGS and Swiss Federal Institute for Forest, Snow and Landscape Research (WSL). Each workshop focused on a different simulation model.

RAMMS (rapid mass movement simulation) online workshop – 19th March 2021

RAMMS is a powerful numerical simulation tool currently used in many countries for landslide simulations. RAMMS has been developed by a team of experts at the WSL Institute for Snow and Avalanche Research (SLF) and the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL).

The workshop was led by RAMMS experts from these same institutions, namely Dr. Perry Bartelt (leader of the RAMMS research group in Davos) Mr. Marc Christen (technical program leader for RAMMS at the WSL in Davos) and Dr. Brian McArdell (former member of RAMMS research group). The workshop consisted of a short overview of RAMMS, introduction to the user interface, guided examples of landslides from both Switzerland and Sri Lanka, a short overview of new developments in RAMMS followed by more discussions on application to landslides in Sri Lanka.

Laharz online workshop – 6th May 2021

Laharz is a statistically based computer program capable of generating debris-flow and lahar hazard maps very quickly, even in the absence of site-specific information other than topography. It is a python-language computer program built on a GIS platform and is a product of United States Geological Survey (USGS). The workshop was led by USGS geologists Dr. Corina Cerovski-Darriau and Mr. Stephen Slaughter and included a brief overview of Laharz, group exercises and demonstrations using examples from both USA and Sri Lanka and a short overview on future of Laharz.

The workshops were a great opportunity for NBRO scientists to learn from the experts. In the course of developing NBRO’s landslide susceptibility maps into hazard and risk maps, the workshops have provided NBRO with valuable tool options to experiment with while run-out modelling. NBRO is immensely grateful towards OFDA/USAID, USGS and WSL for their support and efforts in making these workshops successful with special mention to Mr. Stephen Slaughter, the USGS contact point for NBRO, for all the help provided in organization and coordination of the workshops

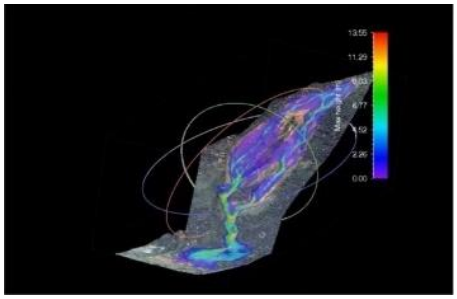


Figure 1: A simulation done using RAMMS

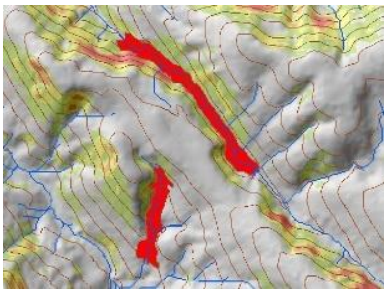


Figure 2: A simulation done using LAHARZ

Major Consultancy Projects

Clearing geotechnical issues in construction projects

NBRO conducts investigations and issues reports as requested by authorities such as UDA, CMC and Tourist Board, prior to approving projects that involve construction of high-rise buildings and large building complexes where extensive excavation and foundation works are carried out and can impact negatively on neighbouring buildings.

Year	2017	2018	2019	2020	2021
No. Reports & Renewals	32	38	20	09	44

Issuing condition reports on buildings

NBRO conducts investigations to assess the condition of buildings and their structural integrity and then issues relevant reports as a fee-based service. This is done as per a client request or a court order. Often such services are required to assess 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 recent details.

Year	2015	2016	2017	2018	2019	2020	2021
No. Reports	42	60	148	116	124	116	141

Geotechnical Investigations and Designs for Central Expressway Project

Detailed geotechnical investigation and engineering design for Central Expressway Project Phase 3 (CEP-III) from Pothuhera to Galagedara were undertaken by Geotechnical Engineering Division (GED) of NBRO during the period from October to December 2021.

The GED provided soft ground improvement methodology and foundation design for Stage II from Pothuhera to Rambukkana covering around 9.5 km and assisted the RDA to smoothly carry out this nationally important mega project. Geotechnical investigation was carried out along the road stretch covering 293 boreholes; this being one of the largest projects undertaken by NBRO during the recent past.

Engineering geologists of the division modelled the subsurface profiles using the borehole information while design engineers carried out the designs related to soft ground improvement, cut slopes, embankments and foundation structures for overpasses, underpasses & culverts. Testing of soils, rocks and water for design purposes and related studies were carried out by the accredited soil, building materials and environmental laboratories of the NBRO. The total estimated cost of this consultancy work would be about Rs. 95.0 Mn.



