



# Performance Review of Rubber Research Institute of Sri Lanka

---

**2017-2020**

## The Review Team

**1. Dr. I J de Zoysa (Chairperson)**

*Plant Pathologist*

*Former Director General of Department of Agriculture*

**2. Dr. M T K Gunasekera (member)**

*Biotechnologist*

*Former Head of the Plant Breeding Division, Tea Research Institute*

*Agribusiness Specialist of World Bank Project on Agriculture Sector Modernization*

**3. Mr. A.A.M.T. Adikari (member)**

*Senior Deputy Director*

*Industrial Technology Institute*

## Abbreviations

AEU	Agricultural Economics Unit
ASD	Advisory Services Department
ARU	Adaptive Research Unit
AV&IT	Audio Visual & Information Technology
B & PD	Biochemistry & Physiology Department
BU	Biometry Unit
CRTA	Colombo Rubber Traders' Association
EDB	Export Development Board
EO	Experimental Officer
FEASC	Finite Element Analysis and Simulation Centre
GPBD	Genetics & Plant Breeding Department
HOD	Head of Department
ID	Information Dissemination
IDB	Industrial Development Board
M&E	Monitoring & Evaluation
MPIE	Ministry of Plantation & Export Agriculture
NR	Natural Rubber
NASTEC	National Science & Technology Commission
PA	Planters' Association of Ceylon
PCD	Polymer Chemistry Department
PP & MD	Plant pathology & Microbiology Department
PPP	Public-Private partnership
PRISL	Plastics and Rubber Institute of Sri Lanka
PSD	Plant Science Department
RDD	Rubber Development Department
RDO	Rubber Development Officer
RMP	Rubber Master Plan

RO	Research Officer
RPC	Regional Plantation companies
RRB	Rubber Research Board
RRP&CED	Raw Rubber Process Development & Chemical Engineering Department
RPD&SC	Rubber Products Development and Services Centre
RR & CAD	Raw Rubber & Chemical Analysis Department
RRISL	Rubber Research Institute of Sri Lanka
RT & DD	Rubber Technology & Development Department
S & PN	Soil & Plant Nutrition Department
SR	Synthetic Rubber
SLAMERP	Sri Lanka Association of Manufacturers and Exporters of Rubber Products
SLRS	Sri Lanka Rubber Secretariat
SRI	Sri Lanka Society of Rubber Industry
TT	Technology Transfer

## Acknowledgements

The Review team wishes to thank the Chairperson and the members of the Rubber Research Board, Additional Director, Deputy Directors, Heads of Departments, Heads of Units and staff of RRISL for making necessary arrangements to conduct this review. The arrangements were quite good and staff members were highly supportive and necessary information were made available as requested. Special thanks are due to DDR (Biology), Dr. P Seneviratne who coordinated and facilitated this review excellently from RRISL end.

We would like to acknowledge the support of Rubber Research Board members (specially Dr. LMK Tillakeratnae), Secretary General/ Sri Lanka Rubber Secretariat, Director/*Thurusaviya* Fund, Secretary General/ Planters' Association, Director General/ Sri Lanka Association of Manufacturers & Exporters of rubber products, Rubber nursery managers, representatives of rubber smallholders, estate managers, manufacturers and University Academia by providing feedback to our questionnaires and attending the virtual meetings *via* Zoom app. technology.

Finally, the Review team wishes to thank the Acting Director Dr. Nazima Ahamed, NASTEC for inviting us to carry out this review and Mrs. Rasitha Perera, Scientist, NASTEC for excellent coordination between NASTEC, RRISL, Stakeholders and the Review team and making arrangements to conduct this review successfully and organizing virtual meetings when normal meetings were not allowed due to travel restrictions imposed with the Covid-19 pandemic situation prevailing in the country.

## Table of Contents

The Review Team.....	2
Abbreviations.....	3
Acknowledgements.....	5
List of Annexures .....	7
1. Introduction.....	8
2. Purpose of Review .....	15
3. Procedure Adopted for Performance Review .....	16
4. Management Assessment.....	188
4.1. Institutional response to external and internal environment in planning organizational strategy .....	188
4.2. Planning S & T Programs and priorities.....	255
4.3. Planning S & T/ R & D Projects.....	311
4.4. Project management and maintenance of quality.....	344
4.5. Human Resource Management .....	38
4.6. Management of organizational assets .....	43
4.7. Coordinating and integrating the internal functions/ units/activities.....	47
4.8. Partnership in managing information dissemination .....	51
4.9. Monitoring, evaluation and reporting procedures .....	566
5. Output Assessment .....	60
5.1. Technologies developed and transferred to industry / entrepreneurs .....	60
5.2. Information Dissemination / Extension .....	62
5.3. Research Publications .....	63
5.4. Patents .....	63
5.5. Services (Testing, Calibrations, Consultations, Advisory and etc.) .....	64
5.6. Trainings.....	64
6. Overview of the Institution’s performance and contribution to national development .....	67
7. Outcomes of Stakeholders meetings/ replies for questionnaires .....	711
8. Overall Judgment on Different Aspects & Recommendations for Improvement.....	755
9. References.....	833
10. Annexures.....	85

## List of Annexures

1. SWOT Analysis
2. Technologies developed
3. Technologies transferred to industry/ entrepreneurs
4. Services of RRISL
5. Collaborative projects of Technology Departments
6. Financial Progress of different Departments
7. No. of Scientific staff
8. Publications
9. Trainings for staff on new and emerging technologies
10. Trainings for stakeholders
11. Questionnaires given for obtaining views of different stakeholders
12. Schedule of Visits and Virtual Meetings held by the Review Team

## 1. Introduction

### Rubber Industry in Sri Lanka

Rubber production in Sri Lanka commenced in 1876 with planting of 1919 seedlings at Henarathgoda Botanic gardens, Gampaha introduced by Henry Wickham from a collection of seeds from Amazon, Brazil which were first propagated in the nurseries of Kew Gardens, England. Another set of germplasm, also from Amazon were planted in the Royal Botanic Gardens, Peradeniya by R M Cross, some of which are still available at both places. (Personal communications, Dr.S.Wijesundara, former DG and Dr. S. Krishnaraja, present DG, Dept. of Botanic Gardens). With the performance of those plants, Sri Lanka was selected as the most suitable site for propagation and distribution of rubber plants to the other countries in the region. Rubber crop was given high priority in colonial era and the extent increased mainly to export raw rubber and export earnings were ranked second only to tea. Rubber industry had been a key pillar of the Sri Lankan economy over one and half century and its significance has not diminished. Rubber is a renewable resource based industry with global linkages which sustains thousands of rural people.

The total extent under rubber increased gradually and in 1928 it reached up to 230,000 ha; however, in 1982 that was around 180,000 ha and annual production was 125,000 tons. Rubber extent declined further and that was fluctuated during 2017 – 2020 to from a mere 136,800 to 138,300 ha and total annual production from 83,200 tons. to 78,200. From the inception, seedling rubbers were planted but at present grafted plants accounts almost 100% of the cultivation. Productive plantations are around 70% of the total extent. Small holders (*ie.* land extent less than 8 ha) occupy large portion of the total extent which is around 85,000 ha. (64%) and their productivity surpasses that of the larger estates by over 20%. Estate sector owns 46,000 ha (35%) and 1600 ha (1%) belong to Government companies.

National productivity is one of the lowest in the region, being 774 and 667 kg/ha/year in 2018 and 2019 respectively. Some South-East Asian countries who entered the Natural Rubber (NR) production much later, are far ahead of us and obtain 1400-1700 kg/ha annually. Moreover, Sri Lanka was at the fourth place as a NR producer of the world in 1960s, has now fallen to 12<sup>th</sup> position.

Application of new technologies including using of improved high yielding RRISL clones is lacking, especially in small holders sector, due to poor extension services. Shortage of labour, especially skilled rubber tappers and low productivity of the tappers, high cost of managing young plantations till they become tappable age are some other constraints. However, this sector provides employment for around 200,000 persons; of them 40% are females.



The traditional rubber growing Districts are located in the Wet Zone include Colombo, Gampaha, Kalutara, Kandy, Matale, Galle, Matara, Kurunegala, Ratnapura and Kegalle. The highest density of plantations is concentrated to a triangle called a ‘Mega Zone’ consisting of Kalutara, Rathnapura and Kegalle Districts. Rubber is also grown in non- traditional Districts such as Monaragala, Hambantota, Ampara, Vaunia and Mulaithivu, where around 40,000 ha have been identified and research are being undertaken to find out feasibility of the cultivations where land and labour availability is comparatively high. Research results so far revealed that extreme dry climate was not very suitable for rubber due to high seedling mortality resulting in poor stand establishment. The quality of latex is high in plants in the Intermediate Zone.

Sri Lanka produces all types of raw rubber, viz., ribbed smoked sheets (RSS), crepe, technically specified rubber (TSR), latex concentrates and specialty rubber. At present 60% of the rubber produced are used locally by manufacturing sector which had grown well (7% growth annually) in the recent past. This resulted in increase of local demand for raw rubber steadily and in 2018 and that was around 130,000 tons while 76,000 tons of natural as well as synthetic rubber were imported to bridge the shortfall. Export revenue earned in 2018 was US \$ 01 billion, contributing to 5% of the total export earnings of the country, which accounts only 0.25% of the global market share.

The bulk of the value added export volume comprises industrial solid tyres, tubes, rubberized tracks, surgical & other gloves. There is a huge potential for increasing our share in the global market as it is expected to grow with the needs of the industries and certainly of health sector due to worldwide spread of Covid-19 pandemic. The world NR consumption is dominated by China with 2483,000 tons followed by India 516,000 tons and USA 475,000 tons in 2016.

The potential of rubber wood as timber has been recognized recently which accounts 10% of industry turnover and 4% of the export earnings. It is commendable that timber volume is incorporated to the breeding program of RRISL as one of the criteria of clone selection. In addition, research on processing of rubber wood should be explored.

## **Institutional Framework**

### **Ministry of Plantation Industries & Export Agriculture (MPIE)**

State Ministry of Company Estate Reforms, Tea and Rubber Estates Related Crops Cultivation and Factories Modernization and Tea and Rubber Export Promotion (MP/SMTR)

(During the early part of the requested review period i.e., 2017- 2019, name of the relevant Ministry was Ministry of Plantation Industries and that was changed to MPIE in 2020)

Ministry of Plantation Industries & Export Agriculture (MPIE) is the apex government organization responsible for formulation, implementation, monitoring, and evaluation of policies, plans, programs and projects; in relation to the subjects of plantation industries. Vision and mission of MPIE are stated as follows;

**Vision** – *‘Achieving national prosperity through the development of the plantation industry’*

**Mission** – *‘To enhance profitability, productivity and sustainability of the plantation industry through economically, socially and environmentally established plantation sector’.*

**Ministry purview**, as per the Gazette extraordinary No. 2196/21 dated 6<sup>th</sup> October 2020, is

*‘Re-orienting overall plantation industry aimed at attracting export market by diversification of value added production through adoption of research techniques, new technological tools and the optimum utilization of land’.*

The priority areas identified by the Ministry, relevant to rubber sector are raising production by providing quality seeds and planting material, enhance international competitiveness for productivity, **promote value addition industries**, expansion of market opportunities, protection of industries by coordinating relevant institutions, issuance of licenses related to fragmentation of rubber lands and their control; optimum utilization of rubber lands through multiple cropping and integrated farming, thereby increasing production and employment; matters relating to development, **promotion and research activities of rubber**; implementation of policies for promotion of bio protection and resource use.

Relevant institutions for rubber, brought under the Ministry as per the Gazette extraordinary No. 2153/12 dated 10<sup>th</sup> December 2019, are Rubber Research Institute (RRI), Rubber Development Department (RDD), National Institute for Plantation management, Tea & rubber estate (control of fragmentation) Board, *Thurusaviya* fund, Sri Lanka Rubber Manufacturing and Export Corporation, Sri Lanka State Plantation Corporation and Janatha Estate Development Board.

The Sri Lanka Rubber Secretariat (SLRS) of the Ministry in consultation with the rubber stake holders had prepared the Rubber Master Plan(RMP), a national agenda for development of rubber industry for the period of 2017- 2026; addressing key constraints of the sector and implemented with the funds of Asian Development Bank and the Government of Australia. SLRS is responsible for coordinating and facilitate implementing the RMP. It had clearly identified responsibilities and targets, achievements of which would depend on concerted effort of all stakeholders. This plan has set ambitious target of achieving a gross industry turnover of US \$ 4.4 b. in 2025, of which target set for rubber products manufacturing sub sector is 3.6b. RRI has a major role in achieving this target, by generating necessary technologies and transferring those effectively to the end users together with RDD and *‘Thurusaviya’* fund.

## Overview of Rubber Research Institute

### History and Governance

Establishment of Rubber Research Scheme of Ceylon in 1910 had been the origin of natural rubber research initiative. This was re-named Ceylon Rubber Research Scheme (CRRS) in 1913 with Government funding of 60% of its annual budget. Legal recognition for CRRS was granted by Rubber Research Ordinance No. 10 of 1930. The Ordinance provided authority for collection of a 'cess' from rubber exports, to be utilized for research on natural rubber and administered by a Board of Management, named Rubber Research Board (RRB) which was established for the purpose of developing the rubber industry and establishing and maintaining a Rubber Research Institution and otherwise managing, conducting, encouraging and promoting research in respect of rubber and all problems connected with the rubber industry. Subsequently, there had been several amendments to the first Ordinance in 1934, 1936 and 1946. That was further refined by amended Acts in 1949, 1950, 1951 and 1953. The most recent amendment was Act No 28 of 2003. Another draft amendment had been prepared and it is yet to be presented to the Parliament.

RRB at present comprises 11 members including Chairperson appointed by the Minister, *ex-officio* members from the MPIE, Ministry of Finance, Chairman of the Planters Association, Director General of RDD, Director of *Thurusaviya* Fund, Director of RRI and Chairperson of Council for Agricultural Research Policy (CARP). Additionally, members from large rubber plantations, rubber manufacturing and trading sectors are also appointed by the Minister.

Dartonfield estate of 178 acres at Agalawatte, was procured for establishment of CRRS and TEH O'Brien was appointed as the first Director. As this research scheme had made tangible contribution in R&D, further expansions were made by addition of 1000 acres in 1942 and 1955. CRRS was officially re-named Rubber Research Institute of Ceylon (now Sri Lanka) under the provisions of the Rubber Research (Amendment) Act No 30 of 1951. RRISL had been the oldest Rubber Research Institute in the world and has a proud record of service to the rubber industry, and is the nodal agency charged with the statutory responsibility for research and development on all aspects of rubber cultivation and processing for the benefit of the rubber industry.

## **Vision of RRI**

*Emerge as the centre of excellence in providing high quality scientific technologies to the rubber industry.*

## **Mission of RRI**

*Revitalize the rubber sector by developing economically and environmentally sustainable innovations and transferring latest technologies to the stakeholders through training and advisory services.*

## **Objectives of RRI**

- *Increase productivity to international standards.*
- *Increase national production of NR to meet the increasing demand.*
- *Optimal and sustainable use land, labour and other resources.*
- *Maximize domestic value addition to NR.*
- *Encourage individual competency and self-development RRISL personnel and in the process, improve the organizational effectiveness of the Institute.*

## **Policies of RRI**

- *Continuation of the research and extension activities on all aspects of rubber production and processing.*
- *Continue to promote environmentally friendly and sustainable agricultural industry.*
- *Transfer the developed technologies through training and advisory services.*

(The above statements were obtained from the website of RRISL. These statements should be reviewed periodically. One of the members of RRB suggested revising those statements as follows- Include in Objectives ‘Increase NR production to curtail imports and increase exports of rubber and latex’ and ‘Continuation of all R&E activities to maximize the utilization of alternative sources of energy (Solar power) for rubber production and processing).

Main Institute is established in Dartonfield estate (74.3 ha) is a part of the Dartonfield Group which comprise two more estates, viz . Galewatta (184.4 ha) and Nivithigalakele (73.2 ha). Research sub-stations are Nivithigalakele (Mathugama) where Genetics & Plant Breeding Department is located; while Kuruwita, Polgahawela and Monaragala represent different

agro-ecological zones where feasibility studies on rubber cultivation and adaptive research are being carried out. These estates and the factory at Dartonfield are managed by the Estate Department of RRI.

Presently, Institute specializes in rubber research, both in the biology of the crop and chemistry of the natural rubber and technology of value added products. Rubber Technology Departments are located at Rathmalana. Further, the institute is committed to strategic technology transfer activities and training of extension personnel and other stake holders; and the Advisory Services Department to achieve that purpose is also located at Rathmalana.

