SCIENCE & TECHNOLOGY

POLICY FRAMEWORK ON RESEARCH AND DEVELOPMENT FOR PUBLIC CONSULTATION

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தேசிய மக்கள் சக்தி
JATHIKA JANA BALAWEGAYA (NPP)

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INTRODUCTION

Progress in advanced societies is driven by scientific findings and technological innovations. Sri Lanka's advancement in science and technology was held back by a lack of visionary leadership, time-sensitive goals, established priorities, a collective action plan and proportional investment.

Sri Lanka has allocated only 0.12% of its gross domestic product (GDP) for research and development (R&D), while countries that were similar in geo-political and economic stature to Sri Lanka, such as Malaysia, spent 1%, Thailand 1.2%, and Vietnam 0.42%. Furthermore, South Korea has allocated 4.6%, Japan 3.6%, USA 3.5%, and China 3% of their GDP, becoming world leaders in R&D today.

The science and technology policy serves as a guideline for enriching scientific and technological knowledge, allocating resources, and establishing regulatory framework for research and development. It reflects the government's motivation and commitment to using science and technology to drive industrial development and economic growth, while also achieving the overall human development within society.

Historically, Sri Lanka has attempted the implementation of science and technology through various initiatives, including the establishment of the National Science Foundation (NSF-1968), National Research Council (NRC-1978), Presidential Task Force (1991), Science and Technology Development Act (1994), National Science and Technology Commission (NASTEC-1998), and Coordinating Secretariat for Science, Technology and Innovation (COSTI-2013). These efforts have been accompanied by the introduction of multiple national science and technology policies.

However, due to the inadequate appreciation of the role of R&D in national development by political leadership, governments, and the public, the research has not significantly contributed to economic and social development as it should have been. Furthermore, the lack of leadership and authority in the R&D system, the absence of collaboration among research institutions, and the low participation of the private sector in research activities have further exacerbated the R&D efforts in Sri Lanka.

Despite Sri Lanka's economy relying on various export products and services, minimum efforts have been made to develop value-added products and services within those sectors.

Sri Lanka is rich in various natural resources, and through the application of R&D, these resources can be transformed into value-added products effectively at a low cost, yielding significantly higher profits in the international market.

These natural resources include highly biodiverse endemic fauna and flora with untapped medicinal value, geological resources (gems, minerals, mineral-based fertilizers, etc.), the surrounding sea of Sri Lanka, well-balanced soil and tropical weather suitable for year-round agriculture, consistent annual solar energy, wind power, and rivers and lake embankments with very high potentials for energy generation etc.

Sri Lanka is uniquely enriched with thousands of years old historical texts, stone scripts and belief systems as well as cultural and lifestyle practices. Applying cutting-edge R&D to study this Tacit Knowledge can

identify hidden, untapped, nature-friendly technologies and scientific practices, providing our own solutions to modern-day challenges.

In addition, Sri Lanka frequently suffers from infectious diseases like dengue, as well as chronic illnesses such as diabetes, cancer, stress, heart disease, and regional kidney diseases. The country also faces natural challenges, including frequent weather changes resulting in heavy rains, floods, landslides, droughts, coastal erosion, etc. Furthermore, issues like elephant-human conflicts, animal pests such as peacocks and monkeys, extinction of native wild animals and plants, the spread of wild and weed plants and insects in agricultural fields, and deforestation are prevalent. Scientifically planned R&D programs can resolve these economically important issues effectively.

The current "linear" education system in Sri Lanka fails to provide school or university students with adequate technical training and scientific research experience. Sri Lanka has long suffered from brain drain, which has recently escalated to extreme levels. Developing a supportive infrastructure conducive to R&D would enormously contribute to the retention of an educated population and potentially reverse the brain drain.

Educated Sri Lankan migrants have made substantial impacts in their host countries, showcasing the nation's immense human potential. Innovators are emerging even at the village level in Sri Lanka, but there are no mechanisms to harness their ideas and products and provide the necessary infrastructure for further development.

Application of R&D can transform unique systems like our traditional medical system to develop pharmaceuticals, supplements, and services (medical and nursing) and also transform the tourism sector into a well-developed industry.

A well-defined and empowered policy framework in R&D without any political and bureaucratic interference is necessary to effectively utilize the natural and human resources to transform as engines of economic and social development to uplift all Sri Lankans.

VISION

Innovation- and invention-driven research and development for economic prosperity, social wellbeing and environmental sustainability.

PRINCIPLES

- Duly support science and technology innovations by improving existing conditions, creating new opportunities or discovering new applications. Foster collaboration among scientists and institutions to mutually support research programs and share resources through the scientific exchange of knowledge, materials, and facilities.
- Encourage inventors to experiment with their novel ideas and develop new inventions.
- The Government is considered as the key role player in science and technology policy formulation, providing R&D infrastructure, funding, implementation and regulation.
- The private sector, the public, and the international community are also active participants in the R&D process.
- R&D directly contributes to establishing a productive and sustainable economy. The benefits are distributed equitably to the public.

- The R&D process is strengthened by a centralized administrative committee and a high-level research management institute, which apply, govern, and regulate the core principles of R&D. Additionally, a series of research management divisions are established to maintain the independence and free thinking of various research sectors.
- The entire R&D process is to be an independent and transparent mechanism, free from political and other bureaucratic interferences, and incorporate elements of equity, diversity and inclusion as universal guiding principles.
- Ensure fair opportunities for all stakeholders to participate in the R&D process through diverse grant funding pathways and transparent and impartial selection.
- Definitive funding allocation by the government budget for R&D activities that are on par or above nations of similar socio-economic stature.
- The research is conducted in accordance with nationally and internationally accepted ethical practices and applicable treaties.
- The researchers are educated, made aware, and held accountable for upholding the highest level of internationally accepted R&D standards.
- The natural resources are utilized sustainably for research with minimal environmental impact to preserve these resources for future generations.
- R&D in areas such as national security, economy, geopolitics, and state and foreign policy are considered as highly sensitive subject matters.
- R&D is utilized to improve physical and mental health, a data-driven education and decision-making, cultivate positive thinking, and develop competent human beings who are sensitive and responsible to society and the environment.

OVERALL GOAL

Leverage science and technology by establishing a well-structured R&D mechanism, harnessing the potential for innovation and invention to elevate Sri Lanka to a new "Renaissance Era”.

OBJECTIVES

- ◊ Bring cutting-edge scientific and technological knowledge to Sri Lanka and regularly incorporate new discoveries and technologies being developed worldwide.
- ◊ Produce value-added products and services via R&D to compete in the local and international markets.
- ◊ Facilitate the active participation of private sector investors, entrepreneurs, and industrialists in the R&D process.
- ◊ Apply intermediate technological solutions that rural people can purchase or construct from resources that are available locally to improve their well-being.
- ◊ Promote universities, industries and government linkages in conducting joint R&D.
- ◊ Facilitate "student-centred R&D experience" by improving basic infrastructure, including laboratories in schools, universities, technical colleges and other research institutes.