Other Technical Interventions

Quality development of bricks for the restoration work of Deeghawapi Stupa

The “Deeghawapi Stupa” was first built in the 3rd century. Since then, it had been rebuilt on several occasions. Due to the present condition of the stupa, it was proposed to involve National Building Research Organisation in the supervision of clay brick manufacturing process. Previously, this process was conducted under the supervision of the Department of Archaeology. The Manager Laboratory and divisional scientists made frequent site visits to supervise the process and clay bricks were tested for compression strength. Building Material Research and Testing Division of NBRO later introduced process modifications as improvisation measures.






Containing Slope Instability observed in Colombo-Kandy Road at Kadugannawa

Land instability was noted in the month of November 2021 on the roadside slopes above the Colombo-Kandy Road at Pahala Kadugannawa near the 98 km post in 25 / A Ganetenna Grama Niladhari Division of Mawanella Divisional Secretariat in the Kegalle District. The tension cracks appeared on 2021-11-10 and officials of NBRO conducted a preliminary field study of the site. Then, NBRO and the Road Development Authority acted urgently to temporarily close the main road following instructions of the District Secretary of Kegalle in view of the potentially dangerous situation prevailing at the site.

Thereafter, the following steps were taken as short-term measures

1. Covering of the cracks associated with the upper slope of the unstable zone
2. Introducing a surface drainage system to regulate the surface drainage pattern in the upper zone of the potential unstable slope and divert rainwater away from the unstable zone.
3. Constructing of 6-8 horizontal drains depending on the location of the land for quick removal of ground water collected internally from the unstable zone.
4. Carrying out a geophysical survey along the main axis of the unstable zone and along two selected axes along the unstable slope zone parallel to the Colombo-Kandy main road to study the overburden thickness and slip surface depth of the surface of the unstable zone.

According to the geophysical investigation carried out on the above unstable ground and the available data, there is a layer of soil about 5-6 m thick around this place and depending on the location of the rock in the interior *(undulating surfaces of the bed rock / Corrugated nature)* and it was also observed that there is a natural resistance to move down this volatile zone.

The gradual increase in stress cracks created in this unstable zone was observed in 11 locations over a period of 3 days. According to data, a slight displacement was observed in these areas, but no significant horizontal or vertical displacement has been observed so far.

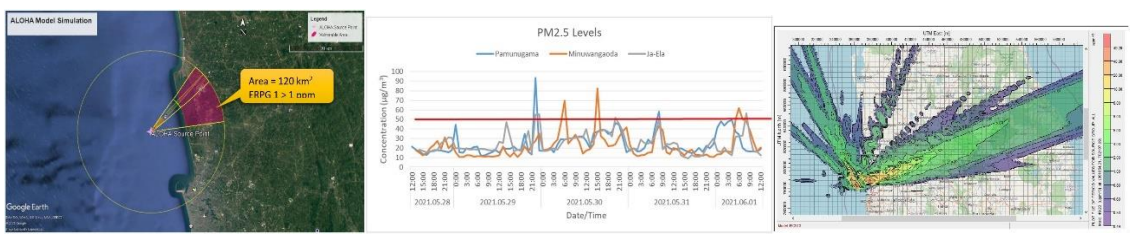
NBRO and the RDA have been able to temporarily control the situation. In view of the above, the NBRO proposed to reopen the Colombo-Kandy main road to traffic in the above area after 17th November 2021 in accordance with the recommendations made by the NBRO under normal weather conditions. It is imperative to introduce long-term sustainable methods designed based on the data obtained from the preliminary research currently being conducted and the results of future detailed studies. A report containing detailed plans will be issued in the near future.

Air Pollution Impact due to the Fire in MV X-press Pearl Ship near the Colombo Port

Based on a request made by Marine Environmental Protection Authority (MEPA) of Sri Lanka to provide technical support to assess the impact on air quality due to the fire in MV X-press Pearl ship near Colombo Port, the NBRO conducted a comprehensive study on air quality in affected areas.

Once a ship is on fire, most of the chemicals and other materials stored in the vessel decompose and release smoke containing chemical vapour to the atmosphere, as criteria air pollutants generated due to the combustion products depending on the composition of such materials. These fires may release hazardous pollutants such as dioxins, furans & other organic pollutants, heavy metals, and in addition, greenhouse gases such as Carbon Dioxide to the atmosphere depending on the nature of the burning materials and flame temperature. Released air pollutants then disperse into surrounding areas depending on the metrological conditions.

As per the observations made during this particular fire, generated air pollutants dispersed as a plume to the inland areas when prevailing wind was from West and South-west. The results of measurements taken indicated high pollution levels in areas close to the ship whereas significant levels were not recorded in other areas identified earlier as critical. The continuous monitoring data indicated that some peak pollution levels exceeding national standard levels existed only for few hours with the changing meteorological conditions.



Air quality dispersion model software was run to assess the ground level concentration of pollutants generated by the fire. This modelling indicated that the contribution made by the fire increased the ambient pollutant levels by two-fold, and that the predicted levels were well within the standard levels since the ambient air pollutant levels during these days were very low due to the COVID-19 lockdown scenario. The load calculation data indicated that a total of between 8000 to 13000 metric tons of air pollutants were released to the atmosphere, depending on the amount of burnt mass due to this incident at MV X-press Pearl ship.