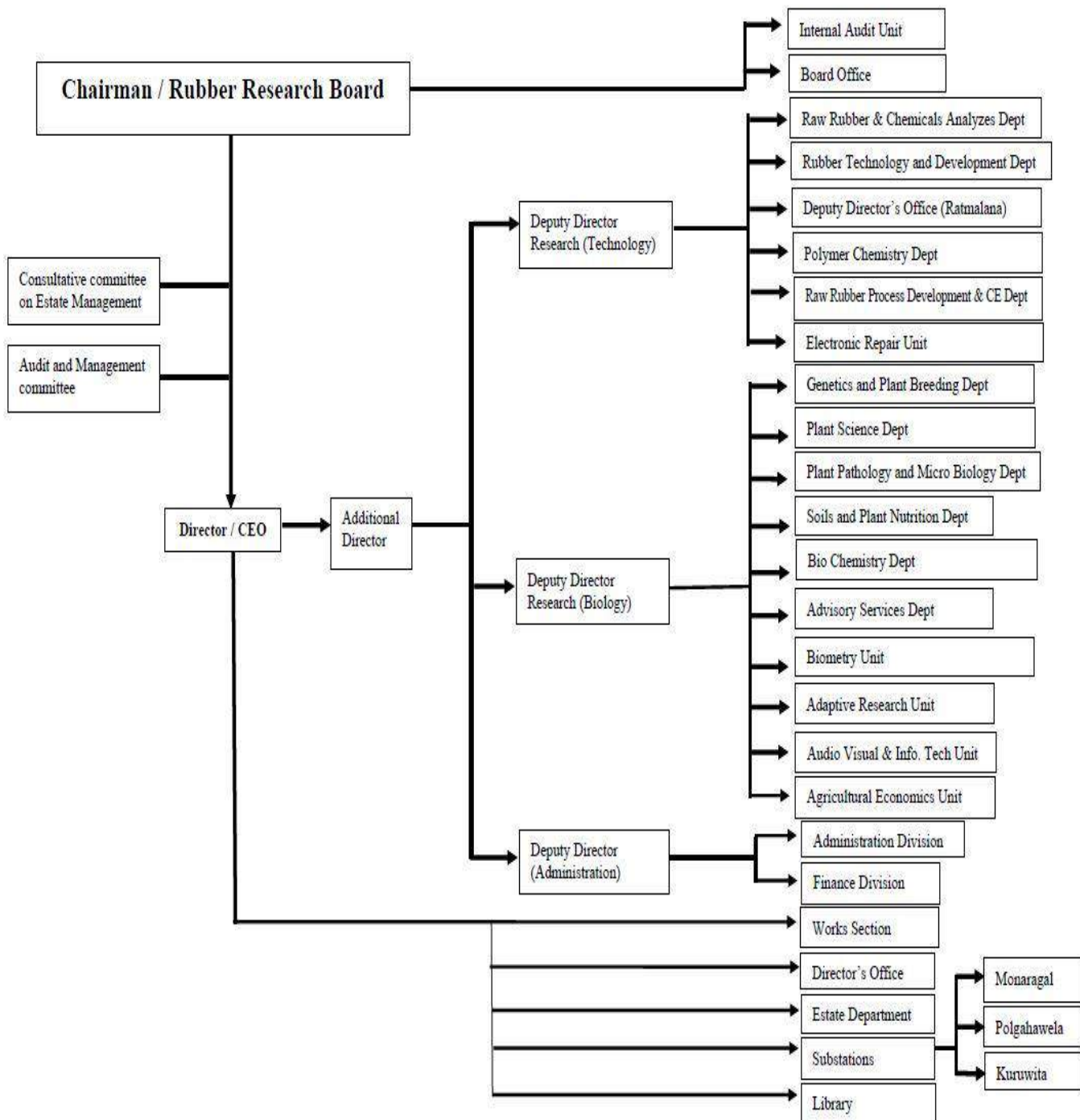
Director, RRI is responsible for overall research & development of the rubber sector. However, this position is being vacant for over 03 years and an Acting Director had not been appointed till the Director's position is filled; which is a major obstacle in managing the institute properly. Additional Director supervises the duties of 03 Deputy Directors *viz.*, DDR (Biology), DDR (Technology) and DD (Administration). DDR (Biology) is responsible for research and development of 5 biological research Departments *viz.* Plant Science, Genetics & Plant Breeding, Plant Pathology, Soils & Plant Nutrition and Biochemistry & Physiology in addition to Advisory Services Department and Adaptive research, Agricultural economics, Biometry and Audio-visual & information technology Units; while DDR (Technology) is responsible for research and development of 4 Technology Departments. *viz.*, Raw rubber processing development & Chemical engineering, Raw rubber & Chemical analysis, Polymer chemistry and Rubber technology & development Departments. DD (Administration) is responsible in managing Administration and Accounts Departments (Ref. Organization Structure of RRISL, p14).

Funds for the Institute are mainly provided from the Treasury through MPIE, as *cess* income is no longer available for research & development. In addition, local funding bodies *viz.* SLCARP, NSF and NRC provide financial assistance under competitive funding initiatives. UNDP-FAO funds have been received as well for a research project during the review period.

Research & development programs are planned considering the national and industry needs. Problems of the stake holders are conveyed to the researchers through field visits, discussions with stakeholders in Scientific committee, and researchable areas were identified and research projects were formulated by researchers under the guidance of senior researchers and DDRs and finalized in research review committee with suggestions of reviewers representing academia and private sector, however, this had not met regularly.

## RUBBER RESEARCH INSTITUTE OF SRI LANKA

### ORGANIZATION STRUCTURE



(Source- RRISL website)

## 2. Purpose of Review

Rubber Research Institute of Sri Lanka is a semi-Government institute and has a responsibility to address issues related to the rubber industry, well-being of the society involved and enhance economic prosperity of the country by integration of new technologies.

The main purpose of performance evaluation is to reflect on what has been done in the past (2017- 2019)) as no system can be efficiently run without regular observation and checking of its results and outcomes leading to transformations and improvements. A review culture is necessary for enhancing competitive advantages and for assuring state support.

### **The reasons for conducting a review can be listed as follows:**

- To obtain information on how to improve activities of the institution.
- To induce a self-reflection by the scientists on the results and outcomes of R&D activities, the way they are performed leading to strategic orientation towards the desired goals.
- To assess effectiveness of the activities.
- To encourage good management of the institute.
- To improve internal and external transparency.
- To recommend future resource commitments.
- To gather information for policy change.
- To inform the stakeholders about the institutional competencies

### 3. Procedure Adopted for Performance Review

The Science & Development Act No. 11 of 1994 mandates the National Science and Technology Commission (NASTEC) to review the progress of S&T institutions in relation to objects set out in Section 2 of the Act. The NASTEC in consultation with RRI decided on a schedule for the review. This was followed by NASTEC requesting a Self-assessment Report (SAR) from the CEO of the Institution. The format for the Self-assessment Report had been prepared and forwarded by NASTEC.

A review team comprising of 03 members was identified by NASTEC in consultation with RRI and formally appointed to review the progress of the institute. The team was guided by the directions given in the guidelines for the performance review manual of S & T Institutions (Section 7).

NASTEC initially requested to carry out the review for the period 2016-2018 and that was supposed to start in 2020, but due to the spread of Covid-19 virus pandemic, commencement of the review was delayed until 2021. Further, Dr. Waidyanatha *et al* have conducted a review on RRI for the period 2010- 2016. Therefore, NASTEC advised us to carry out this review for the period 2017-2019 and include data for the year 2020 as well, if available.

#### **The review process has 4 distinctive phases:**

1. Preparation for review
2. Visits of review team to institution /holding virtual meetings and initiating other communicating methods with officers, stakeholders and other relevant personal when travel restrictions were imposed due to spread of Covid-19 virus
3. Preparation of draft report by Review team and submit to the RRI for comments
4. Preparation and submission of the final review report by the review team to NASTEC



## **Preparation for the review**

1. NASTEC had identified RRI as the institution to be reviewed in consultation with the relevant CEO.
2. NASTEC forwarded a copy of the format for Self – Assessment Report (SAR) to the relevant CEO.
3. RRI completed the Self– Assessment Report for the period 2017-2019 and submitted to NASTEC.
4. NASTEC and the Institution agreed on the composition of the review panel identified from the pool of trained reviewers and appointed them.
5. Copies of the Self-Assessment Report were sent to the review team for study.
6. Director, NASTEC met the Review team to be reviewed in advance of the visit to RRI to identify lines of inquiry and further information and documentation they need during the review visits. The team also identified individuals and groups they wish to meet during the visits to RRI and NASTEC made arrangements for review visits subsequently.

Spread of Covid-19 virus pandemic in Sri Lanka hampered some of the pre-arranged visits by the review committee to RRISL and meetings with representatives of different stakeholders, hence some of the meetings were held virtually through Zoom app. technology.

## 4. Management Assessment

### *4.1. Institutional response to external and internal environment in planning organizational strategy*

*The external environment of an institution (e.g. consumer/industry needs, government policies, market conditions, partners, and competitors) will critically affect its performance. Science & Technology institutions need to regularly assess these in order to plan and respond effectively to challenges and opportunities, and to deliver results that are relevant and useful. The external environment of Science & Technology / Research & Development institution is vibrant due to changes in stakeholder conditions and needs. It is important for an institution to periodically review and adjust its directions and goals, to meet these changes. These adjustments in turn may require significant actions, such as changes in focus and programs, organizational structure, and management strategies.*

Rubber Research Institute of Sri Lanka (RRISL) functions under the management of Rubber Research Board (RRB) is the only government institute mandated to carry out research and development (R&D) for the betterment of the local rubber industry. The RRISL is responsible to follow government policies and development goals already in place when preparing their strategic/action plans. The ability of RRISL to produce useful and relevant outputs depends on among others; internal policies, strategies, management practices and the way in which these are applied.

Policies and regulations applicable to rubber industry have been evolving over a long period and since independence, rubber industry became part of national development agenda; and policies were geared to promote socio-economic growth and equitable income distribution. Most of the policies and regulations govern and support upstream rubber production and trading activities. More recently, certain modifications were made to the policy framework with the aim of developing the downstream manufacturing industry. However, as the rubber industry comprises of a continuous chain of interdependent activities, an integrated policy and institutional framework that covers the entire value chain is of paramount importance. As a whole, the industry may look forward for a complete review and revival of the policy, regulatory and institutional framework to create an enabling environment conducive for rapid development of the industry, thus enabling the realization of its true potential.

Policies specifically related to rubber sector are not very well documented except the scattered inclusions in following documents:

- 1. Sri Lanka Rubber Industry Development Master Plan 2017 -2026:**  
A National Agenda for Rubber Industry Development formulated by the Sri Lanka Rubber Secretariat.
- 2. Plantation Industry Policy (NPIP) Framework – 2006**
- 3. National Policy framework of the Government of Sri Lanka (Vistas of Prosperity and Splendour) - 2019**

The institute has identified its own strengths, weaknesses, opportunities and threats (SWOT) through analyzing internal and external environmental factors as indicated in the strategic plan (2017-2019) and also in the self-assessment report (SAR). However, consideration of those external and internal factors in formulating Strategic Plans leading to institute's Action Plans seems not having a clear rationale.

SWOT analysis of the institute should be updated giving due considerations regularly, preferably in a brainstorming session involving all categories of staff as many important factors had been overlooked in preparing SWOT analysis. The review team has prepared a SWOT analysis from the information collected and given in Annex 01. Measures to alleviate Weaknesses and Threats while obtaining maximum output of Strengths and Opportunities should be considered in planning organizational strategies.

### **Mainstreaming sector policies into strategic plans and activities of RRISL:**

Involvement of internal members (Management, Research and Extension staff) is evident in initial stages of formulation of the annual action plan of the Institute. However, the engagement and participation of relevant stakeholders especially the smallholders and manufacturers in this process is not very strong as there is no formal mechanism that is in place at the moment. Also the mechanism or process followed in evaluating, reviewing and finalizing leading to develop strategic and action plans for RRISL by the management is somewhat ambiguous and need to be formalized. The R&D programs of different Departments/Units show some overlaps and the Management interventions in this regard is very much needed to sort that out to avoid duplication of work.

## **State and private sector institutes /stakeholders related to the Rubber industry:**

### **Public sector Institutions:**

Rubber industry is overseen by Government Ministries, Departments and statutory bodies. Irrespective of the size, the rubber sector is being served in different ways and intensity by state owned institutions. Different issues related to certain selected activities in the rubber industry value chain are addressed by the RRISL, Rubber Development Department (RDD), EDB, IDB, Rubber Products Development and Services Center (RPDSC) and ITI within their mandated scopes and budgets but measures taken so far are seems insufficient to solve diverse industry problems, especially for the SMEs. The Ministry of Industries has its own direct assistance programs. Some state Universities too provide certain services.

The RRISL addresses the technological issues across the entire value chain activities including upstream and downstream. Its focus is more on upstream activities. It, however, attempts to build up advanced capabilities to cater to a more modern rubber products and process sector. Upon request, the RRISL assist manufacturers to find solutions for problems encountered during manufacture of rubber based products. Similarly, training and demonstration programs are conducted for the benefit of SME manufacturers and entrepreneurs interested in setting up small scale production units. Its laboratories offer testing services to the industry at a nominal fee although it has not gained accreditation of relevant foreign bodies. Some of the large scale rubber industries in the country were set up with RRISL support, namely Lordstar, Dipped Products and Elastomeric Engineering. The RRISL at present has serious limitations with regards to updating its laboratories with modern equipment, acquisition of new technologies and attracting and retention of high caliber scientists/technologists which reduces its potential to serve the sector.

According to the information provided in the website of RDD (accessed on 30 April 2021), extension services are provided for: Land preparation, planting of rubber including advices on planting density, holing and filling, intercropping & mixed cropping, use of fertilizer, diseases infecting to rubber plants, recommended methods for tapping, use of rain guards, production of smoked sheet rubber. The above functions overlap with advisory services provided by ASD and other Departments of RRISL. Therefore, proper coordination to avoid duplication of work is necessary among these government organizations.

Rubber Products Development and Services Centre (RPD&SC) under the purview of IDB is the most important state agency that supports SMEs engaged in rubber products manufacturing.

According to the information appeared in their website (accessed on 8/5/2021.) it provides technical services and information, expert consultancy and advisory services related to rubber and rubber based products. It also offers quality control, product testing facilities and issue of certificates related to above testing with national and international standards. The Rubber Products Development and Services Centre's laboratories are equipped with a comprehensive range of physical and mechanical testing equipment for quality testing of rubber compounds and finished products. Its services on Product and process development are tailor made to meet the specific needs of the clients.

The above facts shed lights into the need of proper collaboration and coordination among those key institutes to improve the effectiveness of services delivered to the rubber manufacturing sector.

It is expected that these issues will be addressed through the Sri Lanka Rubber Secretariat during the implementation of Rubber Master Plan (RMP). However, coordination of activities, implementation and monitoring requires a robust mechanism without which the set targets may not be achieved though planned. There are 25 Projects coming under 10 Programs in the implementation schedule of RMP, and RRISL is expected to play a leading role in Projects No. 17 & 18, viz. 'Establishment of Rubber industry technology consortium, RITC' (which is not established yet) and 'Introduction of refinements to current technological practices in rubber production', respectively which are included in Program No. 07, *ie.* 'Industry-wide Technological Capability Development'. In addition, RRISL is given responsibilities in many other projects out of the 25 Projects listed. Establishment of FEASC at Rathmalana is completed now and is functioning well under the Project No. 20.

**Private sector institutions:**

The rubber industry is served by four strong industry associations that are members of the industry apex body, Sri Lanka Society of Rubber Industry (SRI).

They are:

- (i) Colombo Rubber Traders' Association (CRTA),
- (ii) Planters' Association of Ceylon (PA),
- (iii) Sri Lanka Association of Manufacturers and Exporters of Rubber Products (SLAMERP)
- (iv) Plastics and Rubber Institute of Sri Lanka (PRISL).

These institutions meet specific professional and trade objectives while the industry apex body SRI focus on macro aspects. As a collaborative platform, the Sri Lanka Rubber Secretariat was established in 2012 to support the master planning initiative and to facilitate public-private cooperation.

Coordination among external key agencies and RRISL to promote collaboration is very important for congruency and sustainability of the industry and the agencies.

### **Public- Private Partnership initiatives: A new initiative for income generation**

RRISL has received Rs.50 Million, from the Government of Sri Lanka (GOSL), to establish the “Finite Element Analysis and Simulation Centre” (FEASC) to provide services to the Private sector for modeling and simulation of rubber products and other items enabling Sri Lanka to increase value addition of natural and synthetic rubber to compete effectively in the global market. The service is available on a fee-for-service basis to the industry. It’s a Public Private partnership between RRISL and the Plastics and Rubber Institute of Sri Lanka (PRISL) supported by the Sri Lanka Association of Manufacturers and Exporters of Rubber Products (SLAMERP). This is one of the timely initiatives as per the activities proposed in the Rubber Master plan. It was revealed that there are no experts in all the areas to handle to offer a better service. It is proposed that the staff should be given training on relevant areas and incentives for the staff to support and ensure the sustainability of the center.

**Researchers and the Management should pay more attention to the above mentioned external and internal environment and especially the relevant projects of RMP when preparing Strategic/ Acton plans and implement the projects to achieve the set goals of the Rubber Industry of this country.**

Management practice	Level of Practice (Performance Indicators) Strong/ Moderate/ Weak	Comments / Evidence
Government policies and development goals are used/ considered to establish goals and plan organizational strategy for the institution	Moderate	It is not clear whether the policies and goals are considered in strategic planning. It is a follow up of the former plans with a few alterations.
The organizational mandate (as specified by the relevant Act) is considered in strategic planning	Moderate	Rubber research Ordinance No.10 of 1930 had granted authority to carry out research & development work on all aspects of rubber industry. Since then, many other public & private organizations have been developed and some of the responsibilities had to be shared and it is not very clear that those changes were considered in strategic planning.
The institution is responsive to changes in Government policies and strategies	Moderate	Responsive to policy changes to a certain extent, however practical implementation of the activities to serve the policies remains unclear.
Factors such as strengths, weaknesses, threats and opportunities are considered in strategic planning	Moderate	To a certain degree and not at planning stage every year. SWOT analysis should be reviewed and updated regularly.
Stakeholders needs are taken into consideration in strategic planning	Weak	Scientific committee meetings, requests from manufacturers and extension feedback that consider in identifying the needs. RMP also gives information on stakeholders' needs and guidelines for planning. However, there is no regular exclusive forum for updating need identification of the sector, especially of the smallholders.

The Board of Governors is involved in strategic planning	Weak	Not involved in strategic planning.
The extent to which staff members are involved in strategic planning	Moderate	According to SAR, individual research projects are planned by the researchers in different disciplines under the guidance of senior researchers and refined after having discussions with the management.
Government allocations and alternative funding opportunities (donor funding) are considered in strategic planning	Moderate	Govt. allocation is based on the amount of funds requested by the Institute and distributed to each Department considering the requests made and not on priority activities identified for each year. Donor funding is obtained through forwarding research proposals by individual researchers.
The extent to which policies and plans of the organization are reviewed and updated	Weak	No evidence on reviewing or updating the policies (as appearing on the website of RRISL). Strategic/Annual Action Plans are reviewed and updated to a lesser extent.



## *4.2. Planning S & T Programs and priorities*

*A program is “an organized set of research projects, activities or experiments that are oriented towards the attainment of specific objectives”. Programs are higher in research hierarchy than projects. Program objectives should be consistent with organizational strategies and reflect user needs and development goals.*

A “program” is considered in this specific case as the “thematic area” of R&D, (Thematic Research), where it encompasses all related inter-disciplinary research projects, activities or experiments that are oriented to achieve a specific objective reaching beyond Departmental boundaries.