- ◊ Establish a "research- and investor-friendly" atmosphere by simplifying and streamlining procedures to minimize bureaucratic administrative obstacles and legal/court processes.
- ◊ Develop data-driven methods and systematic approaches to enhance scientific research and provide funding for school children, teachers, university students and faculty to engage in R&D.
- ◊ Provide facilities, incentives, and provisions to encourage Sri Lankan scientists to remain in the country, thereby preventing brain drain and enticing those who have left to return, facilitating reverse brain drain.
- ◊ Establishing series of state-of-the-art libraries around the country, featuring e-services equipped with modern technological advancements such as AI, providing access to the latest research findings, publications and educational materials across all disciplines.
- ◊ Apply R&D and innovative technological solutions to minimize the wastage of time on the road and in house holds providing an environment for the public to enjoy life.
- ◊ Communicate all research findings to the public and update this policy from time to time, based on the outcome of evaluations.

ACTIONS

The following six areas have been identified as priority areas for science and technology investment.

1. **Agriculture, fisheries, livestock, food security & safety sectors**
2. **Health, education, and science subject sectors**
3. **Information technology, communication, engineering, energy, maritime, transport and other technology-related sectors**
4. **Environment, land, water, air, and mineral resources sectors**
5. **Human development, art, history, culture and heritage sectors**
6. **National security, economics, geopolitics, public and foreign affairs sectors**

1

Agriculture, fisheries, livestock, food security & safety sectors

R&D in this sector includes rice and other grain types, vegetables and fruits, main plantation exports such as tea, coconut, rubber, along with other exports such as spices, cinnamon, pepper cardamom, etc. Also, research on plant tissue culture and genetic engineering, efficient transportation, packaging, storage and value addition of fruits, vegetables, grains, etc. Furthermore, R&D on fisheries and aquaculture, including marine, brackish and freshwater fishing, with control and sustainable use. The overall goals are to achieve food sovereignty and enhance agriculture and aquatic-related production.

- ◊ Identifying high-yielding crops and forage varieties with R&D focus on biotic and abiotic stress resilience and improving their crop management for local conditions to maximize production efficiency.
- ◊ Researching food processing and the development of value-added

products with the objectives of preserving food and generating income.

- ◊ Conducting research to identify appropriate crops and integrations for lands considering the agro-eco systems enhancing land productivity.
- ◊ Investigating methods for conserving forage and adding value through the production of hay, silage, and leaf meals.
- ◊ Researching reproduction and breeding by selecting high-yielding breeds of cows and adapting artificial insemination to suit extensive or semi-intensive systems.
- ◊ Conducting research into affordable housing, barn management methods, optimal dairy farm sizes, and suitable lands for small to medium-sized dairy operations.
- ◊ Performing farmer-centred research for crop diversification and beneficial management practices to boost productivity while minimizing environmental harm.
- ◊ Exploring methods to maximize agricultural productivity, improve carbon sequestration, and mitigate greenhouse gas emissions by transitioning to data-driven farming through the integration of modern technologies and Indigenous knowledge.
- ◊ Researching and identification of strategies for efficient management of agricultural inputs such as water, fertilizer, and agrochemicals while preserving the agricultural environment.
- ◊ Exploring controlled environment agriculture, including vertical farming and maximizing yield within limited land by digital agriculture interface assuring the product quality.
- ◊ Launching research to increase value addition of major export crops to maximize economic gains, ensuring sustainability and competitiveness in international markets.
- ◊ Applying modern genetics (reverse genetics, forward genetics,

genome edition, omics approaches) to produce various products (food, medicine, food supplements, agricultural applications) conserving protected species and plants.

- ◊ Exploring the impact of climate change on the sustainability and economic viability of major economic crops and developing strategies to enhance their resilience supporting local economies.
- ◊ Enhancing climate-smart crop management practices across various farming systems through the integration of precision farming technologies, sensor-based approaches, biocontrol strategies, and other innovative methods to ensure economic returns for farmers while prioritizing food safety, environmental protection, and productivity improvements.
- ◊ Conducting market and stakeholder research to identify and devise sustainable marketing strategies that protect the interests of producers and consumers.
- ◊ Exploring and inventing cost-effective, eco-friendly packaging materials, fabric, handicrafts, mats and bags, etc., by utilizing resources such as invasive plant species, agricultural waste materials, etc. (aquatic weeds, banana and pineapple plant wastes).
- ◊ Researching conservation agriculture and regenerative agriculture technologies through crop-livestock integration to promote sustainable farming.
- ◊ Exploring Indigenous knowledge and circular bioeconomy concepts in agriculture research to preserve ecological footprints.
- ◊ Performing socio-economic research to optimize government resources and agricultural infrastructure, aiming to boost economic growth and reduce fiscal burdens and to identify areas/sectors to be strengthened.

- ◊ Researching on export potential crops and new crops that are to be unveiled for the modern market (Eg. Anona, Moringa, Pandon, etc.).
- ◊ Initiating targeted research on fisheries and aquatic resources management to support the blue economy and achieving specific Sustainable Development Goals (SDGs).
- ◊ Integrating research efforts to address critical social aspects, gender dynamics, and enhancing business sustainability and profitability within the fisheries and aquaculture sectors.
- ◊ Applying novel technologies to developing sustainable and commercially viable advanced aquaculture production systems to increase unit production.
- ◊ Conducting research focusing on bioprospecting and developing value-added products from marine resources (living and non-living) such as drugs, cosmetics, nutraceuticals, etc., and developing aquatic biotechnology applications to reduce post-harvest losses.
- ◊ Conducting research to enhance the accuracy of identifying fish-rich areas, developing artificial fish aggregation devices (FADs) to boost fish populations, and exploring the feasibility of using new techniques such as drone technology for monitoring these areas and aquacultural farming.
- ◊ Advancing vessels and storage facilities with solar power, liquefied natural gas (LNG), and other hybrid technologies, and modernizing vessels and fishing methods to reduce fuel costs and post-harvest losses.
- ◊ Conducting research to promote sustainable tourism by developing activity-based alternative tourist destination maps and utilizing the aesthetic values of oceanic environments, terrestrial and aquatic biodiversity, and resources.
- ◊ Conducting research to explore aquaculture diversification, including exploring new species, enhancing native species,

diagnosing and treating fish diseases, improving brooders and brooder production, formulating feed and nutrition, enhancing the quality of local fishery products, and standardizing products.

- ◊ Performing experiments and designing new systems, to prevent intrusions and Illegal, Unreported, and Unregulated (IUU) fishing, including bottom trawling. This will enhance maritime security, stop/reduce IUU fishing and protect the marine resources in the waters of Sri Lanka.
- ◊ Assessing marine fish resources scientifically, developing prediction models, and determining the carrying capacity of freshwater and brackish water systems.
- ◊ Establishing a state-of-the-art research and monitoring centre equipped with advanced laboratory facilities to ensure the quality and safety of seafood production, meeting national and international standards and certifications.
- ◊ Conducting research on conservation and protection strategies for living aquatic resources, including captive breeding, tissue culture, gene banking, restocking, and relocating based on conservation status.