Other Income Generating Activities

Provision of technical testing and consultancy services in the fields of landslide studies and services, geotechnical engineering, project management services, building materials, human settlements planning and environmental management was continued as summarized below:

Activity/ Division	No. of consultancy jobs	No. of testing/Investigation jobs	Total Income Generated (Rs. Mn.)
Landslide Research & Risk Management Division	1075	-	100.62
Geotechnical Engineering & Testing Division	231	137	160.91
Environment Studies & Services Division	312	389	52.80
Building Materials Research & Testing Division	4	2649	40.46
Project Management Division	25	120	32.90
Human Settlements Planning & Training Division	2	42	15.83
Consultancy work RLVMM Project			66.10
Other Revenue	-	-	53.80
Total			**523.42**

Projects with Foreign / Donor Collaboration

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

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

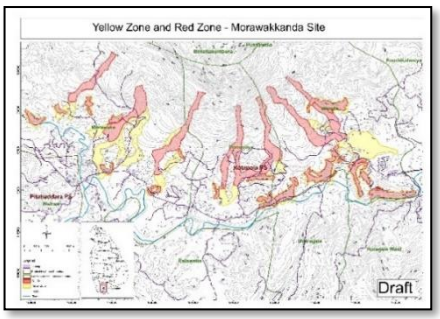
  Mitigation work of 4 hazardous sites (landslide sites in Badulusirigama, Udamadura & Kandy and Alagumale rockfall site), were completed under Phase – I of the Technical Cooperation for Landslide mitigation Project (TCLMP) with the assistance of JICA. The project works were carried out by NBRO, Koiwa Corporation and Earth System Science Limited with Nippon Koei working as the consultant.

  Phase – II of the TCLMP now referred to as Project "SABO" commenced as a three-year project aiming at capacity strengthening on the development of non-structural measures for landslide risk reduction in Sri Lanka with especial emphasis on conducting site specific hazard mapping and risk assessments, issuing landslide early warning at local level, improving existing observation system and alerts, and applying risk assessments of sediment disasters to land-use planning and development standards. At the beginning, three pilot sites from Kegalle, Badulla and Matara were selected for project implementation. In order to achieve the targeted outputs of the project, the following three working groups have been appointed.

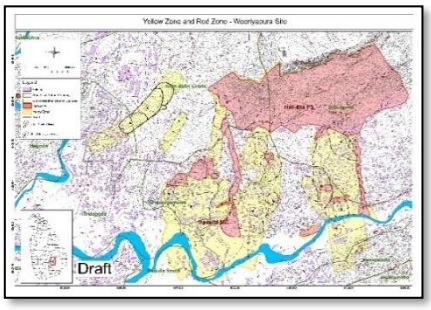
Working group 1 (WG1)	-	Hazard Analysis and Risk Assessment
Working group 2 (WG2)	-	Sediment Disaster Early Warning System
Working group 3 (WG3)	-	Land Use Planning and Development Standards

  Under WG1, the following works were carried out: review of the existing methodology on Landslide Hazard Zonation Mapping and Risk assessment; improving system for managing landslide disaster records; collecting and analyzing records of past landslide disasters; preparation of draft manuals on site specific hazard mapping and risk assessment; preparation of site specific hazard maps for the three pilot sites using Red zone and Yellow Zone concept; conducting landslide flow path simulation using Hyper KANAKO model for three pilot sites, and conducting site-specific hazard mapping in areas other than pilot sites. In addition, workshops, training and mini-seminars were conducted for the NBRO staff.

  In 2021, the following works were carried out: automation of the Y/R zone demarcation methodology, update the Y/R zone demarcation methodology based on LHZM of NBRO, update of the y/R maps of three pilot sites, conducting site-specific hazard mapping for the selected 12 sites in Kegalle District, Field verification of Y/R zone maps of three pilot sites and other 12 sites, submitting of the final Y/R zone maps of 12 sites to the GA of Kegalle District.



Site Specific Hazard Output of Morawakkanda pilot site



Site Specific Hazard Output of Weeriyapura pilot site

Under WG2, NBRO has completed some enhancement works of landslide early warning process for the improvement in efficiency of issuance the landslide early warning and rainfall monitoring activities, prepared a landslide inventory database using past landslide investigating reports and other available sources and the rainfall threshold calculation work has been carried out for all 12 landslide-prone districts with the available rainfall and landslide data. With this study, 24, 48, 72 hrs. One-hour rainfall threshold values and soil water index values were derived for the above areas. For the issuance of landslide early warning, the rainfall critical line which was obtained from combination of the short-time and long-time rainfall values can be utilized. Landslide movement detecting and monitoring instruments were installed at Udapotha in Kegalle district and Weeriyapura in Badulla district and the values can be observed through OSASI System. Online landslide information management system was developed to enhance the landslide risk assessment process in Sri Lanka.