Objectives and goals identified by each Department /Unit of the institute in the R&D programs are in line with the organizational strategies and reflect the needs of the stakeholders to a greater extent. However, it is unclear whether the national policies identified/changed recently have been considered in strategic and activity planning.

The Action plans of the RRISL clearly show that there are no such thematic modes of R&D undertaken in the past, present or planned in the near future (Refer: Action plans of the 2017, 2018, 2019 and 2020). The SAR and the discussions the review team had with the staff and the management did not highlight building up research teams and inter-Departmental programs within the RRISL. This is very much evident in the Annual Action plans where the achievements and activities have been listed separately for each Department /Unit. This is further substantiated with the identification of Departments/Units named as “Thrust areas” (Source: strategic plan 2017-2019 -page 15). This implies that the R&D programs are confined to Departments/Units and as such have been listed Department-wise in the Action plans. This highlights that the programs do not operate in a formal interdisciplinary manner and majority are executed in the manner of Departmental programs. **When a Department needs support and collaboration from other Departments, it happens in rather informal manner. There is no proper coordination, inter-departmental research dialogues to formulate multidisciplinary projects and programs to cater the needs of the sector and to effectively use the available and scarce resources (physical, human and financial).**

As there is no multi-disciplinary thematic R&D in place, some overlaps are evident and the dissemination of research outputs and knowledge seems to have issues as more than one Department is involved in disseminating knowledge in the same research fields but with different outputs, information and data to the stakeholder. This leads to a situation where stakeholders find it difficult to assimilate the knowledge to put into practice thinking which information/guidelines to be followed. This is a weakness identified in formulating programs of the institute. Thus, working in Departmental mode in silos seems not only cause a lot of

waste and unnecessary overheads and may also lead to inconsistencies in the information disseminated to the stakeholders, which can be a significant barrier when it comes to providing a seamless advisory package. This can certainly affect the stakeholders' confidence on the institute's deliverables. Higher management interventions to solve this issue by considering structural changes and proper coordination and collaboration among relevant Departments/Units are very much needed to serve the sector objectively. The ultimate goal of this kind of intervention is to remove conflicts and create synergy among all players engaged in TT in the Institute while disseminating clearly defined R&D outputs to make an impact in the sector.

The Science & Technology and Research & Development programs of RRISL are initiated by the Heads of Departments/Units with the interactions within the Departmental team of scientists/researchers. It is top to bottom as well as bottom to top approach. Research Program objectives, though not operated in the mode of multi-disciplinary manner, is consistent with organizational strategies and reflect user needs and development goals to a certain extent. Making use of the data on future demand predicted by IRSG (International Rubber Study Group) and other international bodies must be strongly taken into consideration to decide on research priorities, rather than working blindly to promote products for which the future demand is declining.

Some Principal Research Officers expressed their concerns over research dialogues carried out in-house to develop R&D programs with no meaningful dialogue but focuses mainly on trivial administrative matters and targeting personal issues. Instead, they are of the view that it is important to develop a research culture and eco-system where researchers and management can initiate a productive dialogue with openness to new ideas and lateral thinking among peers to shape the R&D agenda of the institute more effectively utilizing core competencies and capacities related to various fields through collaboration to put multidisciplinary thematic programs in place. The review team unequivocally acknowledges the fact that there are experts in all areas in the RRISL but the active research dialogue is far more remote due to weak management structure. Furthermore, the silo mentality seems to prevent researchers from designing an appropriate technology solution and deprived the positive impact on the sector/industry on the investment made. Therefore, encouraging researchers to share their perspectives and cross-pollinate ideas seems critical over the R&D dialogues.

Program formulation considering stakeholder (mainly smallholders) needs remains unclear as there is no formal mechanism in place at the moment to incorporate the needs and to workout researchable areas. Furthermore, there was no actual documentary evidence to verify this procedure.

**To address the above issues, it is proposed that the RRISL to periodically review and adjust its R&D directions and goals, to meet the ever-changing stakeholder needs by organizing stakeholder dialogue exclusively focusing on need identification and prioritization of R&D programs at least biennial (once every two years).**

Program planning need to follow a formal procedure with the active participation of Senior Scientists in relevant fields from RRISL as well as external experts representing academia, other sister institutes, progressive industry counterparts as well as SMEs. Setting up of a committee (may be named as “Consultative Committee on Research”) comprised of external expertise would be useful to facilitate the process.

The adjustments and improvements in the R&D programs in turn may require changes in routine activities / programs of the institute’s overall program and also to work-out a process to improve cross-boundary collaboration. This requires a strong management intervention, especially a role played by the two DDRs in formulating thematic research and identifying Departments where collaborations deem necessary and also determining clear roles and responsibilities for team members. By doing this, significant amount of resources can be saved while increasing the efficiency and the effectiveness of the program outputs targeting stakeholder needs. More holistic approach in R&D has therefore become central in planning institute’s R&D programs moving beyond Departmental boundaries that artificially segment the institute’s programs into more Departmental silos.

The above mentioned proposals can make a transformation in the institute, however, requires a collaborative effort from all parts of the organization, no matter how different their processes, systems, and cultures have been in the past. Breaking down silo mentality will help the institute to harness the right mix of knowledge and skills needed to bring about R&D outputs that the industry would require while making the organization more flexible and agile for the future. Thus, it is proposed to consider making changes in the organizational structure and management strategies to address the aforementioned issues with a strong intervention of the management including the Board.

Management practice	Level of Practice (Performance Indicators) Strong /Moderate /Weak	Comments/ Evidence
National development goals are considered in planning programs & setting priorities	Moderate - Weak	Considered to a certain extent but there is no evidence of priority setting.
Board of Governors participate in planning and priority setting of program	Weak	Not apparent as of now. They are more on to solving administrative matters.
The extent to which the staff of the institution participate in programme planning and priority setting	Weak	Staff at different layers participates in formulating Annual action plan but not in program planning and priority setting.
Stakeholder interests are considered in programme planning	Moderate	There is no exclusive forum for identifying stakeholder interests in place at present. Instead there are interactions /dialogues at various levels: eg: Scientific committee where RPCs are met; Research – Extension dialogue. No forum for the smallholders except they come out with their issues during extension activities and trainings conducted by the RRISL. A formal mechanism of incorporating stakeholder needs regularly (annually or biannual) into R&D programs was not observed.

<p>The extent to which programmes are planned and approved through appropriate procedures</p>	<p>Moderate</p>	<p>There is no such approval mechanism especially when external funding is requested. The proposals are prepared by the researchers and submit it through the management. The management do not get involved in critically reviewing the contents of the proposals before submitting to the funding agencies. Nevertheless, those projects are supposed to be reviewed by the funding agency before approving.</p> <p>These projects may perhaps hamper the important routine activities of the Department due to paying more attention by the researchers to projects receiving external funds as researchers are experiencing more independence in implementing project activities and spending funds .</p>
<p>The extent to which the availability of funds (government allocations and other funds) generating funds are taken into consideration in planning programmes</p>	<p>Weak</p>	<p>Comprehensive budget preparation guidelines and requirements for R&amp;D planning are not followed. It is just the budget requested by each Department/Unit and the activities are adjusted to fit the received allocations. Researchers are not interested in generating funds as such funds are directed to the Treasury.</p>
<p>The obtaining of necessary equipment is considered in planning programmes</p>	<p>Moderate</p>	<p>Yes. This happens at Departmental level but not critically reviewed by the higher management to divert funds based on the needs of the issues to be addressed by the RRISL.</p>
<p>Stakeholders are represented in the institution's planning and review committees.</p>	<p>Weak</p>	<p>Stakeholders are not represented in planning and review committees. It is the scientific committee which is a big group of knowledge dissemination forum for estate sector where the main focus is not planning and reviewing.</p>

<p>The extent to which socio economic and commercialization of aspects are considered in programme planning.</p>	<p>Weak</p>	<p>No evidence of considering socio-economic aspects in planning programs. Commercialization of research outputs by the Institute is not allowed under present legal framework.</p>
<p>Effectiveness and efficiency of institutional procedures in approving new S&amp; T programmes.</p>	<p>Weak</p>	<p>Intervention of higher management in objectively analysing and approving the institute's programs presented by Departments is not evident</p>

### ***4.3. Planning S & T/ R & D Projects***

*A project is a set of activities designed to achieve specific objectives within a specified period of time. A project includes interrelated research activities or experiments, schedule of activities to be completed within a specific time period, budget, inputs and outputs, focused towards intended beneficiaries. Projects are the building blocks of programmes. For an institution to achieve its objectives, it is necessary for projects to be well planned in terms of their expected outputs, activities, and input requirements.*

Research projects are initially formulated and discussed by Head and the staff within the Departments/units including activities relevant to each project. The planned activities including KPIs, Financial & Physical targets/outputs, timelines, quarterly targets & responsible person for each activity are documented by the Department and then forwarded to the management who compile those into one document (Annual Action plan) which is then submit to the Board for onward transmission to the Ministry. It was revealed that higher management at the Directorate level and the Board do not get intervene with making changes in the Departmental Action plan. Constraints in implementation of capital projects seems to affect routine R&D activities which is considered as a major impediment and thus need critical analysis to identify the needs of the sector and availability of the other physical and human resources and prioritize the programs accordingly .

The projects identified under the institute's Action plan for implementation are mostly not interdependent and seems to be implemented as stand-alone. Some projects will support the performance enhancement with other related disciplines working in separate Departments/ Units but in an informal manner. A major weakness observed in the Action plan is that there are neither inter-disciplinary projects nor inter-Departmental coordination in place in the institute's R&D programs. **However, the rationale should be to develop R&D programs and Projects based on key thematic areas with a robust M&E mechanism in place to ensure the planned outputs and outcomes. Management intervention at the two DDRs level should be central for inter-disciplinary coordination and communication.** It will act as the bridge between all relevant parties for timely implementation of projects and responsible for results. Therefore, effectiveness of the institutional program as a whole need to be assured through identifying cross-cutting areas and integration of planned programs and projects across Departmental boundaries.

Basic research projects on rubber production and processing are given low priority as for want of experienced scientists and sophisticated equipment. This deficiency could be rectified by inviting the local University/ foreign researchers if they have experience and facilities; for collaborative research projects.

Management practice	Level of Practice (Performance Indicators) Strong/ Moderate / Weak	Comments/ Evidence
The staff is provided with guidance for project planning	Moderate	Guidance or trainings are not provided to the staff who are actively involved with project planning
Previous research results/data are used for planning projects	Moderate	Most of the research projects are of long term nature and thus, consideration is given in planning on-going projects. Access to previous research data and international literature should be improved and researchers should be guided properly to use those when a new project is planned.
The extent to which the institution follows a formal process for preparation, review and approval of projects	Weak	No critical preparation, review or approval process in place at present. This should be carried out at HOD level initially and at higher management level and with participation of external scientists as well before approving.
The extent to which organizational plans (e.g. medium-term plan, corporate plan, strategy etc.) are used to guide project selection and planning	Moderate	Though there was a corporate plan in the past, now it's not there. The institute roll over the action plan annually. Strategic plan-Rubber sector (2017-2019) and Rubber Industry Master plan (2017-2026) are taken as base documents to a certain extent.



Multidisciplinary projects/ activities are encouraged by the institutions	Weak	As described above, multi-disciplinary projects are not evident and also no such plans for future.
Foreign collaborations are encouraged and incorporated in planning.	Weak	Only to a lesser extent. Limited to International clone exchange program facilitated by International Rubber Research & Development Board and a project on rubber technology with New Zealand collaboration. .
Partnership with private sector is encouraged by the institution	Moderate	Existing arrangements are mainly with the Technology Departments at Ratmalana. No PPP is evident in Biology section
The extent to which development research/activities are considered in planning projects	Moderate	Development and demonstration of research findings as applicable are attended to and seems to give priority when planning the future projects
The extent to which basic research are considered when planning projects	Moderate	Relevant basic research are being done, and focus is more on applied research due to industry needs and non-availability of sufficient HR.
The degree to which adverse effects on environment are considered in planning projects	Strong	Several technologies have developed viz. Water saving techniques using recycling of water in processing rubber; slow release fertilizer; reusable porous fertiliser tube for immature rubber; site specific fertilizer recommendation, use of bio-control measures for management of white-root disease etc.

#### ***4.4. Project management and maintenance of quality***

*Proper project management and quality assurance/improvement practices are needed to ensure effective research operations, the quality of output and achievement of desired objectives.*

Project management and quality assurance aspects of the institute can be rated as moderate. The effectiveness of procedures, governed by the management for project management is not up to the expectation. However, there are areas such as availability of equipment; building and infrastructure facilities are at satisfactory level in the main Departments at Dartonfield, Nivitigalakele and Rathmalana, but not at sub-stations/regional stations. Furthermore, there is a shortage of research officers trained at PhD level. At each Department/discipline there should be at least one research officer trained at PhD level, otherwise, this would affect the quality of the research outputs. The support staff also lacks regular training and updating on new techniques and equipment handling.

Program reviews and discussions are held from time to time. Every effort has been taken to complete projects on time as scheduled. However, due to above mentioned factors and insufficient availability of facilities to access scientific literature, databases, journals and other electronic material through internet, and printed information, the projects have suffered to a greater extent.

**We propose to seek broader scientific linkages among national and international agencies and research institutes to enhance the quality of research outputs. Possibility of having agreements to exchange scientific journals with local and foreign Universities, International research institutes and other relevant bodies should be explored. Further, the support of Apex scientific organizations like NASTEC, CARP, NSF, NRC and international organizations could be obtained to get access for updated scientific literature.**

The team noted that the S&PN and Rubber Technology Departments are in the process of setting up ground work to acquire laboratory accreditation to ensure the credibility of laboratory procedures and test results by maintaining accreditation by SLAB.

As there are no sufficient staff and also adding capital projects year by year, achieving targets within timelines may not be possible. Therefore, it is important to identify priorities within the Institutes' action plan and also Departments/Units too need to prioritize their own activities accordingly while allocating available resources to realistically complete the planned actions in time. Otherwise, timelines indicated in the action plan is meaningless.

There is a monthly progress review meetings for researchers to monitor the progress of research projects and to discuss the problems encountered by researchers, but there was no evidence to find whether activities are completed within the planned time frame. There is no indication in the SAR, Annual Reports and Annual Reviews or in other documentary sources of any information on regular monitoring procedure and evaluation, which ensures project management and the quality of research. **The review team strongly felt that the progress of ongoing projects must be examined regularly, to maintain quality and applicability of outputs and this procedure should involve with the participation of external evaluators, along with the internal team of experts as stated elsewhere in this report.**

One of the key projects earmarked in the Master Plan is: Finite Element Analysis & Simulation Centre (FEASC). It is a state- of- the art analytical tool, used in modern product design & simulation with the PPP model. This will be available on a fee-for-service basis to the industry. This facility will ensure delivering quality service to the stakeholders to enhance the industry’s technical capabilities to produce high value-added products.

Management Practice	Level of Practice (Performance Indicators) Strong/ Moderate / Weak	Comments/ Evidence
The effectiveness of the procedures for resource allocation at different levels (organization, departments, program etc.)	Moderate	<p>The procedure is not clear, and the fund allocation depends on the request made by Departments/Units. Most of the Dept.s receive about 80% of the requested funds and no prioritization based on current needs of the sector or Govt. policies or goals.</p> <p>There is no central committee or critical management involvement in other resource allocation. Most of the resources are going for maintenance of the campus and related activities. Need more attention and rationale in resource allocation at Program level.</p>

<p>Ensuring that instruments, equipment and infrastructure facilities are sufficient for implementation of projects</p>	<p>Moderate</p>	<p>There are areas where infra-structure upgrade is necessary to meet the demand of the sector and to maintain the professionalism and competence of outputs delivered.</p> <p>Infra-structure facilities of the sub-stations have to be upgraded.</p>
<p>The effectiveness of administrative procedures and support for project implementation (procurement and distribution of equipment and materials, transport arrangements, etc.)</p>	<p>Weak</p>	<p>Institute's Annual procurement plan form the basis of allocation of equipment and materials and no substantial issues associated with that. However, unavailability of vehicles in running condition and transport arrangements are not acceptable to support R&amp;D and extension work mainly due to delays in procurement procedures of spare parts.</p>
<p>Formal monitoring and review processes are used to direct projects towards achievement of objectives</p>	<p>Weak</p>	<p>No such formal mechanism or system is in place at the moment. It's a meeting arranged by DDRs to discuss the research projects but mostly confined to discuss internal issues and administrative matters. No proper research guidance. No rewards and incentives based on performances; seniority is the main criteria for promotions</p>
<p>The extent to which the researchers are supported by the required technical / field staff.</p>	<p>Weak</p>	<p>This is exacerbated with large number of vacant posts at all levels. The available support staff gives strong support but the numbers are not sufficient and their knowledge should be updated by allowing them to participate in training programs</p>

Ensuring that established field / lab methods, and appropriate protocols are used	Weak	Some researchers consult Agric. Economics and Biometry units to obtain statistically valid and economically feasible designs for their experiments and use appropriate protocols. This procedure should be made compulsory for all researchers; from designing to analysing results, to obtain meaningful outputs.
Research projects/ S& T activities are completed within the planned time frame.	Weak	No documentary evidence to support this statement. A mechanism should be developed to monitor this and find out factors hampering the completion of the projects within the time frame.
Ensuring that scientists / researchers have access to adequate scientific information (scientific journals, internet, international databases, advanced research institutes, universities etc.) that strengthens the quality of research.	Weak	According to research staff, they do not have access to updated information and high calibre research journals.  No adequate internet facilities and access to scientific information and current research publications.
The extent to which quality assurance practices are followed by the institutions	Moderate	Planning the groundwork to acquire accreditation for testing facilities.
Ensuring that researchers/ scientists have access to computers and necessary software	Moderate	Scientists have access to computers but software for some units, especially for Audio Visual Unit and some software necessary for data analysis are lacking.

#### 4.5. Human Resource Management

*Availability of an adequate number of qualified staff and effective management of human resources are key determinants of organizational performance. Establishing a cadre of qualified staff takes many years. To keep pace with new developments in science, technology, and management, it is also essential to upgrade staff regularly. Staff planning, selection, recruitment, evaluation, and training are key components of human resources management that need to be in place for effective performance of an institution.*

The key components of human resource management viz., staff planning, selection, recruitment, evaluation, and training should be given high priority as qualified, experienced and skilled HR is a treasure to any organization.