2

Health, education, and science subject sectors

This group includes R&D on infectious diseases (dengue, etc.), non-communicable diseases (chronic kidney disease - CKD, etc.), other diseases, dentistry, new diagnostic methods, drug development including Indigenous medical sector, microbiology, pharmacology, use of technology and artificial intelligence and health service management. Education sector research includes development of education policies, curricular, teaching-learning methods and facilities. In the science sector, molecular, nanotechnology, biological, chemical, nuclear, and physical science research are included.

- ◊ Applying cutting-edge scientific methods such as genomics, biochemistry, nanotechnology, metabolomics, proteomics, and AI to solve special health problems such as dengue, CKD, infectious diseases, other problems, etc. relevant to Sri Lanka.
- ◊ Assessing modern facilities to improve the local drug formulation process to protect drug safety by preventing substandard drugs from entering the local market.
- ◊ Establishing the capacity to enter the international market through the production of pharmaceutical ingredients, including active pharmaceutical ingredients (APIs).

- ◊ Assessing the cost-effectiveness of health/medical interventions for disease management.
- ◊ Investigating the effectiveness of locally available food supplements for improving the nutritional levels of children.
- ◊ Strengthening mobile clinics and screening facilities with modern technologies such as AI to prevent premature deaths and reduce healthcare expenses by facilitating early diagnosis of diseases like cancer, diabetes, heart attacks, etc.
- ◊ Developing equipment, tools, devices, smart phone applications and other software or items for improving the quality of patient care.
- ◊ Developing remote health services (Telehealth) to reach every citizen, saving patients' time and easy accessibility of all types of healthcare services, by integrating communication and information technologies with medical technologies.
- ◊ Conducting a nation-wide study on Indigenous treatment methods with the aim of scientifically documenting the findings.
- ◊ Developing marketable products such as medicines, nutraceuticals, food supplements, etc., utilizing Indigenous knowledge by establishing medicinal plant gardens, cutting-edge tissue culture and genetic engineering centres, and laboratories to target local and international markets.
- ◊ Conducting research to establish a collaborated health care system by merging traditional and western treatment practices.
- ◊ Conducting R&D in the dental sector to develop law cost dental care products, dentures, moulds, implantable devices, etc., and promote dental tourism.
- ◊ Leveraging international expertise in designing and implementing the newly introduced vocational education stream.
- ◊ Introducing data-driven curricular enhancements and fostering industry-academic partnerships to broaden next-gen employment opportunities.

- ◊ Providing mobile facilities such as laboratories, libraries/e-libraries and experimental kits to schools that do not have these permanent facilities to engage in their research activities.
- ◊ Integrating technology-based methods such as interactive apps and virtual learning platforms to promote research activities in rural/remote schools until the teacher shortage issue is resolved.
- ◊ Creating opportunities for promoting Science and Technology education by engaging in R&D activities, such as national and international conferences, seminars, science competitions, and presentations,as well as facilitating funding through grant mechanisms.
- ◊ Establishing university, industry and community organization partnership programs to develop curriculum and teacher training methods focused on real-world problem solving, inquiry-driven, integrative learning-based teaching practices.
- ◊ Developing and adapting technology solutions to enhance accessibility and support learning for students with disabilities in schools and higher education institutes, such as screen readers, speech-to-text software, alternative input devices, and special learning materials.
- ◊ Creating an integrated inter-industry production system by bringing together various resources utilizing Sri Lanka's biodiversity and natural resources. The R&D focus would be on pharmaceuticals, neutraceuticals (nutritional food supplements) and other commercial products, such as essential oils (perfumes), cosmetics, propagation of seeds and tissue culture products from plants that can add value to 'health-based' tourism and other industries (see Appendix 3).
- ◊ Conducting nanotechnology-driven research to promote products, such as solar cell technologies, electronics, pharmaceuticals, energy efficient inventions, environmental remediation components, and parts for future automobile and other machinery manufacturing.

3

Information technology, communication, engineering, energy, maritime, transport and other technology-related sectors

This sector includes R&D on topics such as digitalization, data science, information technology, and artificial intelligence (AI). It includes the development of both small- and large-scale technical equipment and the integration of technology into various sectors, such as automated machine and tool manufacturing, rural and small-scale industries, architecture, telecommunications, agriculture, medicine, maritime, transport, and energy (including fossil fuels, electricity, solar, and wind), among others.

- ◊ Conducting comprehensive research to build an 'Artificial Intelligence' (AI)-based large language model (LLM) for Sinhalese and Tamil languages that can be leveraged in public and private sector services and operations to reduce language barriers and create opportunities to effectively interact between different ethnic groups.

- ◊ Identifying current challenges faced by the government and private sector in Sri Lanka around Cyber security and related technologies and conducting research to address those challenges and prepare Sri Lankans for global competition.
- ◊ Conducting feasibility studies and discovery activities to leverage blockchain technology in secure transactional and record use cases like land registration, voting, and identity verification. Collaborate with industry partners to pilot solutions, enhancing transparency and security in Sri Lanka.
- ◊ Exploring studies to identify the Internet of Things (IoT), which can enable automation in many areas like municipal council operation automation, disaster management, homes, healthcare, smart electricity meters, and smart agriculture, driving advancements in sensors and data analytics.
- ◊ Initiating research and designing a comprehensive data governance framework and enabling data-driven business culture across private and public sectors for more accurate and sustainable economic growth across various sectors such as infrastructure, finance, healthcare, food & agriculture, energy, education, wildlife, climate and weather.
- ◊ Exploring feasibility studies and promoting 5G technologies to required areas in Sri Lanka and developing research initiatives to identify use cases where technology can improve efficiency and productivity, such as smart agriculture, telemedicine and remote healthcare, enhanced education (remote learning, virtual classrooms, and interactive educational content), industrial automation, public safety and emergency services, and tourism (virtual tours of historical sites, augmented reality guides, and real-time language translation services).

- ◊ Initiating research activities on sustainable IT practices, minimizing e-waste and environmental impacts and fostering a greener tech industry in Sri Lanka to contribute to global climate change mitigation efforts.
- ◊ Applying R&D to develop local standards pertaining to Sri Lankan conditions applicable to soil, sand, rock, brick, bitumen and other local construction materials aiming to reduce construction costs and minimize resource wastage, promoting sustainable engineering practices.
- ◊ Performing R&D and developing a set of standards and long-term plans for infrastructure development in various public construction projects to avoid wasteful and environmentally incompatible construction practices.
- ◊ Developing Sri Lankan building codes tailored to specific climate conditions, availability of local ingredients and other local factors and researching to improve these codes for maintaining the safety, economic efficiency and overall construction quality in the country.
- ◊ Developing a high-resolution weather and renewable energy forecasting system using machine learning and satellite data to optimize energy generation and enhance the resilience of Sri Lanka's electricity supply.
- ◊ Conducting a feasibility study to repurpose used EV batteries for energy storage and low-cost lighting, ensure safety through battery repair and reconditioning, develop necessary chargers and controllers, train local experts, and implement affordable lighting solutions.
- ◊ Setting up waste-to-power plants in urban areas and converting waste or biogas into electricity or heat within microgrid setups to bolster community self-sufficiency and encourage renewable energy adoption.