In Output 3, the Project has been discussing the appropriate land use and necessary governmental and local efforts in the area designated by the Yellow / Red zones. For instance, in Yellow zone, strengthening early warning and evacuation system should be enhanced by the central and local governments. In Red zone, new construction of buildings and/or public facilities must be controlled not to create new risk.

It is expected to hold discussions with local authorities, districts and DS divisions as well as the central development agencies such as UDA. At the same time, it is also important to guide what kind of structural measures should be applied to develop the area designated by the Yellow / Red zones. Both the land use regulation and the development standards will be summarized in a "Guideline for Disaster Resilient Land Use Regulation / Development Standards" to apply in landslide-prone communities in the country.

Development of early warning technology of rain-induced rapid and long-travel landslides in Sri Lanka - SATREPS (JICA)

The International Landslide Consortium (ICL) and NBRO jointly carry out a project titled "Disaster risk reduction of rain-induced rapid and long-travelling landslides" under Science and Technology Research Partnership for Sustainable Development (SATREPS) of Japan Science and Technology Agency (JST). This five-year Japan-Sri Lanka joint project is implemented in 2019-2023 period. This project proposes introducing advanced technology through the global partners of ISDR-ICL Sendai Partnerships 2015-2025, to disaster risk reduction of rain-induced rapid and long-travelling landslides. Several local and Japanese collaborating and support agencies participate in this project work. Work related to following outcomes have been commenced.

1. Technology of 24 hours in-advance prediction of heavy rainfalls and resulting ground water pressure build-ups is developed. A technology to identify locations of rain-induced rapid long-travelling landslides and their moving areas is developed.
2. Technology and framework for effective risk communication to community people living in mountains and local cities are developed.
3. A system for early warning of rain-induced rapid long-travelling landslides is developed by integrating the technologies mentioned above based on the joint research in the pilot study sites. The developed system with guidelines and manuals is provided for the use in other areas in Sri Lanka.
4. The above technologies that are developed will ensure the safety of the public and secure vulnerable communities from landslides and associated hazards.

Project office was established in Tokyo and four NBRO scientists are being trained in Japan under capacity development. More training programmes for stakeholders have been planned and some

scientists have been already nominated for future training. Equipment to strengthen the geotechnical engineering divisional laboratory with sophisticated equipment such Landslide Simulator have been received.

Reduction of Landslide Vulnerability by Mitigation Measures Project (RLVMMP)

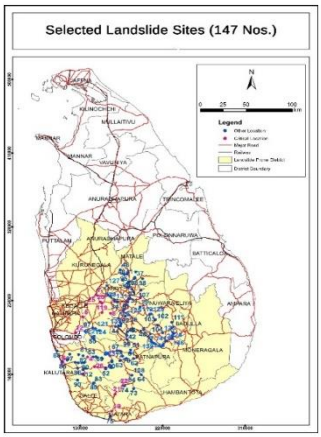
NBRO commenced the Reduction of Landslide Vulnerability by Mitigation Measures Project (RLVMMP) originated from Cabinet-approved Integrated Landslide Mitigation Programme. This mega project includes mitigation of identified high-risk landslide sites and also, roadside unstable slopes and unstable slopes along the railway lines in the hill country over 3 years. The main components of this project are:

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

147 sites are requiring immediate mitigation, had been prioritized by NBRO jointly with local authorities, Road Development Authority, and Sri Lanka Railway.

The Project Management Unit continued its duties with the available project staff and with the assistance of NBRO supporting staff**.**

Province	District	No of Sites
Central	Kandy	18
	Matale	12
	Nuwara Eliya	14
North Western	Kurunegala	04
Sabaragamuwa	Kegalle	18
	Ratnapura	32
Southern	Matara	06
Uva	Badulla	20
Western	Colombo	01
	Kalutara	22
TOTAL		**147**



Package 1, 2, 3, 4A, 4B and 4C of Phase I have been awarded at the end of the year 2021 to the selected contractors and the construction works of 24 Landslide sites have commenced in Ratnapura, Kalutara, Matara, Kandy, Kegalle, Kurunegala and Colombo Districts. The procurement process of the civil work contract for Package 7 in Phase II has been started and the contract will be awarded in mid-2022. The investigation and designing phase of Package 5 of Phase II was also completed and the procurement process will be started in early 2022.

Landslide mitigation sites Durekanda (Left) & Galaboda (Mid) and Ayagama (Right) in Ratnapura district

MOBILISE 3.0: Digital Toolset for Building Resilient Communities

The National Building Research Organisation has recently been successful in securing an innovation grant (30M Rupees), by working with the Kalutara District Secretariat and the University of Salford in the UK, to trial a set of advanced digital solutions that can help local agencies and communities to work together to build their local resilience against climate-induced disasters such as landslides and floods.