Table 1- Staff Development

No. of employees	2017			2018		
	Cadre	No. filled	Vacancies	Cadre	No. filled	Vacancies
S&T Personnel	80	03	40	80	02	47
Administrative staff	18	01	05	18	00	06
Technical staff	110	27	12	110	00	26
Supporting staff	267	01	14	267	00	10
<b>Total</b>	<b>475</b>	<b>32</b>	<b>71</b>	<b>475</b>	<b>02</b>	<b>89</b>

(Source- Self Assessment Report of RRISL)

According to the Table 1 (given in SAR forwarded by RRI), total number of institute's staff cadre is 475 and vacancies are 71 and 89 in 2017 and 2018 respectively; out of which total cadre of S&T personnel is 80 and vacancies are 40 and 47 (50% and 59% of the approved cadre ) in the above mentioned years respectively. Out of 33 available S&T personnel in 2018, 13 are Ph.D. holders and 03 are already in higher management positions. Only 10 Ph.Ds, 03 M.Phls , 02 M.ScS and 13 B.ScS are available for fulltime research/ advisory work. No. of vacancies filled in 2017 and 2018 are 03 and 02 respectively and this number is not at

all adequate when 40 and 47 vacancies should be filled respectively during those years. RRB and higher management should seriously consider this pathetic situation and take all possible measures to fill the S&T vacancies urgently as fresh recruits require at least 8-10 years to acquire qualifications and experience to become an independent researcher to work without supervision. Leaving of highly qualified S&T personnel aggravate this condition further. Seven senior researchers have left the RRISL for University jobs during the review period which is a big loss for the Institute.

As RRI is situated in an isolated environment, the management has a big responsibility to provide infra-structure facilities and eager to solve problems related to carrier developments of staff and thereby keep the morale of them high, which would in turn attract and retain staff at the institute.

**Management should take steps to convince the Government to update salary structures, allowances, incentives, rewards etc. and provide comparable facilities to those of Universities to retain most valuable human resources in the Institute. The proposed University of Plantation Research and Management (UPRM) would be a good solution for retaining scientists.**

**At present, there is a vacuum of qualified scientists available for research and guidance of young researchers; and this vacuum would grow bigger in the near future creating a very unhealthy environment affecting the performance of the institute. Therefore, as a short-term remedial measure, management should consider recruiting retired scientists on contract basis for the above purpose for a specified period and make arrangements to recruit maximum possible fresh scientists as an emergency investment for future.**

Cadre positions of field officers attached to ASD should be increased to cater the modernization of extension system which is dealt elsewhere in this report as TT is a mandate of RRI.

Comparatively, available number of the other staff categories *viz.*, administrative, technical and supporting staff are quite sufficient. However, some vacant positions (*viz.*, store keeper for 10 years and procurement officer for 04 years) should be filled urgently for provision of better service to S&T personnel. Promotional prospects and carrier developments of technical officers should be updated to be comparable with that of the other sister organizations to avoid frustration among this important category of staff. Disputes over the updated SOR could be overcome by having discussions with the affected categories of staff and make arrangements to approve it without much delay.

Regular training for staff should be given high priority to keep pace with the new developments of science, technology and management which would enhance the performance of the institute eventually. Some foreign trainings of short- term and study tours/ attending to conferences and a local post-graduate training were received by the officers during the review period, which is not adequate for a scientific institution like RRI. Post-graduate trainings should be provided in reputed foreign Universities whenever possible. Sufficient funds should be allocated for this purpose. Further, there should be a long term training schedule to identify training needs and selection of suitable officers. **It should make compulsory that the officers promoted to higher posts and the officers in line for higher promotional posts should be given relevant trainings as a routine measure to carry out responsibilities effectively in their new/ expected to promote posts.**

Procedure of staff performance appraisal is limited to a routine form filling process which is to be included in the personnel file for the purpose of approval of annual increments and other admin-requirements and does not reflect actual appraisal of staff performance. This is not a very satisfactory measure and that procedure should be reviewed by a competent committee/ organization and revise to cater the needs of present and future challenges. Likewise, promotions/rewards/incentives schemes should be established to motivate all categories of staff.

**An updated Management Information system (MIS) with details of staff is a long felt necessity for facilitating the management to take correct decisions timely in HR management.**

The top most management position of the Institute is the Director post and this is being vacant for more than 03 years and most of the above-mentioned administration/management lapses could be rectified by appointing a Director who has the legal authority and accountability and able to take constructive decisions in time and manage the institute smoothly. Consequences of this matter are dealt in detail elsewhere in this report. The RRB and the higher management should intervene positively and settle the management disputes before it deteriorate further. End result of all these management lapses badly affects the outputs of the Institute and finally productivity of the rubber industry in this country which we are experiencing now.



Management Practice	Level of Practice Performance Indicators) Strong/ Moderate/ Weak	Comments/ Evidence
The institution maintains and updates staff information in a database (including bio data, disciplines, experience, publications, projects)	Moderate	Administration Dept. maintains a staff database with basic information. That should be updated regularly with staff and research project information. Trained staff on operation of the database is necessary.
The institution, plans and updates its staff recruitments based on programme and project needs	Weak	Carder positions had been approved for the whole Institute but not based on different programs and project needs. Recruitments to fill the vacancies in the approved cadre are not sufficient.
The effectiveness of the selection procedures and the schemes of recruitment	Weak	Present selection procedures & schemes of recruitments (SOR) which were effective from 2011 are being updating now but staff of different categories are not satisfied with the reforms. Delays in updating SOR caused frustration among staff.
Training is based on institution and program objectives and on merit	Weak	Training needs should be identified by the HODs and selection procedure is not clear. Sufficient funds should be allocated to fulfil the requirements.

<p>The effectiveness of the procedures in promoting a good working environment and maintaining high staff morale.</p>	<p>Weak</p>	<p>RRISL has peaceful environment for research work but facing problems of retaining trained staff which reflects that they are not very satisfied with the available facilities/ salaries/ carrier development opportunities etc. Management should consider this matter seriously and provide attractive terms to maintain high staff morale.</p>
<p>The effectiveness of staff performance appraisals</p>	<p>Weak</p>	<p>This is limited to an admin requirement. Has to be restructured &amp; improved to be a more meaningful appraisal.</p>
<p>The effectiveness of rewards and incentive schemes in motivating the staff</p>	<p>Weak</p>	<p>There is no formal rewards &amp; incentive scheme for motivation of staff.</p>
<p>The effectiveness of managing staff turnover, absenteeism and work interruptions.</p>	<p>Strong</p>	<p>Most of the staff members are residing in RRISL premises. Transport service is available from Rathmalana to RRISL and return, for the officers living outside hence; the staff turnover is quite good.</p>

#### ***4.6. Management of organizational assets***

***Organizational assets include not only staff buildings, equipment, and finances, but also include assets such as knowledge, technologies developed, intellectual property, and even credibility and reputation. A continuous effort is needed to protect all of these assets, because they are the basis for the sustainability of the institution and allow it to continue delivering quality research and service outputs.***

The Headquarters of present RRISL was established at Dartonfield, Agalawatte in 1934 and legal authority to carryout R&D work was granted by the Rubber Research Ordinance of 1930. Biological Research Departments with reasonably equipped laboratories, Administration, Accounts and Estate Departments; Biometry, Socio-Economics, Adaptive research, AV&IT, Internal Audit and Works Units; Library, Factory, Auditorium, Estate office, RRB office and Director's office, are situated at the main office complex in Dartonfield estate. In addition, residential quarters for all categories of staff, guest house, club house and medical office are also established at the same premises.

Sub Stations of RRI include Nivithigalakele housing Genetics & Plant Breeding Department with laboratories, plant nurseries, training center and staff quarters; Rathmalana housing Technology Research Departments, ASD, Auditorium, RRB office, Electronic repair unit and staff quarters. Furthermore, additional sub-stations are situated at Kuruwita, Polgahawela and Monaragala representing several agro-ecological zones. All these assets are maintained by the estate manager with supporting staff.

The physical assets of Headquarters and sub-stations are included in an updated database by the Accounts Dept. by providing a standardized code for every store item for easy identification (even though this is not a 100% fool-proof method, it could be improved further) and facilitating the members of annual Board of Survey to carry out their work in a methodical way, which is a commendable process.

Infrastructure facilities are maintained well and a pleasing environment is observed by visitors of the institute. Recent infrastructure developments *viz.*, expansion of soil drying area, renovation of some laboratories and office buildings, construction of new buildings for tissue culture lab, Accounts Dept. and Works unit are commendable. Establishment of Finite Element Analysis & Simulation Center at Rathmalana with participation of private/ public/ University under the RMP is a good achievement. Measures are being undertaking to obtain accreditation for S&PN and Technology laboratories.

Equipment are maintained reasonably well and EOs and TOs were given trainings on maintenance and handling. Scientists sometimes face problems of getting after sale service and repair of expensive laboratory equipment as import & supplying agencies do not provide such facilities. This could be rectified by contacting the producing companies abroad and having service agreements which would facilitate after sale service and free service during the warranty period. A procedure should be developed to obtain spare parts for such instruments

from mother companies together with the other sister laboratories. Possibility of obtaining support from Apex bodies like NSF, NRC, NASTEC, CARP etc. should be explored for this purpose as many local scientific institutes face similar problems.

RRISL is the pioneer institute that had been generated technological knowledge throughout the history to improve rubber industry of Sri Lanka to reach its current status which had been second only to tea as a foreign exchange earner in historical days.

Protection and recording of the knowledge generated, technologies developed, patents and intellectual properties are carried out to certain extent by the scientists and the management; but procedures are not formal and proper. **Modern developments of Information technologies should be used to establish a good repository to archive experimental results and databases of the above mentioned assets for the use of future generation. This was discussed elsewhere in this report.**

**A Committee comprising scientists/ competent authorities with good knowledge on protection of intellectual property rights(IPR) should be appointed for preparation of guidelines to formalize the procedure of IPR as this area is not given due consideration in the past.**

Management Practice	Level of Practice (Performance Indicators) Strong/ Moderate/ Weak	Comments/ Evidence
The ability of the institution to carry out its mandate and the assigned statutory powers	Moderate	The institute has reasonably well equipped labs and well maintained infra-structure facilities (even though some of those are not modernized enough) and able to carry out research mandate well but due to lack of field level officers and insufficient use of modern ICT, TT activities are not performed up to the expected level.
Infrastructure (buildings, stations, fields, roads) is satisfactorily maintained.	Strong	Infra-structure is well maintained.
Vehicles and equipment (lab, field, office) are properly managed and maintained.	Weak	Vehicles are not maintained properly due to long delays in purchasing of necessary spare parts affecting field transportation badly and thereby field experiments and TT activities suffer very much.
The effectiveness of procedures to ensure that equipment are in working order	Strong	Equipment are maintained comparatively well.

<p>The effectiveness of the institution's overall strategy in generation and proper utilization of funds</p>	<p>Moderate</p>	<p>Institute generates certain amount of funds from services, consultancies etc. however, those are transferred to consolidated fund of the Treasury. Funds received from the treasury is utilized for different activities of RRISL but some essential items like trainings for staff, subsistence, improvement to vehicle fleet &amp; facilities of substations are overlooked.</p>
<p>The extent to which the institution identifies opportunities for income generation and cost recovery</p>	<p>Weak</p>	<p>Income generation has not given much priority as those cannot be utilized directly.</p>
<p>The extent to which the intellectual property rights of the institute are protected</p>	<p>Weak</p>	<p>Need to introduce/formulate an IPR policy for the Institute and ensure royalty and licence fee to incentivise the inventors</p>

#### *4.7. Coordinating and integrating the internal functions/ units/activities*

*The planning and coordination of units (departments, divisions, committees, research stations, etc.) and interaction among them are often neglected and it affects the overall performance of the institution. The organization of these units and the overall structure need to be reviewed from time to time to ensure smooth and efficient operations. The planning and coordination of units, logistics, resources, and information flows are necessary to achieve integration and smooth functioning.*

Dartonfield estate where main laboratories of RRISL are established is a residential Research Institute with well-maintained infra-structure facilities and has a peaceful environment for research activities.

Overall coordination and integrating the internal functions/ units/ activities of RRISL are managed by Rubber Research Board (RRB) at the top level to whom the authority had been granted by Rubber Research Ordinance of 1930. In addition, RRISL has higher and middle level management hierarchy, representing Director, Additional Director, Deputy Directors (Biology, Technology, and Administration) and Heads of Departments/Units respectively.

The Director position is being vacant for about 03 years, and as a result, overall coordination and integrating the internal functions/ units/ activities are not functioning properly at top level. At least covering up position for the Director is yet to be appointed, to manage the Institute smoothly otherwise the lapses of management and coordination are inevitable. Further, delays in solving the current issues, viz, delays in filling vacancies of staff, regular repair and maintenance of vehicles, modernization of digitized management information system (MIS) and internet facilities; not updating rates of subsistence and fuel allowances for field workers etc. are evident and create frustration among staff, which is affecting overall performance of the Institute badly.

Regular reviews on organization of units and overall structure of the Institute had not been taken place properly during the review period and as a result, overlaps of research projects i.e., Physiology research are carried out by both PSD and B &PD wasting meager resources, creating unhealthy atmosphere among researchers and discourage collaboration among Departments. Management should facilitate and monitor proper collaboration and coordination of activities of these two Departments to ensure that there are no duplicate of work and the outcomes are synergistic.

The four Technology Departments are badly affected by shortage of human resources and possibility of restructuring those departments should be considered until the sufficient numbers of trained scientists are recruited. AV&IT Unit could be placed in ASD to improve

TT activities using more modern IT technologies. Adaptive Research Unit also could be amalgamated with ASD as the responsibility of that Unit is testing the adaptability and farmer preferences of new clones and technologies in different climatic zones and socio-economic regions.

Higher management should encourage cooperation and collaboration among Research Departments to increase research output and create research culture. Further, it should enhance friendly atmosphere between scientific and supporting staff. Further, if researchers are not getting enough support from supporting staff, main function of the Institute *ie*, research activities would suffer. Researchers should have peace of mind to undertake research activities without hanging around supporting staff for settling administrative issues.

Collaboration of research between some Departments is not up to the expected level. eg, Genetics and Plant Breeding research should have collaboration from other Departments, such as Plant Pathology, Plant science, Biochemistry & Physiology, Soil chemistry & Plant nutrition, Rubber Technology etc. and work as a team to produce clones of high performance with desirable attributes. At present, this is in operation to a certain extent informally and lapses are inevitable.

**Therefore, the Review Team suggest that the management should form a strong and dedicated formal research team for development of new clones with desirable characters and provide support and incentives to build team spirit. Further, collaboration among the other Departments also should be encouraged on research theme/ program/activity basis and build formal teams, to increase outputs, avoid overlaps and utilize meager resources efficiently, eg: working teams for technology transfer, adaptive research, research projects on rubber tapping etc.**

Additionally, it should make compulsory for researchers to consult Biometry Unit, to get advice on statistical validity in experimental designing at the early stages of planning, data collection during implementation of experiments and on data analysis after completion of the research projects to minimize experimental errors. Support of the Agric. Economics Unit should be obtained for economic analysis (cost/benefit etc.) at planning and of research outputs.

Adaptability of developed technologies should be tested by Adaptive Research Unit with the support of the relevant researchers who developed the technologies, researchers of Economics and Advisory Departments, extension officers of RDD and managers/ growers of respective estates; in different locations both in smallholdings and large estates, with relevant processors/ manufacturers and fine tune the developed technologies before releasing those; which helps adoption process easy. Extension workers could use these adaptability trials for making growers aware on clones and technologies in the pipeline for future release. Further, this



would give a good opportunity to obtain additional data on growers' acceptability and feasibility of those clones and technologies.

**A formal 'Clonal and Technology Release Committee' comprising relevant members of RRISL, RRB, RDD, Estate sector, smallholders, stakeholders of processing and value addition sectors and etc. should be formed for the purpose of releasing new clones and new technologies. Presentation of experimental data obtained at different stages of the above process and data on field adaptability and level of acceptance of growers/processors/manufacturers should make compulsory for releasing clones and technologies to end-users.**

Management Practice	Level of Practice (Performance indicators)  Strong /Moderate /Weak	Comments/ Evidence
The extent to which institution is evaluated internally and restructured based on current needs	Moderate	Annual Review reports on performances are prepared by each Dept. & a composite volume is published as Annual Review of RRISL which is also uploaded to the RRISL website. No evidence on restructuring carried out based on above performances/current needs.  Finance & Administration Depts. had digitized the information system, to cater the current needs, which should be extended to cover the whole Institute.

<p>The effectiveness of internal communication and coordination mechanisms</p>	<p>Moderate</p>	<p>Internal communication is being fulfilled with Intercom telephone network. Local Area Network is functioning between Agalawatte and Rathmalana. It needs to get the other sub-stations also connected to this network. Internet facilities are updated but it suffers inherent lapses of low speed and low signals due to isolated nature of Dartonfield. Upgrading the system to suit the future needs is necessary.</p>
<p>Institution's overall direction and coordination are provided by a central planning committee / unit.</p>	<p>Moderate</p>	<p>There is no 'Central planning committee' as such. RRB and higher management are providing direction and coordination. Needs improvement.</p>
<p>The extent to which different units are assigned clearly defined functions</p>	<p>Moderate</p>	<p>Different units &amp; sub stations are assigned clearly defined functions but deviations and overlaps in some cases as stated earlier, should have been avoided.</p>
<p>Responsibilities of research/management staff are clearly identified</p>	<p>Strong</p>	<p>Responsibilities have been assigned and hierarchy is maintained. Need to improve and create a friendly atmosphere.</p>
<p>Effectiveness of using appropriate reporting procedures and feedback in management at different levels</p>	<p>Moderate</p>	<p>Reporting and feedback procedures should be regularize and improve.</p>

#### ***4.8. Partnership in managing information dissemination***

*An important requirement of all S& T / Research & Development institutions is management of dissemination of technology and information to users. The partnership / linking up with other actors in Science & Technology and information system (including, universities, industries, private sector, international research organizations, extension, farmers etc.) promotes information exchange, collaboration, and cost sharing, and ultimately improves the quality and relevance of research.*

Mission and Policy statements of RRI clearly state that transfer of developed technologies is its one of the missions and policies. In line with this mandated function, RRISL has several linkages to transfer the developed technologies to cater the needs of both upstream and downstream sectors. viz, Research publications in scientific journals including ‘Journal of RRISL’ , Annual Reviews, Annual reports, Research Bulletins (‘*Rubber puwath*’ in Sinhala), Conferences, Seminars, Workshops, Advisory Circulars/Leaflets in Sinhala & English and Training programs conducted at Nivithigalakele, Rathmalana, Kalutara, Kegalle and Rathnapura. In addition, Post graduates/ Diploma students and school children are provided requested trainings/knowledge on available technologies and trainings on research activities.