- ◊ Investing in R&D for innovative rooftop solar technologies, establishing local manufacturing for solar inverters and battery chargers, and promoting domestically manufactured products to support the anticipated GW-scale deployment of rooftop solar in the country.
- ◊ Investigating graphene-based battery and supercapacitor technology, leveraging Sri Lanka's graphite resources and mining capabilities to investigate potential benefits such as faster charging, higher energy density, and enhanced durability, with the aim of advancing battery technology.
- ◊ Evaluating small modular reactor (SMR) technologies comprehensively to understand costs, benefits, risks, and training needs while addressing public concerns through disseminating accurate scientific information to form an informed consensus.
- ◊ Developing minimum energy standards for buildings, implementing modern technologies like motion/light sensors and energy management systems while conducting research to develop and locally manufacture smart building energy control equipment tailored to local conditions.
- ◊ Developing offshore wind projects to reduce fossil fuel reliance and meet renewable energy targets.
- ◊ Researching cost-effective, eco-friendly solar panel production techniques and enhancing grid integration methods, including energy storage solutions, to optimize system design for better performance and reliability.
- ◊ Strengthening Sri Lanka's chemical sector by producing essential chemicals, such as sodium hydroxide, hydrochloric acid, and detergents, utilizing the chlor-alkali process and electrolysis of saltwater to generate key raw materials, promoting economic growth, reducing import dependence, and supporting sustainable practices.

- ◊ Establishing a task force with expertise in bigdata, machine learning, AI, community networking, and social media to investigate effective approaches to identify rural entrepreneurs with the necessary skills and expertise that can be developed into small industries, presentingi ntermediate technological solutions.
- ◊ Implementing several pilot Technology Development Centres in selected key districts. These would capture the current activities and resources of existing programs and examine the feasibility of providing an R&D infrastructure for rural industry owners and aspiring entrepreneurs. Areas to focus on include optimal packaging systems (canning vs bottling), effective preservation of degradable products (e.g. humidity control, desiccation and dehydration), information on intellectual property rights and procedures (i.e. patenting) and connecting grassroot producers with national and international market opportunities.
- ◊ Digitalizing and coordinating all modes of public transport from timetables to ticketing, well-suited for Sri Lanka through proper R&D applications.
- ◊ Improving and expanding the maintenance and modernizing public transport fleet with continuous local R&D applications.
- ◊ Modernizing bicycles for various applications and producing motor-driven bicycles through R&D, particularly for use in hilly areas and the construction of cycle lanes in main towns.
- ◊ Conducting research to ascertain the capacity gaps in the maritime domain, including prioritizing the Emergency Disaster Response and Preparedness perspective to support the ambitious goal of transforming Sri Lanka into the maritime hub in the region.
- ◊ Conducting research and establishing a permanent Maritime Emergency Response Collaborative Mechanism, incorporating all stakeholder agencies to coordinate actions related to marine accidents and protection of the marine environment.

4

Environment, land, water, air, and mineral resources sectors

This group includes R&D topics on forest & wildlife resources, air, water, land and noise pollution, development of surface and sub-surface water resources, water demand (domestic, irrigation, industry, environments) management, water pollution control and treatment methods, climate changes, sustainable environment and biodiversity conservation etc. Also includes R&D applications on land resources such as graphite, rock phosphate, dolomite, gems, clay, limestone, calcite, etc.

◊ Strengthening R&D funds needed by universities and other researchers to characterize Sri Lanka's biodiversity as 'hot spots' and nominate areas for enhanced legal protection. This would include habitat and vegetation mapping, and categorizing areas based on "risk" factors and land use threats.

- ◊ Sequencing the gene pool of endangered species and taking steps to conserve it.
- ◊ Conducting research to develop workable solutions to reduce conflicts with animals, such as using special frequency sounds, sensitive and flashing lights to deterrence, exploring bees to repel elephants and reducing animal electrocution.
- ◊ Strengthening research on catchment-scale vegetation and land use mapping with the latest tools, identifying knowledge gaps, and digitizing relevant data. Identifying areas for sustainable and ecological restoration and those requiring full protection to prevent deforestation, excessive land clearing and the degradation of watershed catchments, wetlands, streams and rivers.
- ◊ Applying R&D to improve water treatment capabilities, taking stock of existing water supplies and water treatment facilities, updating the standards of operational audits that deal with 'risks' to public health, augmenting the distribution system and reviewing and updating National Water Quality standards.
- ◊ Enhancing the mandates of relevant departments to research and address illegal discharges and pollution from hospitals and industries. Implementing scientific waste management methods to prevent environmental pollution and thereby protect sustainable soil and water resources.
- ◊ Developing a comprehensive air pollution monitoring and mitigation strategy to address the urban air quality degradation from industrial and vehicle emissions. Align Sri Lanka with global air quality standards and pollution reduction strategies by building capacity and addressing knowledge and data gaps.
- ◊ Researching on comprehensively mapping and protecting mangrove vegetation across the island by preventing excessive mining in coastal zones and applying modern engineering technologies to protect coastal zone degradation and seashore erosion.

- ◊ Conducting research to promote sustainable eco-tourism using biodiversity and other resources.
- ◊ Adding value to already identified minerals and manufacturing end products and other value-added products. Eg: Producing TiO2 from ilmenite and rutile using low-temperature methods such as autoclaving and introducing and researching on the production of welding rods, rubber, plastic paint, building materials, construction materials, and food industry paints, researching innovative graphite and graphene-based industries, manufacturing ultra-pure precipitated calcium carbonate from calcite for use in pharmaceuticals and many other industries, researching the application of apatite for other uses, manufacturing ultra-pure salt for medical purposes and salt for various industries, and using byproducts of the salt industry for other applications.
- ◊ Exploring and identifying minerals and mineral deposits by using advanced geological, geophysical and geochemical techniques like Airborne Magnetic Geophysical Surveys, geological mapping, and geochemical analysis. Eg. Exploration and research on serpentinite at Ussangoda, Indikolapelessa, Ginigalpelessa (Eg. nickel extraction), gold nuggets found in the Walawe River basin and the source rocks (gold deposits) of these gold nuggets, Seruwila Iron Pyrites ore for the extraction of copper and other noble metals like gold, Rare Earth Elements (REEs) and development of environmentally friendly and cost-effective methods for extracting REEs from ores, identify new gem deposits, and exploring the seabed and identifying minerals and hydrocarbons.
- ◊ Developing environmentally friendly and cost-effective methods for extracting and separating thorium and other rare earth elements from Beruwela monazite sands.
- ◊ Researching innovative applications in material science with ceramic raw materials and exploring new occurrences of ceramic raw materials with minimum environmental impacts.