The grant is being offered as a part of the Program for Asia Resilience to Climate Change (PARCC), run by the World Bank, and funded by the UK's Foreign, Commonwealth & Development Office (FCDO), and administered by the Asian Disaster Preparedness Centre (ADPC). This innovation project won by NBRO is one of the 16 winning projects, selected out of 236 competitive proposals submitted to the climate change innovation challenge led by the Asian Disaster Preparedness Centre.

Figure : Professor Terrance Fernando explains the project to the District Secretary and the team.

The project aims to trial a range of digital solutions developed by the THINKlab at the University of Salford in the UK to overcome limitations in current approaches in preparing for climate-induced disasters. One of the key challenges faced by many countries, such as Sri Lanka, is the lack of an intelligence-driven approach for addressing local disaster risk reduction activities. At present, important climate and disaster risk data are scattered across many government agencies. As a result, it is difficult for government agencies, both at the national and local level to compile relevant intelligence, necessary for building community resilience against climate change and issuing effective early warnings.

This digital innovation project aims to establish a shared risk information environment and a data-driven decision support system for the local agencies in Kalutara to implement a participatory approach for identifying local risks and agreeing on adaptation and risk mitigation actions. Furthermore, the digital solutions developed in this project will trial a community-based early warning system where communities can offer important intelligence to relevant officials through crowdsourcing techniques and receive timely alerts and warnings in advance of possible disaster risks, saving lives. The project will also explore smart city solutions for sending early warning messages to communities that are out of mobile signal coverage.

NBRO Publications

Publication of Electronic Newsletters

6 numbers of Electronic Newsletters were published in year 2021. These newsletters contain;

(i) Publishing the work done during the period.

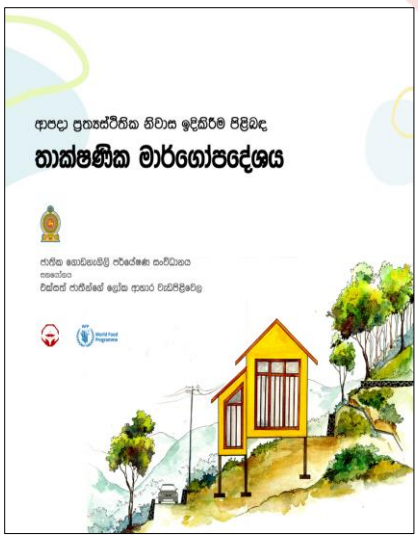
(ii) Recording of daily presentations and its out come

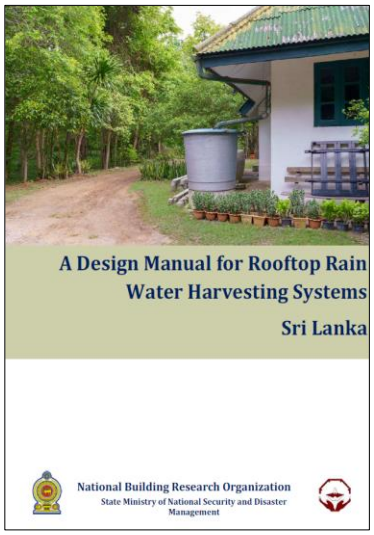
(iii) Discuss thoughts of the team.

Newsletter can be access via below links;

https://publicate.it/p/4.mRqq246286
https://publicate.it/p/0998SG242457
https://publicate.it/p/mV6P.C244954
https://publicate.it/p/UqK9Qj244057
https://publicate.it/p/4.mRqq246286
https://publicate.it/p/_w20UV241436

Publication of Technical Documents



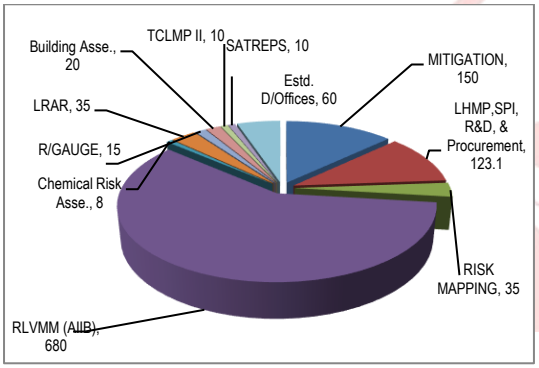


https://www.nbro.gov.lk/images/download/symposium/NBRO_11th_Annual_Research_Symposium_Proceedings---2021.pdf
https://drive.google.com/file/d/1sPbumXD0JfEQPBvCB17-KI8cH_BG_Rfa/view

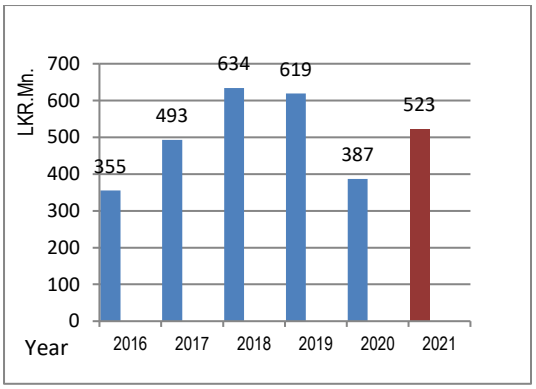
Financial Highlights

In 2021, NBRO recorded consolidated revenue of Rs. 860.26 Mn. Revenue from customary NBRO services Rs. 523.42 Mn. in 2021. The institution depends mostly on this consultancy revenue generated to meet its recurrent expenditure.