Advisory services for plantation companies, large estates and manufacturers of value added rubber products are directly provided by researchers individually or through Scientific Committee meetings conducted once in 06 months. However, the discussions are underway at the Ministry level to make arrangements to cater the RPCs soon.

The main technology transfer arm of RRISL is the Advisory Services Department (ASD) and its main role is transferring the developed technologies to the smallholders sector and ASD does not cater the RPCs or large plantations. Having only around 20 field officers it is not possible to transfer technologies even to the entire smallholders sector. Therefore, this Department is carrying out strategic technology transfer work; as the main role of extension is supposed to fulfill by Rubber Development Department (RDD).

According to the Annual Reviews published for the review period, some of the noteworthy extension strategies carried out by ASD were; establishment of farmer participatory ‘Model Rubber Holdings’, ‘Model Rubber Processing Centers’ with recommended practices and demonstration plots for promotion of usage of rain guards and other matured technologies in 06 Districts, viz: Colombo, Kalutara, Rathnapura, Galle, Matara and Kegalle. In addition, group extension programs called ‘*Vihidum Sathkara*’ were conducted to upgrade selected holdings by facilitating necessary input networks, value addition and strengthening marketing chain to increase adoption of transferred technologies.

However, annual average yield of rubber is falling at an alarming rate during past few years, indicating ineffectiveness of extension process or the technologies provided are not acceptable to the end users. **Hence, we would like to suggest that parts of Dartonfield group estates and estates of sub-stations viz, Kuruwita, Polgahawela and Monaragala also convert to ‘Model Farms’ and use as demonstration purpose where not only smallholders but estate managers and other interested parties also could obtain knowledge on latest recommended technologies. At least one advisory field officer should be stationed at Polgahawela, Kuruwita and Monaragala Sub-Stations and necessary infrastructure facilities should be provided to facilitate technology transfer. Maximum yield of new clones, obtainable at field level could be demonstrated in these Model Farms.**

Use of fast developing communication technologies for information dissemination should be explored wherever applicable, to overcome the shortage of field officers. A dedicated telephone line, social media groups such as Whats App, Viber, Messenger, Instegram etc., TV and radio programs are some of the media that could be used for this purpose. Public awareness programs also could be launched through these mass-media. Researchers should make it a habit to write to the Newspapers on new findings, prediction of rubber price fluctuations etc. Audio- Visual & IT Unit has to be upgraded with necessary equipment and trained staff to cater the needs of this area and make use of modern technologies to enhance TT. Most of the TT activities are concentrated to upstream activities, but downstream activities such as product development and value addition that could be feasible at cottage level also should be given priority, as that would attract young generation and provide additional income for the smallholder families. This is practiced in some countries successfully.

RDD has large No. of field officers and their priority had been given for distribution of subsidies, and planting material with other work assigned to them and extension work is neglected to a certain extent. Additionally, ‘*Thurusaviya* fund’ is providing extension services for rubber processing marketing activities.

Some officers of RRISL inquired about provision of extension services by *Thurisaviya*. Performance Report of RDD mentions the following: “There are two institutions, the Rubber Research Institute which provides scientific and technical advices for development of the rubber industry and the *Thurusaviya* Fund which provides marketing and extension services for small holders, which contributes towards the Development of this Department.” Director/*Thurusaviya* Fund also told us that they are carrying out TT on processing and marketing. So we better clarify this further.

Therefore, advisory, extension and trainings are provided by different entities to the rubber growers (smallholders) such as RRISL, RDD and *Thurusaviya* fund.

As these three sectors *viz*, ASD, RDD and ‘*Thurusaviya* fund’ are transferring technologies on their own way in compartmental basis, the Review Team has observed that there are overlaps and less efficiency of technology transfer, costing meager resources. Ideally, formal linkages and close collaboration should be strengthened among these key players of extension and this has to give high priority as the main goal is increase productivity and income of growers by using modern technologies developed by the researchers with much dedication aiming for that purpose itself.

Further, the involvement of ASD, RRD and TF in extension activities with many overlapping activities and advices, it creates a problem for the small holder rubber farmers to comprehend what advices to be followed. Therefore, it is important to re-structure the advisory and extension activities with the intervention of higher authorities such as Ministry of Plantation; as RRISL cannot solve this issue by itself. For example in tea sector, Advisory and extension for RPCs is by the TRISL while for tea small holders, it is the TSHDA. Likewise, it would be more effective at least this model can be adopted in rubber sector too to avoid overlaps and duplication and more importantly not to confuse the smallholders.

Even though there are several partners transfer the technologies, the adoptions of new technologies developed at RRISL, by the growers are slow; eg: use of new clones with high performances, new tapping and processing technologies, inter-cropping for higher income etc. which indicate that there are constraints for ready acceptance of newly developed technologies by the growers or some socio-economic, environmental, other unidentified factors are affecting adoption. Nevertheless, there had not been any study completed to find out effectiveness and obstacles of spread of technologies used in the above extension strategies.

The Review Team is well aware about the historical perspectives of the Extension system of RRISL which was transferring technologies efficiently with around 200 qualified staff until 1994 and the short sighted decision made by the MPI disabling that and handing over the responsibilities to RDD and *Thrusaviya* fund afterwards, which eventually paralyzed the system up to evolution of the ineffective TT we are experiencing now.

**As this set up is not very satisfactory for efficient technology transfer, the Ministry of Plantation should review the entire process of technology transfer and make necessary remedial measures forthwith.**

**In the meantime, we would like to suggest that the RRISL together with the other partners of extension should carry out a survey to find out the real factors affecting smooth technology transfer and make necessary measures for restructuring the current extension procedure, otherwise the whole effort of research scientists in developing**

**technologies would go waste and outdated. Support from University staff and students may be obtained for the purpose of carrying out the survey.**

**Further, a formal platform for all partners of technology transfer and researchers should be created eg: ‘Research–Extension Dialogue’ and meet annually to discuss about the new technologies developed, get feedback from field officers on socio-economic and other obstacles faced by smallholders and extension workers in transferring technologies, identify researchable problems etc. and workout collaborative implementation plans. Additionally, this would facilitate more collaboration between the officers of ASD, RDD and ‘*Thurusaviya fund*’.**

RRI has a very good and updated website for information dissemination. Audio-visual & IT Unit should be improved with advanced and modern technologies for the purpose of TT. Ideally this Unit should be combined with the ASD to provide an efficient service to the Industry which is stated elsewhere in this report.

Industry-Institutional relationships can be further improved by facilitating more effective and frequent target oriented working relationships among the private sector/RPCs (industry), state institutions such as Universities and relevant Research Institutions. Many who served RRISL previously has moved to Universities and thus, it is easy to initiate formal partnerships to thrive the industry through collaborative efforts. Private sector has funds and research needs whereas state Institutions and Universities have excellent academic and scientific competencies in addition to reasonable infrastructure facilities. If both parties work together, result would be superior technological competencies, which could be converted to innovative products in lucrative markets. eg: Establishment of FEASC to fulfill the needs of the Industry viz, Finite element analysis, 3D design, 3D printing, injection modeling etc.

Management Practice	Level of Practice (Performance Indicators)  Strong/ Moderate /Weak	Comments/ Evidence
The institution systematically plans and performs dissemination of information	Moderate	The RRISL is implementing several information dissemination (ID) measures as stated above to cater the needs of both upstream and downstream sectors. Shortage of field officers and insufficient use of modern IT technologies are affecting badly for carrying out ID effectively at the grass root level.
The extent to which the institution plans and maintains linkages with key partners for sharing and dissemination of information	Moderate	Institute maintains strong linkages with the estate and processing sectors directly for ID. But linkages with the other key partners of ID (RDD& <i>Thurusaviya Fund</i> ) have to be strengthened to cater the needs of smallholders.
The effectiveness of institutional procedures for technology transfer(TT)	Weak	Institutional procedures for TT have to be strengthened further. A Post-Graduate study on ‘Effectiveness of strategic extension procedures for the smallholders’ is being carried by a research officer stationed at Polgahawela Sub-station. Results of this study could be used to strengthen the present status of TT.
The effectiveness of the system to obtain feedback from different types of stakeholders	Weak	Some formal and informal measures are practised to obtain feedback and those should be strengthened further.

#### ***4.9. Monitoring, evaluation and reporting procedures***

*Monitoring (assessing ongoing S&T / research activities) and evaluation (evaluating the value, quality and results of research) are key management processes of public-S& T institutions. Monitoring and evaluation are also important for determining whether the institution is learning from its earlier achievements and failures. Monitoring, evaluation, and reporting procedures need to be properly designed (i.e. integrated into project planning and implementation) and periodically reviewed, in order to provide useful information for decision-making and accountability.*

According to the Self-Assessment Report provided by RRISL for this review, monitoring and evaluation of research projects are formally carried out by monthly progress review meetings summoned by the Deputy Directors (Biology & Technology). All researchers participate in these meetings to discuss the progress of experiments and constraints they face when carrying out research work. In addition, DDR (Biology) conduct 'Technology update' meetings bi-monthly, where Rubber Extension Officers, Experimental Officers and Technical officers get a chance to meet the management and research staff and discuss the outcomes of activities.

A Strategic Plan and Annual Action Plans prepared by RRISL for the review period (2017-2019) indicated targets for each research project. It is not very clear that the HODs/DDRs are assessing or monitoring whether the set targets had been achieved in respective years and review the process, discuss on constraints the researchers had to face if the expected targets had not been reached and implemented remedial measures to overcome the constraints.

A comprehensive repository of information on research projects including those funded by different agencies viz, NSF, NRC, CARP, MPIE, foreign agencies and etc; should be digitized and incorporated into a modern MIS system and updated regularly. Researchers should feed raw and processed data of experiments (confidentiality and accessibility should be secured), financial progress, constraints and other information necessary for smooth management of the research projects, while research projects are being implemented in fields and laboratories regularly.

**This kind of repository is highly valuable as most of the experiments are long term and changes of human resources and due to lack of a proper mechanism to archive data and etc., some valuable information would have got lost forever in the past. Hence, it is highly necessary to archive data as soon as acquiring and make the results open field after publishing/presenting in scientific forums or after a specified time period.**

Annual Reviews and Annual Reports are published summarizing progress of research and development in different Departments, estate management of Dartonfield group including



sub-stations, maintenance of infra-structure facilities etc. and these reports had been uploaded in the website of RRISL, which gives a comprehensive picture on annual progress of the above activities. However, progress of Administration Department is not included here. RRB and the four standing committees *viz.*, Estate Committee, Audit and management Committee, Provident Fund Committee and Scientific Committee are assisting management in monitoring and evaluation which are functioning but their decisions and implementations/actions undertaken also had not been reported in Annual Reports.

Internal Audit Unit is functioning with an Auditor and a Management assistant. According to the Auditor the audit reports submitted by her had not been given due consideration by the higher management and failing to implement the submitted suggestions resulting in lapses of expected improvements.

Individual staff performances are appraised as a routine procedure, but it seems that it remained another paper work for approving increments and other administrative necessities. This process needs a careful upgrading with a good MIS system, to be a more meaningful activity for enhancing productivity and efficiency of staff. DDR (Biology) stated that there had been a suggestion to establish a MIS system sometimes back but the process is still to be implemented.

As human resource is the most important component of any Institution, there should be a mechanism to get information on grievances of staff, implement remedial measures on a regular basis and obtain their views or suggestions for improvements to research & development process as well as staff well-being.

Involvement of external experts on different subject areas and external stakeholders especially rubber manufacturers in research planning and progress monitoring would be useful to improve and upgrade the above processes and increase the transparency of the activities, which is of prime importance for an Institute managed mainly by the Govt. funds.

**Hence we propose setting up of a standing committee comprising of external experts and stakeholders (may be named as Consultative Committee on Research Planning & Monitoring) to facilitate both program & project planning and M&E, and also to guide the RRB on the above matters.**

Management Practice	Level of Practice (Performance Indicators)  Strong /Moderate /Weak	Comments/ Evidence
The institution monitors and evaluates (M&E) its own activities periodically	Moderate	Necessary to upgrade M&E activities to suit the future needs of rubber industry.
M&E is supported by an adequate management information system (MIS), which includes information on projects (e.g. costs, staff, progress, and Results).	Moderate	There are some data bases maintained in the Departments separately. However M&E activities are not supported by a MIS system which should be given high priority.
The extent to which S& T results and other outputs are adequately reported internally (e.g. through reports, internal program reviews, seminars).	Strong	The quality of the reports of S&T results should be upgraded by providing regular trainings on scientific writing and reporting. Upgrade of program reviews could be achieved by obtaining support of distinguished scientists of relevant fields from other Institutions.
External stakeholders contribute to the M & E process in the institution	Weak	Involvement of a properly constituted Research planning & M&E committee seems lacking at the moment. A committee comprised of the above stakeholders should be set up to upgrade M&E process. Contribution from other organizations like Universities and other Research Institutes should be obtained for M&E process regularly.

<p>The extent to which the results of M&amp;E are used for project/ research planning and decision-making.</p>	<p>Moderate</p>	<p>This is carried out to a certain extent but it needs more support from present advances of IT and commitment of researchers and managers of all levels to establish a proper repository of project information and these data would be useful for enhancing proper planning and decision-making .</p>
--	-----------------	--

## 5. Output Assessment

### *5.1. Technologies developed and transferred to industry / entrepreneurs*

RRISL had developed many technological innovations to improve the rubber industry and also to solve the problems encountered by the stakeholders both in upstream and downstream activities (Annexures 02 & 03)

The most outstanding outputs are development of high yielding rubber clones with potential yield exceeding 3500 kg/ha/yr which is around 10 fold increase to that of initial Wickham's collection, good quality latex, higher wood volume together with resistance to major diseases and drought conditions. As rubber is a perennial plant with a long breeding cycle, some molecular tools were modified to shorten the breeding process. Around 6000 germplasm of rubber with diversity of characters are being conserving in different locations and exchange them with the other countries are some other investments for improvement of future research work.

Technologies to improve fertilizer efficiency are among other remarkable outputs such as slow release fertilizer for rubber nursery plants and fertilizer encapsulated coir bricks to reduce fertilizer application cost, reusable porous fertilizer tube with maximizing fertilizer efficiency and minimizing fertilizer wastage for immature rubber plants which are quite appropriate to solve labor shortage problems especially in the Wet Zone. Development of environmental friendly and economically viable biofilm bio-fertilizer using effective microbes associated with rubber rhizosphere is yet another output to increase the available nutrients for plants and liquid organic fertilizer (*Shaka Sara*) using organic materials; mixture of green manure, farm yard manure, crop residues, Eppawela rock phosphate (ERP) and dolomite is an appropriate substitute for chemical fertilizer. Three soil maps relevant to rubber growing areas in Districts of Matara, Galle and Kegalle were developed and 15 different soil series were identified.

Research on tapping frequencies combined with chemical stimulation to increase yield resulted in significant outputs and low intensity harvesting systems (S/2 D4 and S/4 D3) were introduced to 63 ha of smallholdings and 45 ha in fields in RPCs. Solutions for tapping panel dryness, alleviation of drought stress using chemicals for rubber nurseries in non-traditional areas, and other physiological studies generated substantial technologies that contributed to improve the rubber cultivation immensely. Some of the research works on this area were recognized by awards at Plantation Crop Symposia.

Antagonistic fungi viz, *Trichoderma* and *Aspergillus* spp. were found effective against the fungal pathogen causing white- root disease. Survival of these biological control agents in different soils and climatic zones and mass production have to be perfected to achieve effective control of this disease in the fields. Agrochemical recommendations were given to control emerging new pest epidemic of cockchafer grub reported in some parts of Kalutara District.

New test method to estimate dry rubber content at field as replacement for metrolac, polythene and shade net mulch for management of weeds around the base of immature plants up to 18 months, protocol for local production of ethephon stimulant are some other noteworthy outputs.

Most of the technologies developed for the downstream activities were generated at the requests made by the processing and product development companies or aiming at solving the problems encountered by the clientele (eg: Synthetic rubber based compound for sliding shoe of crawlers was developed at the request of Road Development Authority, NR latex compounds suitable to produce parts of robot arms were developed for University of Moratuwa, NR latex foam suitable to manufacture ear plugs was produced at the request of an industrialist, Mechano-chemical reclaiming process for NR based carpet waste at the request of a rubber manufacturer, Non-conductive NBR based compound for grommet used in assembling of electric cables, SBR based compound for condenser end mount and wiring bunch bush and EPDM based compound for suction end mount on request made by a private company engaged in electrical components).

A patented environmental friendly mechano-chemical reclaiming process (Oreclaim) for ground rubber tyre using garlic was received Presidential awards in 2018. The same mechano-chemical process was applied to glove waste and shoe soles were produced by partially replacing the virgin rubber with this recycled material. The shoes consisting of these soles were produced and exported to Europe by a small scale shoe manufacturer.

Some of the research projects were conducted collaboratively with the entrepreneurs/ organizations (eg: High performance, lighter weight prosthetic foot based on nanomaterial filler was developed in collaboration with Sri Lanka Army). Hence, the technology transfer was quite effective and the clientele were satisfied with the outputs.