- ◊ Researching sustainable practices for river sand mining, exploring suitable sand deposits, and investing in research to develop new and improved alternatives to river sand.
- ◊ Investigating natural disasters triggered by climatic changes with cutting-edge technology applicationsto mitigate losses. Collaborating with industry and public forums establishing a "Natural Disaster Management Strategy" tailored for expected extreme weather events during the next decade. This includes insurance schemes and special funding for disaster preparedness and response.
- ◊ Mapping flood zones and investigating correlations to manmade developments for sudden and extended flood occurrences and providing data-driven R&D solutions.
- ◊ Developing high-tech weather applications that can alert the public ahead of various types of natural disasters, such as storms, floods, tsunamis, landslides, etc.
- ◊ Conducting surveys and research on land degradation on higher and steep slopes, and research on increasing soil fertility and structure to prevent landslides.

5

Human development, art, history, culture and heritage sectors

This group includes applying modern R&D technologies to human development, fostering positive, critical and independent thinking, managing stress, and ultimately evolving into an efficient and sensitive human being. It also includes cultural enrichment, promotion, protection, turning various art forms into industries with R&D applications, mass media enhancements, unique ancient technologies and lifestyle studies, and overall human and social development.

◊ Planting the seeds of science, technology, entrepreneurship and humanitarian ideologies in the minds of young children at early ages systematically by organizing author visits to schools, reading inspirational contents/books (impactful biographies of scientists, tech entrepreneurs, humanitarians, etc.), and organize writing competitions, etc.

- ◊ Developing R&D-driven business solutions and entrepreneurship education programs to promote entrepreneurial skills and thinking among high school students.
- ◊ Developing daycare systems by introducing digitalized platforms, providing technology for parents via mobile apps, and launching further R&D on developing daycare as a proper profession.
- ◊ Conducting R&D on home-grown robotic programs or customizing already available humanoid robotic platforms to meet Sri Lankan requirements. Priority will be given to specific user cases for Sri Lanka itself like hospitality industries, elderly care services, and household automation tasks.
- ◊ Assisting the retired or elderly generation by developing modern electronic assistive devices, medication reminder systems, efficient pill dispensers, and telehealth systems and enhancing their independence and comfort by developing visual and communication aids, as well as memory aids, etc.
- ◊ Conducting socio-economic research on optimization of public resources and R&D infrastructure to ease public fiscal burden while enhancing human development.
- ◊ Applying proper R&D to produce drums and other musical instruments, dance costumes, etc., that are resistant to different climates targeting the international market.
- ◊ Incorporating modern technologies through R&D into performing arts such as music, singing, dance, drama, opera, and cinema while preserving their originalities and establishing all these sectors as profitable industries in Sri Lanka.
- ◊ Inviting world-renowned artists, technicians and producers from Hollywood, Bollywood, etc., and conducting research workshops to enrich local artists, technicians and producers and encourage experimental creations via international collaborations.

- ◊ Increase capacities of National Archives through strengthening the use of new technology, including AI, for establishing an efficient system of Archives and public records management.
- ◊ Conducting research at the national level to identify ancient technological advances and practices described in ancient books, beliefs, cultures and lifestyles.
- ◊ Performing appropriate content analysis, surveys, focus group experiments and participant observations for communication sources, including standard electronic and print media, and improving standards of communication effectiveness.

6

National security, economics, geopolitics, public and foreign affairs sectors

These areas are deemed highly sensitive, conducting research essential to national interests. Adequate facilities, infrastructure, and extensively trained human resources will be allocated to undertake R&D in these fields.

IMPLEMENTATION & REGULATION

To ensure effective implementation of the R&D policy and its activities, following institutional mechanisms will be established while enhancing the productivity and efficiency of existing research institutes.

◊ A meritocratically selected, high-powered **"National Research Development and Management Committee (NRDMC)"** for decision-making, policy formulation, monitoring and regulation of the entire national R&D process and associated organizations.

◊ A centralized institute called **"National Institute for Research and Development - NIRD"** and a group of Research Management Divisions **(RMDs)** within **NIRD** to cover various research-related subject areas, align with each of the ministries and their existing research institutes, making the bridge between the central R&D mechanism and ground level R&D community.

Stakeholders in science and technology policy

I. The government,

II. Research institutes, high-tech “incubator” facilities, universities and technical colleges,

III. Private sector (investors, entrepreneurs, manufactures, and industrialists),

IV. General public,

V. The International partners.

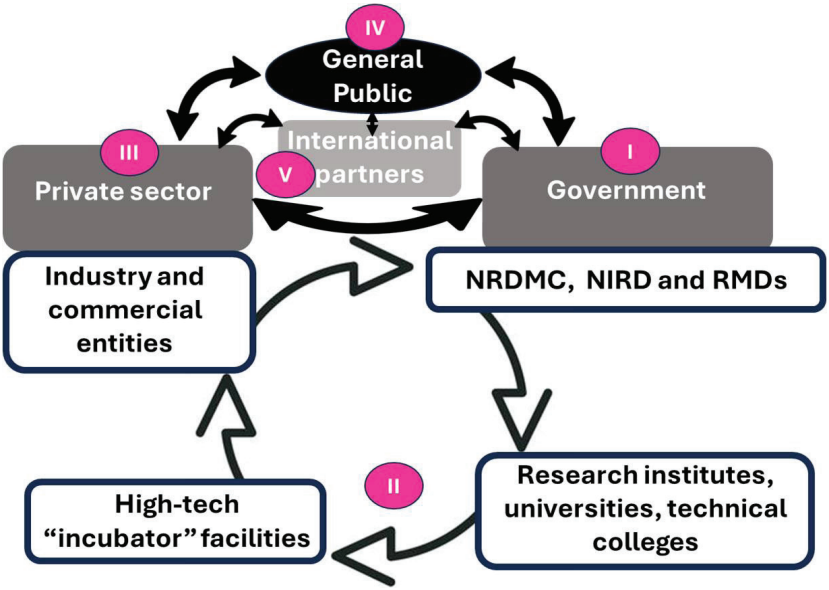

Figure 1: The inter-connection between stakeholders.

The Figure 1 illustrates the interconnection between the R&D stakeholders. The government initially establishes the infrastructure and provides funding through **RMDs** for the R&D process. Proof-of-principle research is carried out by universities, technical colleges, and other research institutes, leading to the creation of sector-specific prototypes. High-tech "incubator" facilities then bridge the gap between the prototype and final products by conducting "de-risking" research. With reduced risk, private sector industries and commercial partners can take over the development of value-added products and services for commercialization in the local and international markets (The private industry, if they wish, should have no restrictions in participating in the entire process from the beginning as well).