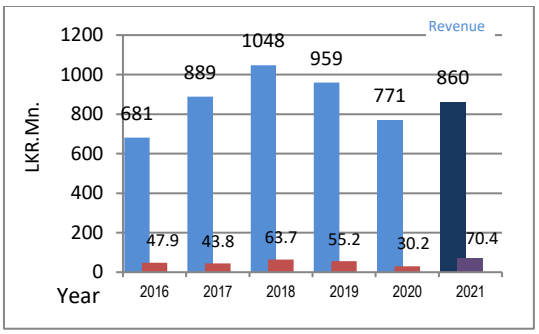
Rs. 336.84 Mn. has been utilized for projects and programs carried out in year 2021 under government grant. Nine district offices of NBRO have been functioning since March 2011 for issuance of Landslide Risk Assessment Reports for development work in landslide-prone districts. Rs. 35.0 Mn. was provided by the Treasury as recurrent expenditure and the balance requirement was met with nominal fee charged from applicants and rest by NBRO revenue.



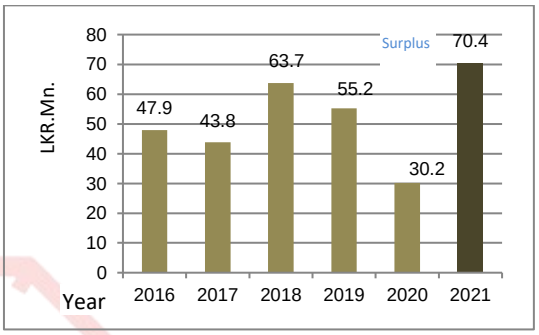
Government Grant for projects- 2021



Income by Testing and Consultancy work



Total Operating Revenue vs net surplus



Net profit earning during 2016 - 2021

In addition, research grant for Landslide Hazard Mapping of Rs. 26.6 Mn, Research & Development Rs. 14.64 Mn, grant for Landslide Special Investigations of Rs. 78.0 Mn. and procurement grant for lab & field, office equipment of Rs. 3.88 Mn. was received from the Treasury.

The consolidated revenue for year 2021 was Rs. 860.2 Mn. while total consolidated expenditure for the corresponding period was Rs. 789.8 Mn. A net profit of Rs. 70.4 Mn. was recorded.

The expenses on personal emoluments for the staff strength of 438 including daily paid employees was Rs. 406.9 Mn. in 2021 as against the staff strength of 490 plus daily paid employees was Rs. 455.0 Mn. In year 2020.

The institution growth and enhanced performance have been mainly due to the courageous effort of the management and the staff of NBRO.

Statement of Financial Position

STATEMENT OF FINANCIAL POSITION AS AT 31ST DECEMBER 2021

Rs.

		Annex No	As at 31.12.2021		As at 31.12.2020
Current Assets					
Cash and cash equivalents		**1**		228,837,920	94,773,584
Receivables	Trade Debtors	**2**	65,763,151		61,020,416
	Sundry Receivables	**3**	27,159,302	92,922,453	28,881,574
				321,760,373	**184,675,574**
Inventories		**4**		4,339,085	3,410,241
Receivables from staff		**5**		98,976,955	101,092,773
Pre-payments		**6**		51,950,721	135,922,914
Other Current Assets					
	Project work in progress	**7**	183,777,832		104,284,321
	Term Deposits	**8**	443,621,164	627,398,996	469,321,082
Non - Current Assets				**1,104,426,128**	**998,706,906**
Infrastructure, Plant & Equipment		**9**	133,404,828		168,435,039
New Lab Building Working in Progress			540,050,649		391,734,775
Mini Laboratories Work in Progress			22,006,166	695,461,643	3,928,967
Total Assets				**1,799,887,771**	**1,562,805,687**
LIABILITIES					
Current Liabilities					
Payables	Advance Received from Clients	**10**	516,527,805		319,910,612
	Sundry payables	**11**	106,807,992	623,335,797	116,845,313
Non – Current Liabilities					
Long term provisions					
	Provision for Gratuity	**12**	84,698,369	84,698,369	103,644,192
Total Liabilities				**708,034,166**	**540,400,117**
Net Assets				**1,091,853,605**	**1,022,405,569**
NET ASSETS / EQUITY					
Capital contributed by Government & Other entities		**13**	587,718,088		588,731,489
Reserves – Revaluation Surplus			27,875,989		27,875,989
Assets acquired			2,264,498	617,858,575	2,264,498
Accumulated Surplus/ (Deficit)					
	Surplus brought forward	**14**	403,533,592	403,533,592	373,363,926
Surplus for the year				70,461,437	30,169,666
Net Assets / Equity				**1,091,853,605**	**1,022,405,569**

Statement of Financial Performance

STATEMENT OF FINANCIAL PERFORMANCE FOR THE YEAR ENDED 31.12.2021

Rs.