Some of the other remarkable outputs are as follows-, Natural rubber (NR) latex based adhesive with good storage and stability for shoes, Non-toxic NR latex based adhesive for paper and paint for rubber toys were developed and commercialized, NR –based fashionable gloves for protection against Covid-19 pandemic, Water-proof coating material for fabric tents was made out of NR latex compound. Reclaiming process for NR glove waste using an

environmental friendly and low cost novel reclaiming agent, novel method to synthesize *in situ* filler incorporated NR latex, Design of a new hybrid solar-bio mass dryer for rubber sheet manufacturing, green NR composites with surface treated fibers of pandanas (*Wetakeiya*), pineapple crown, areca nut husk or *Moringa olifera* crude extract were some other noteworthy outputs.

Researchers are conducting a large volume of commendable research work with limited manpower and other resources. They should be provided with required number of staff, internet facilities and access to international scientific literature to get updated themselves, facilitate collaboration with other relevant disciplines for thematic research programs and provide trainings especially on use of new developments of molecular techniques and other relevant scientific developments to achieve required innovations which would eventually uplift the rubber industry of this country.

Although many technologies developed by RRISL over the past decade, adoption of these technologies by the end-users in the sector is intangible. Stakeholders are of the view that some of the technologies are cost prohibitive.

## ***5.2. Information Dissemination / Extension***

Information dissemination on new technologies developed is carried out by different avenues, as mentioned in the Chapter 4.8. - *Partnership in managing information dissemination*. Publication of Research Bulletins and Advisory leaflets/circulars had been a good way of information dissemination, but that should be carried out regularly for smooth flow of information. Infrastructure and capacity of Audio- Visual Unit could be improved with modern Information & Communication Technologies (ICT) and that could be used by the ASD for technology transfer and communication purpose. We have observed that many innovations are not readily adopted by the growers. A study should be conducted to find out the factors inhibiting the adoption process and steps have to be undertaken to implement the remedial measures.

RRISL should develop good coordination between the partners providing rubber extension services *viz.*, RDD and *Thurusaviya* Fund etc., and work in collaboration with them to improve the quality of the Extension services. Ministry of Plantation and higher authorities may seek possibilities of restructuring the extension services of the rubber industry for providing efficient Communication and Technology Transfer.

### ***5.3. Research Publications***

The researchers of RRISL have published the outcomes of their research work in peer reviewed National and International journals. During the review period, 01 publication in an ISI journal, 10 in the other journals and 16 in Conference/Symposia Proceedings were observed. One book/monograph also was published (Annex-08).

Two Research Project Reports were compiled and handed over after completing research projects funded by NSF and SLCARP. Assistance for completing post-graduate research reports (*viz*, one M.Phil and one M.Sc ) and 12 under- graduate research project reports were provided by the researchers in different disciplines.

Quality of scientific writing has to be improved by providing trainings to young scientists and they have to be guided and encouraged publishing their research findings and also entering raw/analyzed data in a database/repository until they are published as those are Government property.

### ***5.4. Patents***

Researchers of Rubber Technology & Development Department (D.G. Edirisinghe, M.K. Mahanama, M.K.N.N. Rathnawardhana and R.P.D. Gunathilaka) obtained a patent for **‘Mechano-chemical Reclaiming Process (Oreclaim) for Ground Rubber Tyre using Garlic’**, which received Presidential Merit Award in the “Chemistry” category in 2018. This process is an environmental friendly reclaiming process for ground rubber tyre (GRT), produced from tyre waste using grinding machinery. The same mechano-chemical process was applied to glove waste and shoe soles were produced by partially replacing the virgin rubber with this recycled material. The shoes consisting of these soles were produced and exported to Europe by a small scale shoe manufacturer (commercialized).

Researchers of Plant Pathology & Microbiology Department have obtained a patent during the review period for a protocol on skeletonization of rubber leaves which could be used in handicrafts.

Scale and guidelines for commercialization of the patented outputs are not clear. The researchers should be able to commercialize the patented inventions or find avenues for commercialization; otherwise there is no use of obtaining patents and it would only be a mere prestige for them.

RRISL should establish policies and guidelines within the Government legal framework for Intellectual Property Rights, obtaining licenses and royalties for the innovations developed by the researchers and encourage commercialization and open up avenues for generation of funds for the Institute/Government.

### ***5.5. Services (Testing, Calibrations, Consultations, Advisory and etc.)***

In addition to research activities, almost all Departments of RRISL are providing services relevant to their specialty, free of charge or charging a nominal fee.

Summary of the service activities are given in the Annex-04. RRISL is conducting testing services on regular and upon request basis. Many clientele are satisfied with the analytical and other testing services provided by RRISL and especially the services provided by the Rubber Technology Departments as many research projects were tailor-made to fulfill the clientele' requirements.

Services provided could be improved further by obtaining laboratory accreditation (Soil & Plant Nutrients Dept. and Rubber Technology Depts. are already working on this process) and providing incentive payments for the officers engaged in those services. Upgrading necessary equipment that are outdated to provide quality services and enhance the delivery of services by FEASC as this model seems not sustainable the way it operates now. This kind of PPP should be promoted incorporating strategies to ensure its sustainability.

Regular revision of rates of service charges has to be effected with escalating input costs as most of the clientele are able to meet the costs.

### ***5.6. Trainings***

Five training centers are operated to fulfill the training needs of the officers in-service and also of the stakeholders.

#### ***Staff training programs-***

Summary of the training programs conducted are given in Annex-09. Both local and foreign training programs have to be regularized and transparent selection criteria should be developed to minimize the frustration among the staff members. All categories of staff should be provided trainings to improve their efficiency and to update knowledge.



### ***Trainings programs for Stakeholders-***

Regular training programs are conducted by the researchers and advisory officers to update the knowledge of the stakeholders on new technologies developed. Some of the training programs conducted are given in Annex-10.

Apart from the conventional training programs and field practical training programs, possibilities of using fast developing modern communication technologies such as social media has to be explored to provide trainings for many stakeholders, with scarcity of trainers and also in the current situation of travel restrictions with the spread of Covid-19 pandemic.

#### **\* Total S & T staff strength of institution**

According to the SAR provided by the RRISL, approved cadre of S&T personnel is 80 during the review period. Numbers of available S&T personnel were 40 and 33 in 2017 and 2018 respectively; while numbers of vacancies were 40 and 47 respectively in those years. Nevertheless, only 03 and 02 vacancies were filled in that period respectively, which is not at all adequate to carry out the planned research activities. (Table 1, page 38).

#### **\* Comments on productivity of institution based on outputs and S&T staff strength**

Table 02 – Scientific Staff (HODs, PROs, SROs, ROs \*) strength during the review period

Category	2017	2018	2019	2020
1. No. in the Cadre	75	75	75	75
2. No. filled /recruited	04	03	04	00
3. No. available	32	30	32	30
4. No. of vacancies	43	45	43	45
5. No. left for Universities/other jobs (local & abroad)	01	03	02	01
6. No. retired	01	00	00	01

(Source - Administration Dept., RRISL)

The above Table shows that the numbers of scientific staff available for research were 32- 30 (40% of the approved cadre) during the review period which were not at all adequate to carry out productive research and development programs. Numbers of vacancies are around 45 (60% of the approved cadre). Numbers of vacancies filled were 04, 03, 04 and 00 during 2017, 2018, 2019 and 2020 respectively resulting in a huge gap between young and senior generations of scientists.

This condition is not satisfactory for the future of the RRISL as the outputs and performances depend mainly on the trained scientific staff. Seven (07) senior scientists have left for Universities/other jobs during the review period, indicating unattractive benefits/facilities of RRISL. Further, Scientists should be motivated by providing good working environment, facilities for research work, incentives, awards and above all research guidance, training and advices from seniors.

Management should consider these factors and rectify the situation before it get deteriorate further as indicated elsewhere in this report. The researchers have made remarkable contribution even with shortage of S&T staff.

Some of the supporting services are running short of staff and delivery of outputs to carry out the main activities is hampered and eventually affecting the overall research outputs of the Institute. eg: vacancies of procurement officer, store keeper, all supporting staff for Network Administrator, 08 drivers, 23 supporting staff of the Works unit, labourers etc. are not filled for longtime, affecting productivity of the Institute.

## 6. Overview of the Institution's performance and contribution to national development

RRISL is the oldest Rubber Research Institute in the world and has a proud record of service to the rubber industry, and is the nodal agency charged with the statutory responsibility for research and development on all aspects of rubber cultivation and processing for the benefit of the rubber industry.

Performance of the Institute mainly depend on internal factors *viz*, quantity and quality of human resources including scientific, technical, supporting, administrative and management staff; infrastructure facilities, availability of research culture & peaceful environment etc. and external factors *viz*, Govt. policies, guidance of the line Ministry, other Govt. and non-governmental organizations, Service providers, National & International funding agencies, Scientific Apex Bodies, Universities, partners involved in TT, stakeholders including growers, processors, product developers, market facilitators, exporters etc.

The main activities of RRISL could be categorized into research, services, technology transfer and training of stakeholders

### ***Research-***

RRISL had provided several outstanding technological outputs (Chapter 5) to uplift the rubber industry of this country and contributed to the knowledge on cultivation of the rubber tree and technologies for processing and production of value added products since its inception.

RRISL is the pioneer in *Heavea* breeding and made remarkable achievements in improving the rubber genetic material of the Wickham's collection. More collections of germplasm received from International Rubber Research and Development Board (IRRDB) were used to broaden and improve genetic base further. These germplasm were established at Neuchatel Estate and multiplied at three locations representing major climatic zones *viz*, Nivithigalakele, Polgahawela and Moneragala. In addition, some clones were exchanged with several IRRDB member countries to broaden the genetic base which is an important avenue to diversify the germplasm available. Inter-species crosses are also being evaluated for obtaining further diversification.

The most outstanding contribution is the production of high yielding and high quality latex producing clones having higher timber volume of 2000 series with potential yield exceeding 3500kg/ha/yr. Furthermore, those clones were resistant to abiotic stresses (eg: drought) and

biotic stresses such as foliar fungal diseases (eg: *Corynespora* and *Phytophthora* leaf spots, powdery mildew caused by *Oidium* sp.) making that economically feasible and environmentally safe technology; as the growers need not to apply fungicides to control the diseases which is cumbersome, costly, environmentally unfriendly and unsafe. Tolerance to Tapping Panel Dryness (TPD) and Low-Frequency Tapping (LFT) and high timber volume are other important selection criteria in progeny evaluation. Use of molecular methods such as marker assisted selection to shorten the breeding cycle is a significant breakthrough.

Research on nursery management, intercropping, tapping frequencies combined with chemical stimulation to increase yield, solutions for tapping panel dryness, alleviation of drought stress using chemicals for rubber nurseries in non-traditional areas, biochemical and physiological studies generated substantial technologies that contributed to improve the rubber cultivation immensely. Some of the research works on this area were recognized by awards at Plantation Crop Symposia.

Tissue culture of rubber was perfected but proliferation rate was low. Even though micro propagation of rubber for multiplication and mass production of planting material are not feasible and profitable, this technique could be used to produce plant tissues that are used in laboratory breeding techniques such as genetic transformation, mutation breeding etc. Further, tissue culture of some medicinal plants were perfected and that could be used for mass production of planting material to fulfill demand as those were found profitable intercrops with rubber.

Fertilizer encapsulated coir bricks and reusable porous fertilizer tubes were developed as devices of slow release fertilizer for rubber, reduced fertilizer application cost which are commendable options for labor shortage and over-use of fertilizer. Investigations on organic fertilizer resulted in finding a good compost mixture and a liquid organic fertilizer for nursery and immature field plants are quite appropriate for present situation of replacing inorganic fertilizer. Research on mulching with shade nets and polythene found to control weeds effectively as an alternative to weedicides which are considered to pollute environment and unsafe for human health.

White root disease of rubber caused by fungus *Rigidoporus microporus* which is soil-borne and highly destructive and the method of control is removal of infected roots and treatment of infected soil with fungicides which is a laborious operation. Researchers have found antagonistic fungi effective against this pathogen *in-vitro*; if field survival of this bio-control agent is successful and mass production technologies are perfected, it would be a good breakthrough for control this disease.

Some valuable contributions for processing and product development sector which has very high scope for local as well as export market were made by the Rubber Technology Departments. eg: High performance lighter weight prosthetic foot filled with nanomaterial was developed in collaboration SL Army for disabled, Natural rubber (NR) latex based adhesive with good storage stability for shoes, Non-toxic NR latex based adhesive for paper was developed and commercialized, Non-toxic NR latex based paint for rubber toys, Synthetic rubber based compound for sliding shoe of crawlers was developed at the request of Road Development Authority, NR latex foam suitable to manufacture ear plugs was produced at the request of an industrialist, NR latex compounds suitable to produce parts of robot arms were developed for University of Moratuwa, NR –based fashionable gloves for protection against Covid-19 pandemic, Water-proof coating material for fabric tents was made out of NR latex compound. These contributions increased export earnings of rubber sector significantly in the past decade.

### ***Services-***

The Institute is carrying out many services relevant to the rubber industry on regular basis to fulfill the requirements of the clients.

Quality certification of rubber nursery plants is carried out by the research officers had resulted in significant improvement of the plants issued by the government and private sector plant nurseries. Issue of technically specified tapping knives and marking stencils, valuation of damaged trees and fields are other services provided.

Land suitability evaluation and recommendation of appropriate corrective measures for unsuitable lands, site-specific fertilizer recommendations and soil, water, plant and fertilizer sample analyses are commendable services provided to the stakeholders. In addition, three soil maps relevant to rubber growing areas in Districts of Matara, Galle and Kegalle were developed and 15 different soil series were identified.

Issue of Internationally recognized RRISL certificate for raw rubber and rubber processing chemicals for export purpose, test services for rubber industry including waste velar, testing of rubber compounds and products according to international standards, advice and assistance on rubber based products manufacture microbiological reports on rubber related products and soil samples and testing of imported rubber samples for pathogens of quarantine importance are other contributions of the service sector.

## ***Technology transfer and Training of Stake holders -***

Researchers have published their findings in National and International journals, presented and published in conferences, symposia, workshops and seminars. Some have published their findings and recommendations in books/monographs. In addition, Annual Reviews, Annual Reports, Research Bulletins (*'Rubber puwath'* in Sinhala), Advisory Circulars/Leaflets in Sinhala & English and strategic extension programs are conducted by the Advisory services Department. Training programs conducted at Nivithigalakele, Rathmalana, Kalutara, Kegalla and Rathnapura. Further, Under-graduates, Post-graduates and Diploma students and school children are provided requested trainings/knowledge on available technologies.

## 7. Outcomes of Stakeholder Meetings/ Replies for Questionnaires

The review team was unable to have direct meetings with the representatives of the stakeholders as travel restrictions were imposed due to spread of Covid-19 virus pandemic, hence some selected categories of the stakeholders were given questionnaires (Annex-11) to get the feedback needed. Replies of them are summarized and given below. In addition, virtual meetings through Zoom app. were also conducted and most of them were highly cooperative in providing information requested. The contacted categories of stakeholders were as follows-

- a) Estate Managers/Planters' Associations
- b) Nursery Managers
- c) Rubber Smallholders
- d) Rubber products (latex based/ wood based) Manufacturers
- e) Extension Officers of Rubber Development Department
- f) Officers of *Thurusaviya* Fund
- g) Relevant University Researchers
- h) Funding Agencies
- i) Relevant Ministry Officials

The key points highlighted by them are summarized below.

### **a) Estate Managers /Planters' Associations-**

- ✳ Importation of raw latex resulting in reduce prices in the market is a problem.
- ✳ Have a good communication network with RRISL, satisfied with TT & analytical services provided by RRISL, aware of the new technologies developed by RRISL and no difficulties encountered in adopting those.
- ✳ Training needs are agronomic practices on rubber and processing.

#### **b) Nursery Managers of RDD-**

- \* RRI officers are regularly visiting for advises on thinning out unacceptable nursery plants and giving other advises. Capacities of their nurseries are 1,500,000 plants annually. However, the demand is higher than that as some local companies are entering the rubber industry recently.
- \* Shortage of seeds for stock plants due to irregularity of rainfall pattern experienced recently and lack of long term seed storage technologies without losing germination.
- \* Need for establishment of seed gardens with profuse seed producing clones in the Intermediate Zone.
- \* Seek possibility of importing inorganic fertilizer for use in the rubber nurseries or recommend suitable liquid organic fertilizers/ slow-release fertilizers.
- \* New technologies for control of *Pestalotia* and other leaf diseases are needed as importation of fungicides are prohibited.

#### **c) Rubber Smallholders-**

- \* Knowledge on new technologies is not conveyed to the growers and processors readily and efficiently due to unavailability of sufficient number of field officers and as a result, the field officers have to cover a large area while facing shortage of transport facilities.
- \* Latest technologies on tapping frequencies for high yielding clones as a package are not properly transferred to the growers resulting in tapping panel dryness and low productivity.
- \* Need knowledge on clone identification and differences of newly released clones from the earlier released ones.
- \* Latest technologies in management of foliar and root diseases are lacking and present recommendations to manage white-root disease is cumbersome and cost prohibitive.
- \* Explore possibilities of mechanization of tapping. Information needed on suitability and cost effectiveness of the tapping machines imported from China and distributed among growers sometimes back.
- \* Request for advisory leaflets, especially *Rubber puwath* published in Sinhala language and make those available for the growers to buy from the nearest Agrarian Centers/ RDD Extension office.



- \* Requested to disseminate information on new technologies developed through mass and social media as many were unaware of those due to poor communication and information dissemination.
- \* Need information on daily rubber price fluctuations and prefer if this information disseminated through mass media or uploaded to the website of RRISL regularly.
- \* Need to improve marketing facilities as they have to transport the sheet-rubber to the major cities to get better prices.
- \* It was highlighted to include the area under rubber cultivations also as a forest cover of Sri Lanka in data on National forest cover information.