Funders and resources for R&D

I. The government,

II. Private sector (investors, entrepreneurs, manufactures, and industrialists),

III. International grants, project funds, aids, and loans,

IV. Natural resources,

V. Creative human resource.

Specific mechanisms for securing R&D funds for the government

1. **Funding agencies, aids, donations and inter-governmental collaborative agreements:** Local and international agencies and philanthropic donations. Also, inter-governmental collaborative agreements for funds.
2. **Bonds:** Issuance of bonds focusing specific R&D projects.
3. **Accumulated earnings:** Income from self-sustainable government research institutes.
4. **Fees from products and service exports:** Operating a revolving fund from value-added products and services initiated from R&D applications.

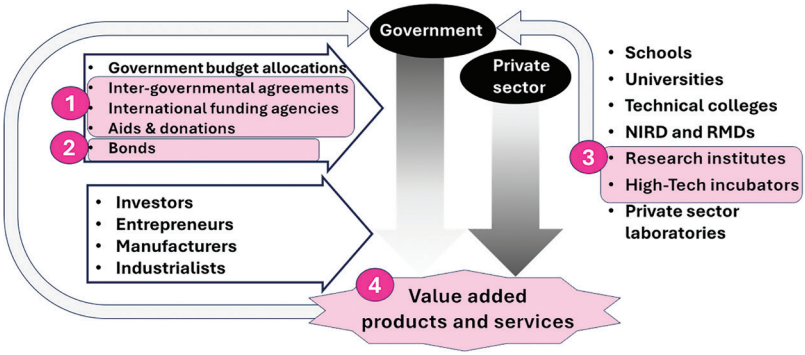

Figure 2: Overall R&D flow chart with various participants and mechanisms for the government to find funds for R&D projects are highlighted: (1) early-stage aid from various sources, (2) bond issuance (3) self-sustainable government research institutes, self-profits through high-tech institutes, and (4) Fees earned from final products and services exports.

Strategies to bring cutting-edge scientific and technological knowledge to Sri Lanka

- ◊ Develop specific and practical plans to leverage the knowledge and experience of internationally trained Sri Lankan scientists. This includes utilizing online telecommunications while they reside abroad, organizing in-person programs during their visit to Sri Lanka, and offering attractive packages to encourage them to return and resettle permanently (reverse brain drain!).
- ◊ Provide necessary facilities to Sri Lankan scientists to acquire new knowledge through advanced technologies such as AI and provide scholarships for them to get international trainings.
- ◊ Organize international conferences, workshops, and other research-related programs in Sri Lanka, attracting distinguished international scientists and potential investors.
- ◊ Develop government-initiated R&D collaborations with international governments, institutes and researchers with support from Sri Lankan embassies in those countries.

Responsibilities and roles of key stakeholders

(I) The government, NRDMC, NIRD and RMDs

The government of Sri Lanka will take the lead in science and technology policy implementation. The **NIRD** will serve as the central government organization for the management of the national R&D process, and the **NRDMC** will oversee the policymaking, funding, implementation and regulation.

NRDMC consists of an expert panel that includes experienced scientists representing all major disciplines, experts in law and intellectual property, vice-chancellors and/or university representatives, research institute representatives, successful business and industry representatives, economists, and secretaries of the Ministry of Science and Technology,

the Ministry of Finance and relevant ministries.

Key Roles of NRDMC

- ◊ Advise the government on science and technology potential and applications in domestic and international affairs.
- ◊ Create, implement, regulate and periodically renew science and technology policy.
- ◊ Prepare research priorities based on the national need, while taking practical steps for R&D that are compatible with government budgets.
- ◊ Conduct a final administrative review of grant funding applications (see Appendix 2) and recommend funding via **RMDs**.
- ◊ Work closely with the private sector, civil society organizations and the public to ensure that government investments in science and technology contribute to social wellbeing, economic prosperity, and environmental sustainability.
- ◊ Support researchers to secure intellectual property (IP) protections by acquiring national or international patents for their inventions.
- ◊ Build strong collaborations between other countries and scientific communities.
- ◊ Ensure to identify and fund all potential innovators irrespective of their education levels, social recognitions, age or gender differences by maintaining equity-diversity-inclusion.
- ◊ Inform the Minister, the Prime Minister and the President about all R&D projects and progress in the country.
- ◊ Prepare and publish a comprehensive annual report on the impact, scale, quality and effectiveness of government investments in the field of science and technology. In this report, the shortcomings of the previous year are pointed out, and advice on corrective measures is provided.

◊ Directly advise the government and the President regarding the resolution of problems related to all science and technology concerns of the country.

Responsibilities of NIRD

◊ Manage and regulate all science and technology research in Sri Lanka as the centralized R&D governing body.

◊ Distribute government funds to **RMDs** as required, and regulate all projects done through various research institutes under each of the **RMD**.

◊ Conduct specific R&D on economy, national security, geopolitics, public and foreign affairs as highly sensitive subjects, advise and inform the government on domestic and international affairs, economics, national security and regional political trends.

◊ Implement systems to identify innovators across Sri Lanka and develop mechanisms to transform their innovations into value-added products and services for commercialization, employment generation, and economic well-being.

◊ Inform the government officials and the public about all activities through official publications, publicity programs, annual reports and conferences.

Responsibilities of RMDs

◊ Supervise and regulate research in all existing research institutes in Sri Lanka, including evaluating project progress, auditing fund expenditure and reporting.Prepare progress reports and inform **NRDMC** and **NIRD**.

◊ Serve as the bridge between the central R&D mechanism and each of the corresponding ministries to fulfil the R&D requirements of each of those ministries.

◊ Identify R&D priorities in consultation with each of the ministries

and announce 'Requests For Applications' (RFAs), which is a formal statement from RMD that asks for grant funding applications in a specific scientific area.

- ◊ Review the scientific merits of applications in the firstlevel as described in Appendix 2 (grant review) and recommend selected applications to **NRDMC** for the second-level administrative reviews.
- ◊ Distribute government funds to applicants and institutes recommended by **NRDMC** after the second-level review.
- ◊ Obtain annual, semi-annual, quarterly, and final reports of all project reports, including accounting and take necessary actions against researchers and institutes that don't adhere to set rules and regulations.
- ◊ Build and support inter-institutional collaborations for research, such as arrangements for using facilities, equipment, machinery, or services in between institutes.
- ◊ Organize local and international conferences related to the subject matter of the **RMD**.
- ◊ Mediate and solve problems faced by researchers and provide timely assistance.