Revenue	Annexure	Year 2021	Budget 2021	Year 2020
Revenue				
Environmental Studies & Services Division	**15**	69,555,218	65,000,000	66,284,071
Geo Technical Engineering & Testing Division	**16**	221,030,070	259,750,000	157,524,997
Landslide Research & Risk Management Division	**17**	262,015,907	251,200,000	226,452,921
Human Settlement Planning & Testing Division	**18**	72,147,579	72,300,000	64,031,993
Building Material Division	**19**	46,784,101	50,750,000	35,505,706
Project Management Division	**20**	134,924,942	214,000,000	167,890,127
Total Operating Revenue		**806,457,817**	**913,000,000**	**717,689,815**
Other Income	**21**	53,809,691	30,000,000	53,654,050
Total Revenue		**860,267,508**	**943,000,000**	**771,343,865**
LESS - Expenses				
Salaries, Wages and Employee Benefits	**22**	406,993,732	511,021,322	454,787,074
Supplies and consumables used	**23**	269,483,120	304,692,350	235,814,360
Depreciation	**24**	60,338,586	8,000,000	6,478,138
Impairment of Property, plant and Equipment	**25**	17,251,255	14,546,765	13,065,378
Other Expenses	**26**	34,628,738	36,422,240	27,780,767
Finance Cost	**27**	110,640	5,000	48,482
Total Expenses		**788,806,071**	**874,687,677**	**737,974,198**
Net Profit before Tax		71,461,437	68,312,323	33,369,666
Income Tax		1,000,000	-	3,200,000
Net Profit after tax		**70,461,437**	**68,312,323**	**30,169,666**

Cash Flow Statement

CASH FLOW STATEMENT FOR THE YEAR ENDED 31.12.2021

Rs.

	2021	2020
Surplus / (Deficit)	**70,461,437**	**30,169,666**
Adjustments		
Depreciation	60,338,586	6,478,138
Provision for Gratuity	-11,629,401	17,539,828
Gratuity Payment	-7,316,420	-7,337,985
Under/Over provision for debtors	-103,971	1,520,492
Non exchange revenue	-18,958,377	-
unrealized Interest Income	-25,301,196	-46,168,030
Operating Surplus(Deficit)before working capital changes	**67,490,658**	**2,202,110**
Changes in working capital		
Increase in Receivables	20,427,822	-15,734,961
Increase in Receivable from Staff	2,115,818	17,654,105
Increase in Pre payments	83,972,193	21,865,065
Increase in Inventories	-928,844	555,606
Increase in Working In Progress	-79,493,510	187,895,293
Increase in Deposits	25,699,918	-5,408,259
Money Received from Client	196,617,192	-194,350,050
Increase in Sundry Creditors	-10,037,320	-22,331,949
Net Cash flows from operating activities	**305,863,927**	**-7,653,038**
Cash flows from investing activities		
Interest Income	1,956,880	46,168,030
Purchase of Fixed Assets	-192,724,849	-100,900,638
Disposal of Fixed Assets	10,000	23,268
Net cash flow from investment activities	**-190,757,968**	**-54,709,341**
Cash flows from financing activities		
Government Grant (Procurement)	8,445,694	11,611,914
Other Government Grants	10,512,683	28,746,841
Cash flows from financing activities	**18,958,337**	**40,358,754**
Net change in Cash and Cash equivalents	134,064,336	-22,003,625
Cash and cash equivalents beginning of the period	94,773,584	116,777,209
Cash and cash equivalents as at 31.12.2020	**228,837,920**	**94,773,584**
Note- Cash and cash equivalents		
Cash at Bank and hand	228,837,920	94,773,584
	228,837,920	**94,773,584**

Notes to Accounts

1. Accounting Policies.

Financial Statements have been prepared by Complying with generally accepted Accounting Principles, Fundamental assumptions, Public Sector Accounting Standards and Accounting Standards introduced by the Institute of Chartered Accountants from time to time and also by considering the followings.

(a) Going Concern

(b) Consistently Application of Accounting Policies.

(c) Revenue and expenses recognition on accrual basis.