#### **d) Rubber products (latex based/ wood based) Manufacturers**

- \* **Problems encountered are** – Fluctuation of rubber prices, lack of good quality NR and less developments in raw rubber processing factories, lack of persons competent in machinery repairs in crepe rubber factories, high price of imported machinery, lack of export market promotion, lack of access to international research information and new technologies, lack of some testing facilities & new compounds with quality specifications and information on foreign rubber end-users.
- \* **Suggestions to overcome the problems are-** Tax concessions for raw rubber, produce SR locally, establish a fund to maintain reasonable price for both growers and manufacturers, provide more facilities out of Western Province and improve rubber production, enhance research on quality improvement on NR and provide trained staff & necessary equipment to RRISL, increase collaboration with industrial and University experts, assistance in increasing communication with foreign buyers & end-users and to explore foreign markets, facilitate more participation in exhibitions and produce at least major chemicals locally (eg: amorphous silica).
- \* **Research areas need to be developed are-** Automobile, high-tech. products, medical accessories, rubber machinery and development of new products.
- \* **Support needed form RRISL are-** Improve rubber production, formulation consultation, advanced material testing, develop & test properties of new compounds, development of market oriented technologies, facilities for nitrosamine test, issue accredited test reports, solutions for problems in manufacture, industry related updates and strengthen communication via Scientific Committee meetings, create social media groups and issue quarterly newsletters regularly.

- \* **Problems in adopting technologies of RRISL are-** Some technologies are expensive, lack of guidance from experts & of training in introducing technologies, lack of compatibility of new technologies with applications, SR for special applications and standards & chemicals in the market.
- \* Most are satisfied with the services provided by RRISL even with limited resources.

**e) Director/ *Thurusaviya* Fund**

- \* 831 farmer committees formed and strengthened. TT is carried out in collaboration with RRISL; however there are overlaps in farmer trainings.
- \* More communications are needed with farmers and manufacturers to identify research needs and research should target the specific issues of the industry.
- \* Requested RRISL to develop technology to produce a highly-efficient machine for production of RSS, similar to that available in India.
- \* Field officers are not getting sufficient training from RRISL.
- \* Training needs- Rubber marketing, tapper training, basic rubber smoke houses and new industries & opportunities.

**f) Secretary General, Sri Lanka Rubber Secretariat**

- \* As long as the cost of replanting and the actual yields are considered, rubber industry is unviable. New clones released by the RRI seem not achieving desired results in the fields and there is a huge yield gap (2000 vs 700 latex kg/ha/year).
- \* Need for good demonstration trials was emphasized.
- \* Value addition to natural rubber has a huge potential in earning foreign exchange and this need to be capitalized.
- \* Condition of the RRISL and its staff to be improved and give them reasonable salaries and perks in order to retain the trained staff.

## 8. Overall Judgment on Different Aspects & Recommendations for Improvement

The review team recognizes the research and development outcomes of the Institute and services offered with limited number of S&T personnel to enhance the productivity of the rubber industry of this country. We have witnessed mixed attitudes of staff on the facilities available; however some scientists were of high morale and having high job satisfaction while some others were not quite satisfied.

Nevertheless, the productivity of the rubber cultivation of Sri Lanka was declining at an alarming rate in the recent past due to various reasons including ineffective technology transfer. Developments in the review period and the recent past indicated that the RRISL was facing problems mainly on management, research and technology transfer aspects which eventually affected the overall performances of the Institute.

We have carried out SWOT analysis based on the information collected, and that is given in Annex- 01, and the suggested recommendations for improvement are given below.

**The review team hope that the RRB, management and the staff of RRISL would give due consideration to implement the suggested recommendations to uplift the present status of RRISL and thereby improve the rubber industry of this country.**

### ***8.1 Recommendations on Management-***

- 1) Ensure to appoint a competent personal for the Director post, the top most management position of the Institute urgently, which is being vacant for more than 03 years; deteriorating overall management of the Institute.
- 2) Fill the vacancies of Science & Technology staff positions urgently (more than 50% of the approved carder positions are vacant at present), as fresh recruits require at least 8-10 years for acquiring qualifications and experience to become an independent researcher to work without guidance.
- 3) Take steps to convince the Government to update salary structures, allowances (especially the subsistence for field officers working in non-traditional areas where accommodation is needed in nearby hotels), incentives, rewards etc. and provide comparable facilities to that of Universities to retain most valuable human resources in the Institute.

- 4) As a short-term remedial measure to fill the vacuum of qualified scientists available for research and guiding of young researchers, recruit retired scientists on contract basis as senior scientists exclusively for a specified period for identified projects or tasks without holding administrative posts.
- 5) Ensure that progress, decisions and implementations/actions taken by Administration Department, RRB and the four Standing Committees *viz.*, Estate Committee, Audit and Management Committee, Provident Fund Committee and Scientific Committee to be reported in Annual Reports of RRISL.
- 6) Increase the awareness of staff members on Vision, Mission and Objectives of the Institute and changes of relevant external environment such as Government policies, stakeholders' requirements, behavior of local and global scenario of the rubber industry and scientific developments in the world should be considered when planning and formulating Action and Strategic plans; as the Institute has a wider role to play at National level.
- 7) Regularly review and adjust the R&D directions and goals, to meet the ever-changing stakeholder needs including representatives from smallholders, by organizing stakeholder dialogue exclusively focusing on need identification and prioritization of R&D programs at least biennial (once in two years).
- 8) Ensure that the researchers have access to relevant global scientific information to strengthen the quality of research. Explore the possibilities of getting support from scientific Apex bodies like NASTEC, CARP, NSF, NRC and international organizations to obtain content pages of relevant journals and important publications from publishers like Science Direct, Springer, Blackwell and etc.
- 9) Seek broader scientific linkages among national and international agencies and Research Institutes to enhance the quality of research outputs and explore the possibility of having agreements to exchange scientific journals with local and foreign Universities, International Research Institutes and other relevant bodies.
- 10) SWOT analysis of the institute should be updated regularly with participation of all categories of staff for formulating measures to alleviate Weaknesses and Threats while obtaining maximum output of Strengths and Opportunities in planning organizational strategies.
- 11) Scrutinize the R&D programs of different Departments/Units to avoid duplication of research work and build formal, strong and dedicated research teams on research theme/ program/activity basis and facilitate coordination and inter-Departmental

research collaboration. Management intervention at the two DDRs level should be central for inter-disciplinary coordination and communication.

- 12) Identify priorities within the Institute's Action plan and allocate funds and other available resources accordingly on program basis to realistically complete the planned activities in time.
- 13) Appoint a standing committee comprising of external experts, relevant members of Rubber Research Board, Relevant Line Ministry personal and stakeholders (may be named as **Consultative Committee on Research Planning & Monitoring**) to scrutinize, evaluate the appropriateness and approve the planned Action and Strategic Plans and Monitor & Evaluate the progress of implemented research programs.
- 14) Formalize and regularize the Progress Monitoring and Evaluation procedure by obtaining the guidance of the above mentioned Consultative Committee.
- 15) Establish a formal '**Clonal and Technology Release Committee (CTRC)**' comprising relevant members of RRISL, RRB, RDD, Estate sector, Smallholders, Stakeholders of processing and value addition sectors and other relevant external experts for approving release of new clones and new technologies.
- 16) Strengthen research on seed production and storage as nursery managers find difficulties in obtaining quality seeds in sufficient quantities for production of good quality seedlings for root-stocks. Ensure to allocate budget provision for these activities and prioritize.
- 17) Advise the RDD to establish seed gardens with profuse seed producing clones in suitable climatic zones preferably in forest areas with the support of Forest Department to meet the increasing demand of stock plants for their nurseries.
- 18) Upgrade information & communication technology section of Audio Visual & IT Unit to strengthen TT activities and amalgamate ARU, and ASD to deliver efficient advisory service to the stakeholders and effectively utilize scarce resources..
- 19) Create a strong Research Department combining Biometry Unit and AEU as there would be better synergistic effect when they work together and strengthen marketing research to advise the growers and manufacturers on market behavior to maximize income earned.

- 20) Ensure strengthening of research on Rubber Technology Development (processing & value addition) by providing necessary human resources and other facilities as the four Technology Departments suffer lack of researchers as well as assisting staff and updated equipment.
- 21) Facilitate proper collaboration and coordination among the relevant public sector key institutes operated in the rubber industry value chain viz, Rubber Development Department (RDD), EDB, IDB/RPDSC, Rubber Products Development and Services Center (RPDSC) and ITI to cater the needs of the Industry effectively.
- 22) Explore the possibilities of improving internet and telecommunication facilities at Dartonfield and Substations.
- 23) Review the present Performance appraisal procedure of staff by appointing a competent committee/ organization and revise to cater the needs of present and future challenges.
- 24) Ensure to give high priority and allocate funds for training of all categories of staff on regular basis and develop a 2-3 year training plan for the entire staff. Allocate sufficient funds to provide Post-graduate trainings in reputed foreign Universities whenever possible.
- 25) Develop a mechanism to identify training needs and selection of suitable officers for trainings. It should make compulsory that the officers promoted to higher posts and the officers in line for higher promotional posts should be given relevant trainings as a routine measure to carry out responsibilities effectively in their new and expected to promote posts respectively.
- 26) Establish recruitments/ promotions/rewards/incentives schemes to motivate all categories of staff and ensure approval of the proposed draft of Scheme of Recruitment (SOR) with the consent of staff and including relevant suggestions forwarded by them to streamline recruitments and promotions.
- 27) Develop an updated Management Information system (MIS) with details of staff, information on research, organizational assets, administration and financial data and other relevant information to facilitate the management to take correct decisions timely in managing the resources and activities.

- 28) Improve the efficiency of procurement procedure to avoid unnecessary delays in buying equipment and spare parts for equipment, machinery and vehicles.
- 29) Ensure availability of sufficient number of vehicles for field work and technology transfer activities and seek possibility of outsourcing urgent needs to speedup service deliveries. eg: vehicle repairs, maintenance of staff quarters etc.
- 30) Develop a procedure for procurement of spare parts for maintenance of imported laboratory equipment and after sale services from relevant foreign mother companies, with assistance of the other sister laboratories. Possibility of obtaining support from Apex bodies like NSF, NRC, NASTEC, CARP etc. should be explored for this purpose as many local scientific institutes face similar problems.
- 31) Appoint a committee comprising scientists/ competent authorities with good knowledge on protection of intellectual property rights (IPR), obtaining patents and commercialization of outputs; for preparation and approval of guidelines of IPR and improve knowledge and awareness of the scientists on the new developments of this area.
- 32) Improve industry-institutional relationships by facilitating more effective and frequent target oriented working relationships among the private sector/RPCs (industry), state institutions such as Universities and other relevant Research Institutions

## **8.2. *Recommendations on Research and Extension-***

- 33) Ensure researchers review relevant scientific literature and acquire knowledge on current developments of the rubber industry before reviewing or formulating Annual Action & Strategic Plans.
- 34) Ensure the researchers consult Biometry Unit to get advice on statistical validity in experimental designing at the early stages of research planning, at data collection during implementation of experiments and on data analysis after completion of the research projects by the researchers, to minimize experimental errors.
- 35) Ensure obtaining support of the Agric. Economics Unit for economic analysis (cost/benefit etc.) at research planning and of final research outputs to increase

adoption of technologies transferred. Reports on economic viability of the new matured technologies expected to be released should be forwarded to the proposed Technology Release Committee meetings when releasing technologies/ new clones etc.

- 36) Ensure that Adaptive Research Unit test the adaptability of developed matured technologies with the support of the relevant researchers who developed the technologies, researchers of Agric. Economics Unit and Advisory Department, extension officers of RDD and managers/ growers of respective estates; in different locations both in smallholdings and large estates, with relevant processors/ manufacturers and fine tune the developed technologies before releasing those; to facilitate adoption process.
- 37) Establish a proper mechanism to archive research data by developing a **digitized comprehensive repository of information** on research projects including those funded by different agencies and incorporate into a modern MIS system and update regularly. Researchers should feed raw and processed data of experiments (confidentiality and accessibility should be secured), financial progress, constraints and other information necessary for smooth management of the research projects, while research projects are being implementing regularly and after publishing outcomes.
- 38) Ensure the Advisory officers carry out a survey together with the other partners of technology transfer to find out the real factors affecting smooth technology transfer and make necessary measures for restructuring the current extension procedure as many technologies developed by the researchers are not reached or adopted by the end-users resulting in broadening the yield gap between the researcher and the grower. (Support from University staff and students may be obtained for the purpose of carrying out the survey).
- 39) Publication of Research Bulletins, Advisory leaflets/circulars had been a successful way of information dissemination, but that should be carried out regularly and published in local languages for smooth flow of information and ensure that those reach the clientele especially the smallholders.
- 40) Use fast developing communication technologies for information dissemination, to overcome the shortage of field officers. A dedicated telephone line, social media groups, TV and radio programs are some of the media that could be used for this purpose. Ensure that Rubber price fluctuations be broadcasted/ telecasted daily as in the past.



- 41) Launch Public awareness programs through mass and social media. Researchers should make it a habit to write to the Newspapers, provide news items to Television and other mass and social media on new research findings and other developments to increase awareness of the Public. Encourage all researchers to write 1-2 page leaflets on topics of current issues and disseminate among relevant stakeholders for a nominal fee. Ensure ASD coordinate these activities.
- 42) Audio- Visual & IT Unit has to be upgraded with necessary equipment, recruit IT specialists and train staff to cater the needs of the clientele and make use of modern technologies to enhance technology transfer by the Advisory Services Department.
- 43) Establish 'Model Farms' as demonstration purpose in estates of Dartonfield group and sub-stations *viz*, Nivithigalakele, Kuruwita, Polgahawela and Monaragala where smallholders, estate managers and other interested parties could obtain knowledge on latest recommended technologies. Special attention should be paid to demonstrate the yield potential of new clones (claimed by the breeders).
- 44) Station at least one advisory field officer at Polgahawela, Kuruwita and Monaragala Sub-Stations and provide necessary infrastructure facilities to facilitate technology transfer.
- 45) Create a formal platform for all partners of technology transfer and take the leading role in organising '**Research-Extension Dialogue**' annually to discuss about the new technologies developed, get feedback from field officers on problems in transferring technologies, socio-economic and other obstacles faced by smallholders in adopting technologies, identify researchable problems etc. and implement a collaborative working plan for technology transfer.

### **8.3. *Recommendations on Services***

- 46) Ensure that the laboratories get accreditation for issuing internationally accepted analytical and other test reports and provide relevant trainings for scientific and technical staff on new developments of testing methods.
- 47) Ensure proper maintenance of equipment and safety of the scientists and technicians.
- 48) Revise service charges regularly to cover the cost of consumables as well as overheads and explore the possibility of generating income for the Government and providing incentives for the S&T personnel involved.
- 49) Give wider publicity to the services offered by Finite Element Analysis & Simulation Center (FEASC) to optimize utilization of the facilities and improving the value addition sector. Consider paying incentives for the RRISL officers involved in providing services in the center.

## 9. References

### **Websites perused:**

FEASC (Finite Element Analysis and Simulation Centre) website: <https://www.feas.lk/>

Industry Capability Report: Sri Lankan Rubber Product Sector - Export Development Board (EDB), Sri Lanka, December 2019

RRISL website: <http://www.rrisl.gov.lk/>

RRD website: <http://www.rubberdev.gov.lk>

Rubber production in Sri Lanka, Wikipedea

### **Web Documents perused:**

Rubber Research (Amendment) Act (No. 28 of 2003)

Rubber Research (Amendment) Act (No. 39 of 1987)

Rubber Research (Amendment) Act (No. 4 of 1979)

Rubber Research (Amendment) Law (No. 35 of 1976)

Rubber Research (Amendment) Act (No. 58 of 1961)

Rubber Products Development and Services Centre (RPD&SC) of IDB

[https://www.idb.gov.lk/index.php?option=com\\_content&view=article&id=64&Itemid=112&lang=en](https://www.idb.gov.lk/index.php?option=com_content&view=article&id=64&Itemid=112&lang=en)

### **National Plantation Industry Policy (NPIP) Framework:**

<http://plantationindustries.gov.lk/web/images/pdf/publications/npip.pdf> [Accessed on 5.3.2021]

### **National Policy framework of the Government of Sri Lanka:**

<http://www.doc.gov.lk/images/pdf/NationalPolicyframeworkEN/FinalDovVer02-English.pdf>[Accessed on 5.3.2021]

**Sri Lanka Rubber Industry Development Master Plan 2017 -2026:** A National Agenda For Rubber Industry Development formulated by the Sri Lanka Rubber Secretariat (<https://www.srilankabusiness.com/pdf/blogs/rubber-master-plan-2017-2026.pdf> [accessed on Apr 16 2021].)

### **Other documents perused:**

Review Manual, Procedure for Performance Review of S&T Institutes, National Science and Technology Commission

RRISL Self-Assessment Report submitted to NASTEC (2019)

RRISL Strategic Plan (2017-2019)

RRISL Action Plan – 2018, 2019, 2021

RRISL Annual Reports – 2017, 2018, 2019, 2020

RRISL Annual Review reports – 2017, 2018, 2019

Strategic Plan – Rubber sector (2021 – 2025), State Ministry of Company Estate Reforms, Tea & Rubber Estates Related Crops, Factories Modernization and Tea & Rubber Export Promotion

Sri Lanka Rubber Industry Development Master Plan 2017 -2026: A National Agenda for Rubber Industry Development Sri Lanka Rubber Secretariat, Ministry of Plantation Industries, Sethsiripaya Stage II, Battaramulla, Sri Lanka

Journal of RRISL – 2017, 2018

Hand guide to Royal Botanic Gardens Peradeniya, 1885

Royal botanic gardens circulars, 1898

Administrative reports of Botanic Gardens Ceylon, Ceylon Administrative reports, Administrative reports of Department of Agriculture 1876, 1877

Dissanayake D M A P and Wasana Wijesuriya (2012). Growing rubber in Uva, Northern and Eastern provinces of Sri Lanka: Importance of an effective Institutional role; *Journal of the Rubber Research Institute of Sri Lanka*, (2012) **92**, 78-91

Lindamudalige P, (2017) Complexities of in the Rubber farming sector, The Sunday Times 22 Oct. 2017 in <https://www.sundaytimes.lk/171022/business-times/complexities-in-the-rubber-farming-sector-264616.html>)

Waidyanatha P., J de Costa, L Karunanayake, J Weerahewa (2017) Review of Research & Development of RRISL 2010-2016. 111pp.

Weeraratne CS (2017) Unrealistic projects in the rubber sector, The Sunday Times, 5 November 2017 (<https://www.pressreader.com/sri-lanka/sunday-times-sri-lanka/20171105/282741997069157>)

Scheme of Recruitment of RRISL – Current version and revised documents.