Administrative structure of science and technology policy

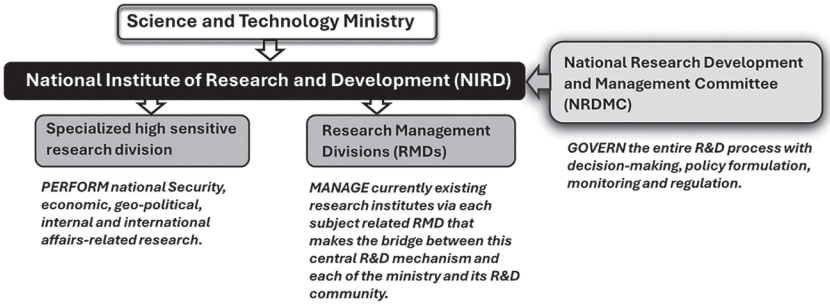

Figure 3: Administrative structure of the entire R&D mechanism under the Science and Technology ministry. **NIRD** functions as the central body of the government R&D control, and high-level **NRDMC** oversees policy

formulation, implementation, and regulation. **NIRD** is again divided into two main divisions: (1) specialized high sensitive research division and (2) Research Management Divisions (**RMDs**).

(II) Research institutes, high-tech "incubator" facilities, universities and technical colleges

Current research institutes:

Sri Lanka has numerous research institutes scattered under various ministries. Although these institutes have been undertaking multiple scientific research for many years, their results barely translate into tangible products, processes, or services that impact the country's social and economic development.

Each institute is closely aligned with its respective ministry and political culture, with the ministry responsible for R&D having limited oversight of research activities across other ministries. Many institutes suffer from inadequate funding and staffing, limiting their capacity to fulfil their mandates. Additionally, the lack of regulations further hampers their productivity.

To address these issues, the existing research institutes will be brought under proposed **RMDs** based on specific subject areas. A detailed survey will be conducted to assess the capacities, facilities, staffing levels, output and efficiency of the current research institutes.

The research institutes that function efficiently will further be strengthened. Currently dispersed but similar research institutes will be consolidated, and resources will be reallocated based on the performance and significance of the institutions.

State-of-the-art basic facilities will be established in non-overlapping areas. To better serve the research community, scattered facilities and equipment will be classified and consolidated into core facilities under each subject stream.

Additionally, new high-tech research institutes ("incubator" facilities)

and research parks will also be established in the future, with gradually increasing funding allocations over time (see Figures 1 and 2).

Universities and technical colleges:

Universities, technical colleges, and other post-secondary educational institutions play a vital role in shaping science and technology policy. However, compared to developed countries, there is less research participation among key individuals such as professors and investigators.

While many want to actively engage and participate in research activities, they lack facilities, funding, collaborations, and overall supportive mechanisms to develop a research culture, leading to a waste of talent and brain drain.

Under this policy, all the universities, technical colleges and other post-secondary educational institutions will be provided with the necessary infrastructure for research, and key researchers will be supported with various funding sources as described in Appendix 1, and collaborative research opportunities.

(III) The private sectoras investors, entrepreneurs, manufactures, and industrialists

The private sector plays a vital role in the economy, contributing to job creation, the provision of goods and services, and stimulating economic growth. It also serves as an important source of tax revenue for the government. Collaborating with the private sector to garner their support for R&D initiatives not only bolsters the country's economic growth but also nurtures their own progress.

Initially, the private sector investment in R&D in Sri Lanka may be limited due to the perception of high risk and uncertain returns.

However, once they understand how value-added products and services can enhance their profitability and offer additional benefits such as

tax incentives, low-interest loans, and access to advanced research infrastructure, their involvement is likely to increase.

Encouraging private sector investment requires increasing returns, reducing risk, addressing institutional barriers, and eliminating unnecessary political interference.

As described above, government initiatives to provide funding and infrastructure for R&D can catalyze private sector involvement. By leveraging intellectual property generated mainly from government-funded research, the private sector, including investors, entrepreneurs, manufactures, and industrialists, can develop final products (see Figures 1 and 2).

Recognizing the private sector as a key partner in Sri Lanka's R&D landscape efforts will be made to incentivize their participation at any stage of the R&D process. In particular, the government will implement targeted programs to attract international investors for mega R&D projects by providing them with various concessions.

The private sector can provide specific funding to government research institutes, universities and other research institutions to carry out their specific research through mutually beneficial contracts. Additionally, funding can be allocated to train postgraduate research students who can contribute to private sector endeavours in the future.

Furthermore, the private sector can contribute to the establishment of high-tech research labs through direct funding, donations and corporate social responsibility (CRS) initiatives.

(IV) The public sector and the creative human resource pool of Sri Lanka

According to the World Bank's Human Capital Index, children born in Sri Lanka today only reach 60% of their potential as adults, highlighting a concerning situation.

To improve the human capital potential, the government plans to

launch programs, with support from the private sector, focusing on scientific research and studies. These initiatives will begin in infancy and childhood, aiming to fully leverage potential in youth and adulthood.

Apart from educators, scientists, researchers and technologists, essential for R&D activities in modern laboratories, harnessing the human potential of the general public and actively involving them in the overall R&D ecosystem is crucial for the country's development.

Public participation in research can occur either 'with' or 'by' the public. Especially in a country like Sri Lanka, the general public can directly contribute to national R&D efforts by providing researchers with important information on indigenous medicine, agriculture, archaeology, cultural heritage, ancient lifestyles, ecology, geology and more. They can also directly engage with such research activities in various capacities.

Special grant funding mechanisms such as Public Research Grants (see Appendix 1) are proposed to support public innovators, including individuals from rural areas to develop their ideas into marketable products via R&D.

Furthermore, establishing strong and understanding partnerships between research teams and the public, for example, patients, such as in clinical trials or other survey studies, can lead to mutually beneficial outcomes.

Recognizing the values of R&D itself would significantly improve the livelihoods of the general public, as many everyday challenges can be handled and resolved via simple R&D applications by individuals.

(V) The International partners

In the contemporary world, there is growing recognition of the potential of innovative researchers in developing countries, and there are increasing opportunities for them to receive international funding through collaborations.

Developed countries with fewer natural resources are interested in contributing to research in underdeveloped countries with rich natural resources to meet their needs. In this background, state-level programs will be implemented to take maximum advantage of these trends while protecting our rights and natural environments.

The primary objective is to engage international organizations and countries to secure donations, grants, funds and investments to support Sri Lanka's R&D efforts.

Also, mechanisms will be developed for international experts in specific research fields to provide state-of-the-art knowledge through visits, remote seminars and workshops, mentorship and training opportunities for young researchers in Sri Lanka. Exchange programs for technicians, students and faculties can also be arranged with foreign countries to benefit both parties.

The establishment of strong collaborations can lead to the procurement and access to high-tech instrumentation at low cost or through donations.

The government will directly and actively be involved in securing and regulating such opportunities through transparent, established programs via Sri Lankan embassies in developed countries, and by engaging Sri Lankan scientists abroad and the diaspora communities.

Science and technology policy monitoring and regulation

As previously outlined, the entire process is overseen and regulated primarily by the **NIRD** under the guidance of **NRDMC**.

All the grant funding types described in Appendix 1 are rigorously regulated from the application to the final completion step, as described in Appendix 2.