(d) Disclosure to deviations to Standards

2. General Accounting Policies.

2.1 Depreciation Policies.

(a) Depreciation is provided based on number of days used

(b) Fixed assets are depreciated on Straight Line basis using the following rates.

Fixed asset type	%
Buildings	2.5
Machinery and Lab Equipment	20
Furniture & Fitting	10
Vehicles	20
General Office Equipment	20
Computer Hardware & accessories	20
Computer Software	20
Drawing Office Equipment	10
Tools	50
Library Books	5
Fire Extinguishers	10

2.2 Valuation of Closing Stock

Unutilized materials stocks have been valued at cost.

2.3 Provision for Gratuity

Provision for gratuity is calculated based on the Actuarial Valuation Method

2.4 Provision for doubtful Debtors

A provision has been made for doubtful debts on the basis of;

(a) 1 % Provision for debts outstanding over 2-10 years.
(b) 25 % Provision for debts outstanding over 10 years.

Human Resource /Capacity Development

NBRO's Vision and Mission were set to develop its capacity to cater the Ministry's DRR needs. With this in view NBRO is in the process of legalizing the institution mission by an act and developing staff capacities to deliver high standard outputs. Recruitment of new employees for essential vacant positions were not done in 2021. However, 18 employees resigned and 2 retired.

No	Salary / Code	Staff Category	Approved Cadre	Staff Available (Permanent)	No of Vacancies (Permanent)	Staff Available (Other Basis)
1	HM 2- 3	Senior Manager (CEO)	01	01	0	-
2	HM 1-3	Senior Manager	08	07	01	-
3	AR2	Senior Academic/ Scientist	25	17	08	-
4	MM 1-1	Middle Management	12	10	02	-
5	AR 1	Academic/ Scientist	124	101	23	51
6	JM 1-1	Junior Management	25	19	06	08
7	MA 2-2	Management Assistant (Tech)	36	28	08	09
8	MA 1-2	Management Assistant (Non Tech)	53	39	14	25
9	PL 1,2&3	Primary	102	79	23	44
	TOTAL		**386**	**301**	**85**	**137**

Recruitment, retirements & resignation of permanent staff in 2021

No	Sal/ Code	Staff Category	No of Recruitment	No of Resignations	No. of Retirement
1	HM 1- 3	Senior Manager (CEO)	-	-	-
2	HM 1-1	Senior Manager	-	-	-
3	MM 1-1/JM 1-1	Middle/ Junior Management	-	03	02
4	AR2	Senior Academic/ Scientist	-		-
5	AR 1	Academic/ Scientist	-	09	-
6	MA 2-2	Management Assistant (Tech)	-	04	-
7	MA 1-2	Management Assistant (Non Tech)	-	2	-
8	PL 1,2&3	Primary	-		-
	TOTAL		-	**18**	**02**

Risk Control Committee on Covid-19 pandemic

The Covid-19 outbreak has affected the smooth operation of NBRO activities and in addition, causing health impacts on its staff. NBRO implements a level of protection as instructed by the national health authorities. Director-General of NBRO appointed a committee comprising of 10 members from all staff categories to manage the situation and to minimize the potential impacts of Covid-19 on the NBRO functions while ensuring good health & safety at NBRO premises, its staff and the clients.

Staff training / attending workshops & seminars

NBRO carried out few training programmes for its staff due to the restrictions imposed by the Covid 19 pandemic. Two scientists were selected for Masters/ Ph.D programmes abroad as given below.

Foreign Training Opportunities in 2021

No	Name	Designation Division	Training Program	Period	Country
1	Mr. K A D S B Jayathilake	Scientist HSPTD	JICA Long Term Training (PhD) under SATREPS	1st April 2021 to 31st March 2024	Japan
2	Mr. E A S N Wimalawardena	Scientist Geologist	Master Program in Environment Science, degree programs in Life and Earth Sciences under JDS.	30th Sep. 2021 to 30th Sep. 2023	Japan

Procurement of equipment

The grant given by the General Treasury in 2021 to procure laboratory and field equipment for research for capacity building in NBRO was effectively utilized. Several major equipment including field accessories were procured under this grant. The key items are listed in the following table.

Division	Item/Equipment	Apprx. Cost (Rs. Mn.)
ESSD	Photometer	0.50
BMD	Portable concrete core drilling machine, Half-cell potential meter	4.00
GETD	T 200 Test Sieves and Field Equipment Accessories	0.84

Equipment received under SATREPS Project

Se. No	Name of Equipment/ Instrument	Amount (JPY Mn.)
1	Weather monitoring system	3.00
2	Monitoring system for landslides – (To be installed at Aranayake and Athwelthota Landslides) Automated inclinometers, Water Level Meters and Extensometers	5.30
3	Tensiometer measurement system	3.10
4	Landslide observation equipment	3.90
5	Forest rainfall measurement system	0.80
6	Ring Shear Apparatus (Landslide Simulator)	28.60
	Total	44.70

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