During the research project, annual, semi-annual or quarterly reports, along with the final report containing results and accounting details, must be submitted to the relevant **RMD** within three months. Failure to provide these reports will result in the withholding of funds for the subsequent quarter at any stage of the project.

For all funded grants, (I) the applicant researcher (i.e. Principal Investigator- PI) and (II) the applicant institute are subjected to a legal obligation (contract) to conduct the relevant research dutifully. Breach of such agreement will have legal implications and may impact future funding prospects for the researcher and/or the institution.

The regulation also includes the proper development of trust, reliability, high-quality products and services and, thereby the establishment of brand names in international markets.

The government, **NRDMC, NIRD** and **RMDs** bear responsibility for regulating the entire R&D process in compliance with international laws, treaties, and regulations, as well as ethical and human standards.

APPENDICES

Appendix 1. The government research grant fund types for R&D

(1) Research grants: These grants are given to postgraduate researchers in universities or higher-level public or private research institutes for their specific research projects.

- ◊ **Basic Research Project Grant Awards:** Awarded for 3-5 years for specific, discipline-specific research projects that have already demonstrated success with preliminary data.
- ◊ **Exploratory/High-Risk-High-Reward Research Grant Awards:** These grants encourage new, high-risk, exploratory and developmental research projects by providing support for the early stages of project development. They are given for 1-2 years and can be used for pilot and feasibility studies.
- ◊ **High Priority, Short-Term Project Awards:** These funds are for high-priority needs, such as under pandemic situations.

(2) Program projects/Center grants:

- ◊ **Core Center Grant Awards:** Support for funding, resources, and facilities for research by several investigators by linking different institutions in the public or private sectors, in different disciplines, that provide a multidisciplinary approach to a joint research effort or focus on a common research problem.

(3) Individual or research training grants:

- ◊ **Pathway to Independence Grant Awards:** These funds are for innovative young graduates and outstanding investigators who are striving to become independent researchers in the basic, translational or clinical research fields.

◊ **Project Training Grant Awards:** Individual grants to provide additional training in specific research areas. These can be used for training within Sri Lanka or abroad.

(4) Undergraduate specific grants:

◊ **Undergraduate Grant Awards:** This is a grant mechanism to support high-level research projects for special degree students as well as other undergraduate students.

(5) School-level research grants:

◊ **School Teacher Training Grant Awards:** Funds required for special training of science teachers to promote the use of science and technology at the school level.

◊ **School Children Project Grant Awards:** Small grant funds for highly talented school children to test their innovative ideas at the school level.

◊ **School Science and Technology Project Planning Grant Awards:** Funds for organizing school-level science competitions, exhibitions, workshops and conferences.

(6) Public Research Grants:

◊ **Small Business Innovation Research Grant Awards:** Intended to stimulate private sector technological innovation by supporting R&D to for-profit organizations on ideas with potential for commercialization.

◊ **Public Research Grant Awards**: These funds are a more open mechanism to provide funding for public research applicants who are not high-level graduates but qualified by experience and do not require established research infrastructure such as laboratories to perform their R&D.

Appendix 2. The government research grant fund distribution mechanism for R&D.

Government funding is provided for research and development in two main ways:

1. Direct funding to public research institutes.
2. Providing various types of grant funds (as described in Appendix 3).

Mechanism for distribution of government funds (grants) for research and development

Eligibility of grant applications is reviewed in two stages:

1. Scientific merit review: This independent scientific review is conducted by independent reviewers/subject matter specialists. These panels are appointed, and confidential reviews are administered by **RMDs**.

   The reviewers will provide an overall impact score based on 5 factors:

- ◊ Significance for society and the country.
- ◊ Innovation potential.
- ◊ The merit of the research proposal.
- ◊ Investigator's qualifications (special attention will be paid to young scientists and early career researchers).
- ◊ Facilities and resources of the institution or laboratories (if applicable).

2. Administrative review: The second level review is conducted by the **NRDMC** at **NIRD**. Here, the applications recommended by the first-level committee as subject-wise superior are again subjected to a scoring classification according to state and time priority requirements. Thereafter, grants will be made to the highest-scoring applications in both of the above steps.

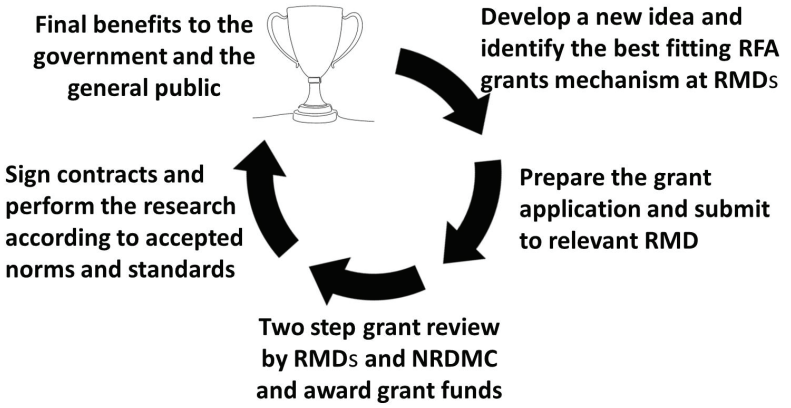

Figure 4. The government research grant fund distribution mechanism for R&D.

Appendix 3. An example of how R&D in one field applies to multiple different industries.

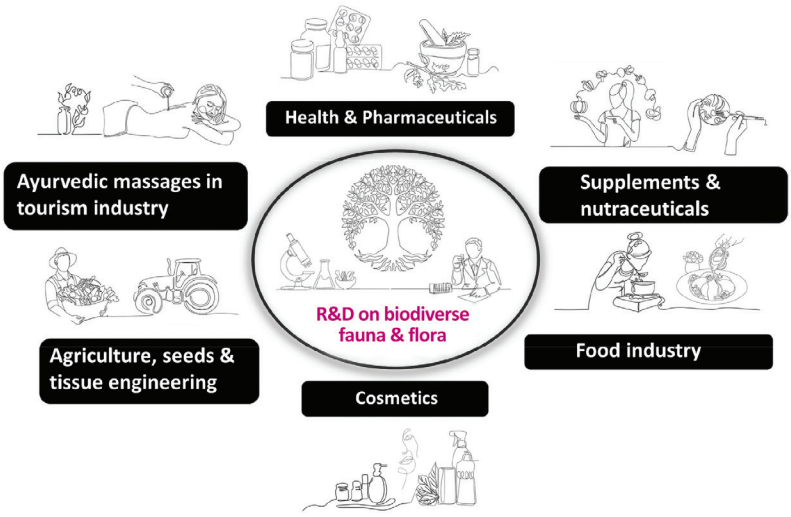

Figure 5: An example of how the development of new value-added products and services through R&D using natural plant and biochemical resources spans through multiple industries.

QUANTUM LEAP

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