## 10. Annexures

### Annex 01 - SWOT Analysis

#### *a) Strengths-*

- Nodal agency in Sri Lanka with statutory responsibility for research and development on all aspects of rubber cultivation, processing and product development and vested with wide power by Act of Parliament.
- More than 100 years' experience and reputation in research & development on rubber and has received many local and international awards.
- Dedicated highly qualified senior scientific staff and trained supporting staff.
- Well managed infra-structure facilities.
- Residential facilities for all categories of staff and daily transport facilities from and to Ratmalana sub-station.
- Availability of own estates and regional stations to support R&D, Extension and training activities
- Mutually beneficial links with National and International scientific organizations
- Financial assistance received from the Government for all activities and additional funds available from different funding organizations for contract research projects.
- Availability of advanced, fully fledged service facility -FEASC, operated in PPP model

***b) Weaknesses-***

- Inability to fill the existing vacancy of the Director post causing managerial problems.
- Large number of unfilled vacancies of S&T personnel hampers smooth implementation of research programs, training of stakeholders and technology transfer.
- Poor remuneration package to recruit and retain qualified personnel in senior research positions is a major hindrance for research activities.
- Unavailability of updated data base/ MIS system hampers management in making correct decisions in time.
- Unavailability of digital repository of research data resulting in loss of invaluable research information.
- Inability to accept the fast developing digitization technologies with relevant software facilities for data base improvement.
- Distraction of highly qualified staff due to isolated nature of the main research Institute and less career development prospects.
- Inadequate library, internet and telecommunication facilities at Dartonfield and some sub-stations.
- Inadequate transport facilities for field work and for technology transfer activities.
- Fewer opportunities for post-graduate and short-term trainings with international experiences.
- Less developed research culture and team spirit among staff, hamper achieving focused outputs.
- Inadequate support from some stakeholders for adaptability testing of newly developed clones and technologies.
- Insufficient adaptability testing of new technologies in different holdings of grower categories and climatic zones causing difficulties in adoption process after recommending those.
- Inadequate infra-structure facilities at Sub-stations.
- Inadequate integrated approach among the partners of technology transfer.
- Less adoption of new technologies by the growers.
- Decreasing trend of national average of rubber production and cultivated extent.
- Inability to invent suitable machinery for inter-cultivation, tapping and processing of latex.
- Frequent meetings and numerous report writing do not provide sufficient time allocation for research activities.

- Some level of frustration among the assistant staff categories due to the delays and procedure adopted in promotions.
- Absence of a proper performance evaluation system

*c) Opportunities-*

- Increasing demand for natural rubber in local and global manufacturing sector.
- Steady increase of growth in local value addition sector.
- Closer links with manufacturers and staff at Technology Departments.
- Attraction of young generation for rubber cultivation and availability of land and labour in non-traditional areas.
- Government support for growing rubber in non-traditional areas.
- Feasibility of income generating intercropping with some cash crops.
- Availability of 10 year Master Plan for rubber with clear directions and partnerships
- Major responsibilities on development of technological innovations were given to RRISL in Rubber Master Plan prepared by the Ministry.

*d) Threats-*

- Global spread of Covid-19 virus pandemic resulted in imposing travel restrictions and paralyzed almost all activities of RRISL.
- Leaving of highly qualified experienced scientists for better jobs in local and foreign Universities.
- Ad hoc national policies and their implementation affect/interrupt planned R&D program

## **Annex 02 - Technologies developed**

- Fertilizer encapsulated coir bricks as a slow release fertilizer.
- Three soil maps relevant to rubber growing areas in Districts of Matara, Galle and Kegalle and 15 different soil series were identified.
- High performance, lighter weight prosthetic foot based on nanomaterial filled was developed in collaboration with SL Army.
- Non-toxic NR latex based paint for rubber toys.
- Synthetic rubber based compound for sliding shoe of crawlers was developed at the request of Road Development Authority.
- NR latex foam suitable to manufacture ear plugs was produced at the request of an industrialist.
- NR latex compounds suitable to produce parts of robot arms were developed for University of Moratuwa.
- NR –based fashionable gloves for protection against Covid-19 pandemic.
- Green NR composites with surface treated fibers of pandanas (*Wetakeiya*), pineapple crown, areca nut husk or *Moringa olifera* crude extract.

## **Annex 03 - Technologies transferred to industry / entrepreneurs**

- Latest technologies for fertilizer application, soil rehabilitation and land preparation for stakeholders.
- Slow release fertilizer for rubber nursery plants to reduce fertilizer application cost by 90%.
- Environmental friendly and economically viable biofilm bio fertilizer using effective microbes associated with rubber rhizosphere.
- Reclaiming process for NR glove waste using an environmental friendly and low cost novel reclaiming agent.
- Imidicloprid was recommended as a substitute for Chlorpyrifos to manage epidemic of Cockchafer grub reported from Elpitiya, Horana, Padukka and Avissawella.
- Antagonistic fungi against causal fungal pathogen of white root disease from rubber growing soils and used as a bio- control agent.
- Novel method to synthesize *in situ* filler incorporated NR latex.
- Design of a new hybrid solar-bio mass dryer for rubber sheet manufacturing.
- Establishment of model rubber holdings, villages and processing centers.
- New test method to estimate dry rubber content at field as replacement for metrolac.



- Reusable porous fertilizer tube with maximizing fertilizer efficiency and minimizing wastage for immature rubber plants.
- Liquid organic fertilizer (*Shaka Sara*) using organic materials; green manure, farm yard manure, crop residues, ERP and dolomite.
- Polythene and shade net mulch for management of weeds around the base of immature plants up to 18 months.
- Protocol for local production of ethephon stimulant.
- Low intensity harvesting systems (S/2 D4 and S/4 D3) were introduced to 63 ha of smallholdings and 45 ha in fields in RPCs.
- Mechano- chemical reclaiming process for NR based carpet waste at the request of a rubber manufacturer.
- Non-conductive NBR based compound for grommet used in assembling of electric cables, SBR based compound for condenser end mount and wiring bunch bush and EPDM based compound for suction end mount on request made by a private company engaged in electrical components.
- Natural rubber (NR) latex based adhesive with good storage stability for shoes.
- Non-toxic NR latex-based adhesive for paper was developed.
- Water-proof coating material for fabric tents was made out of NR latex compound.

#### **Annex 04 - Services (Testing, Calibrations, Consultations, Advisory and etc.)**

- Issue of Internationally recognized RRISL certificate for raw rubber.
- Issue of quality certificate for rubber planting material and advisory services for maintenance of rubber nurseries.
- Test services for rubber industry including waste velar.
- Issue of quality certificate for raw rubber and rubber processing chemicals (export consignments need this certificate).
- Testing services of soil, plant and fertilizer samples.
- Providing microbiological reports on rubber related products and soil samples.
- Providing sample testings for the pathogens of quarantine importance (upon importations).
- White root disease surveying programme and advising on control measures.
- Testing of rubber compounds and products according to international standards.
- Advice and assistance on rubber based products manufacture.

**Annex 05 - Collaborative Projects of Technology Departments, being implementing with external Research Agencies**

No.	Project	Participating Institute
1.	Use of modified rubber as a coupling agent in natural rubber composites	D. Samson Group Pvt. Ltd., Kadawatha, Mahara
2.	Use of sand sludge generated at drinking water treatment plants as a filler in tyre manufacture	Camso-Loard Star PLC and Global Rubber Industries
3.	Novel method of making centrifuged latex with different characteristic features, especially targeting reduction in extractable proteins.	Dipped Product PLC
4.	Feasibility study of GEO 40 Colloidal Silica from GEO 40 in rubber product manufacturing applications	The University of Auckland, NewZealand.
5.	Introduction of new preservative system for NR field latex	Collaborative Industry / University: Glenross Rubber Company (Pvt) Ltd
6.	Effect of calcium carbonate nanoparticles on the properties of natural rubber vulcanizates	University of Peradeniya, Sri Lanka Institute of Nanotechnology
7.	Development of a novel reclaiming process for rubber band waste	Lalan Rubbers
8.	Development of a novel modification process for rigid polyurethane foam waste	D. Samson Industries, Galle and University of Sri Jayewardenepura
9.	Development of a natural rubber based fishing bait	National Aquatic Resources Research and Development Agency (NARA)

### Annex 06 - Financial progress of different Departments

Name of the Department	2017 (Rs. Mn)			2018 (Rs. Mn)			2019 (Rs. Mn)			2020 (Rs. Mn)		
	Estimated Budget	Received Budget	Spent Budget	Estimated Budget	Received Budget	Spent Budget	Estimated Budget	Received Budget	Spent Budget	Estimated Budget	Received Budget	Spent Budget
Plant Science Dept.	2.69	2.69	2.69	2.93	2.93	2.93	5.86	2.93	2.93	2.93	2.93	2.87
Plant Pathology Dept.	2.64	2.64	2.64	2.16	2.16	2.10	4.32	2.16	2.19	2.16	2.16	2.55
Genetics & Plant Breeding Dept.	1.60	1.60	1.60	1.08	1.08	1.58	2.16	1.08	2.58	2.04	2.04	2.75
Soils & Plant Nutrition Dept.	2.04	2.04	2.04	1.62	1.62	1.52	3.24	1.62	1.62	1.62	1.62	1.35
Biochemistry Dept.	2.53	2.53	2.53	1.08	1.08	1.08	2.16	1.08	1.30	1.02	1.02	0.95
ASD & Training Centre	2.06	2.06	2.06	0.49	0.49	0.57	0.98	0.49	0.98	0.50	0.50	1.75

<b>R.R. &amp; C.A. Dept.</b>	1.37	1.37	0.99	2.71	2.71	2.50	5.40	2.70	1.60	1.80	1.80	1.75
<b>R.R. &amp; C.E. Dept.</b>	1.27	1.27	1.27	2.27	2.27	2.12	4.54	2.27	2.34	2.27	2.27	1.48
<b>RT &amp; D</b>	0.64	0.64	0.64	2.16	2.16	1.85	4.32	2.16	1.56	2.16	2.16	1.15
<b>Polymer Chemistry Dept.</b>	0.95	0.95	0.94	2.16	2.16	2.13	4.32	2.16	1.39	2.16	2.16	1.10
<b>Adaptive Research Unit</b>	1.04	1.04	1.30	0.66	0.66	0.85	1.32	0.66	0.75	0.66	0.66	0.43
<b>Biometry Section</b>	0.86	0.86	0.76	0.36	0.36	0.42	0.72	0.36	0.42	0.36	0.36	0.38
<b>Agriculture Economic Unit</b>	0.31	0.31	0.48	0.32	0.32	0.30	0.66	0.33	0.31	0.32	0.32	0.12
<b>Total</b>	<b>20.00</b>	<b>20.00</b>	<b>19.94</b>	<b>20.00</b>	<b>20.00</b>	<b>19.95</b>	<b>40.00</b>	<b>20.00</b>	<b>19.97</b>	<b>20.00</b>	<b>20.00</b>	<b>18.63</b>

**Annex 07 - No. of Scientific Staff (total No. of HODs, PROs, SROs, ROs \*)**

Category	2017	2018	2019	2020
1. No. in the Cadre	75	75	75	75
2. No. filled /recruited	04	03	04	00
3. No. available	32	30	32	30
4. No. of vacancies	43	45	43	45
5. No. left for Universities/other jobs (local & abroad)	01	03	02	01
6. No. retired	01	00	00	01

\*HODs – Heads of Dept.s

PROs - Principal Research Officers

SROs- Senior Research Officers

ROs- Research Officers

(Source – Administration Dept., RRISL)

## **Annex 08 – Publications from 2017-2020**

(Following publications were extracted from Published Annual Review Reports – 2017, 2018 and 2019 and supplemented by an additional list provided by the Additional Director of RRISL).

### **Science Citation Index Expanded**

#### **(a) Full papers in journals**

##### **2017**

Hunupolagama, D.M.N.V., Chandrasekharan, N.V., Wijesundera, W.S.S., Kathriarachchi, H. S., Fernando, T.H.P.S. and Wijesundera, R.L.C. (2017). Unveiling members of *Colletotrichum acutatum* species complex causing *Colletotrichum* Leaf disease of *Hevea brasiliensis* in Sri Lanka. *International Journal of the Current Microbiology* 74, 747-756.

##### **2018**

Attanayake, A.P., Karunanayake, L. and Nilmini, A.H.R.L. (2018). Effect of ethephon stimulation on natural rubber latex properties; new insight into ethephon stimulation. *Journal of the National Science Foundation of Sri Lanka* 46 (2), 179-185. DOI:<http://doi.org/10.4038/jnsfsr.v46i2.8418>.

Dunuwila P , V.H.L. Rodrigo and , Naohiro Goto (2018). Assessing the financial and environmental sustainability in raw rubber processing: a case study with Ribbed smoked sheet manufacture in Sri Lanka. *Indonesian Journal of Life Cycle Assessment and Sustainability*, 2 (1): 1-7.

Dunuwila P, V.H.L. Rodrigo and, Naohiro Goto (2018). Financial and environmental sustainability in manufacturing of crepe rubber in terms of material flow cost accounting and life cycle assessment. *Journal of Cleaner Production*, 182: 587-599.

Dunuwila P , V.H.L. Rodrigo and , Naohiro Goto (2018). Sustainability of natural rubber processing can be improved: A case study with crepe rubber manufacturing in Sri Lanka, *Resources, Conservation a& Recycling*, 113: 417-427

Kirushanthi, T., Etampawala, Thusitha N., Edirisinghe, Dilhara, Pitawala, Jagath and Ratnaweera, D.R. (2018). Development of agro-industrial waste reinforced natural rubber composite: A potential formulation for rubber flooring product. *Journal of Advanced Chemical Sciences* 4, Issue 3, 571-575

Kondarage, Y.G., Pitawala, H.M.J.C., Kirushanthi, T., Edirisinghe, D. and Etampawala and Thusitha, N. (2018). Ceramic waste-based natural rubber composites: An exciting way for improving mechanical properties. *Journal of Advanced Chemical Sciences* 4, Issue 3, 576-582.

Liyanage KK, Khan S, Brooks S, Mortimer PE, Karunarathna SC, Xu J and Hyde KD (2018) Morpho-Molecular Characterization of Two *Ampelomyces* spp. (Pleosporales) Strains Mycoparasites of Powdery Mildew of *Hevea brasiliensis*. *Front. Microbiol.* 9:12. doi: 10.3389/fmicb.2018.00012.

Liyanage, KK, S Khan, S Ranjitkar, H Yu, J Xu, S Brooks, P Beckschäfer, KD Hyde (2018) Evaluation of key meteorological determinants of wintering and flowering patterns of five rubber clones in Xishuangbanna, Yunnan, China, *International journal of biometeorology*, Special issue: 1-92.

Munasinghe, E. S. and Rodrigo, V. H. L. (2018). Lifespan of rubber cultivation can be shortened for high returns: a financial assessment in simulated conditions in Sri Lanka. *Experimental Agriculture* 54 (3): 323-335

Wickramarachchi, A.R., H.M.L.K. herath, U.K. Jayasinghe-Mudalige, J.C. Edirisinghe, J.M.M. Udugama. I.D.M.N. Lokuge and W. Wijesuriya. (2018). An analysis of price behaviour of major poultry products in Sri Lanka. *The journal of Agricultural Sciences*, Vol. 12 (2): pp 138-148.

## **2019:**

Balasooriya, B.M.D.C., Edirisinghe, J.C. and Seneviratne, P. (2019). Nexus between awareness of recommendations and income from rubber cultivation: A structural equation model. *Sri Lanka Journal of Economic Research* 6(2), Pp.29-38.

Jayawardana, Ruwani Kalpana., Hettiarachchi, Rasika., Gunathilaka, Thushara., Thewarapperuma, Anoma., Rathnasooriya, Surani., Baddevidana, Rangika and Gayan, Helaru (2019). Natural and synthetic mulching materials for weed control in immature rubber plantations. *American Journal of Plant Biology.* 4, pp114-117. doi:10.11648/j.ajpb.20190404.20.

Sampath W.D.M., Egodage, S.M. and Edirisinghe, D.G. (2019). Effect of peroxide loading on properties of natural rubber and low-density polyethylene composites. *Journal of Physical Science* 30 (3), Pp.49-69

Sampath, W.D.M., Egodage, S.M. and Edirisinghe, D.G. (2019). Effect of an organotitanate coupling agent on properties of calcium carbonate filled low-density polyethylene and natural rubber composites. *Journal of the National Science Foundation of Sri Lanka* 47 (1), Pp.17-27.

## 2020:

Kalpani K. L. M. Withange S. P., and Palihakkara I. R. (2020), Selection of Superior Genotypes at Early Stage of the Rubber (*Hevea brasiliensis*) Breeding Cycle. *International Journal for Research in Applied Sciences and Biotechnology* Volume-7, Issue-4 (July 2020) 146-155.

Amarasekara, I. N., Withanage S.P., and Palihakkara, I.R., (2020) Quantitative Gene Expression Analysis of Selected Genes to Screen Drought Tolerance of Selected Hevea Clones. *International Journal for Research in Applied Sciences and Biotechnology* (Volume-7, Issue-6 (November 2020))

Dunuwila P, V.H.L. Rodrigo and Naohiro Goto (2020). Improving financial and environmental sustainability in concentrated latex manufacture. *Journal of Cleaner Production*, 255:

I.H.K. Samarasinghe, S. Walpalage, D.G. Edirisinghe and S.M. Egodage – “Study on Sulfur Vulcanized Natural Rubber Formulated with Nitrosamine Safe DiisopropylXanthogen Polysulfide/Tertiary Butyl BenzothiazoleSulphenamide Binary Accelerator System"-Progress in Rubber, Plastics & Recycling Technology. First published online on December 11, 2020.

Jayawardena RS, Hyde KD, Chen YJ, Papp V, Palla B, Papp D, Bhunjun CS, Hurdeal VG, Senwana C, Manawasinghe IS, Harischandra DL, Gautam AK, Avasthi S, Chuankid B, Goonasekara ID, Hongsanan S, Zeng XY, Liyanage KK, Liu N, Karunarathna A, Hapuarachchi KK, Luangharn T, Raspé O, Brahmanage R, Doilom M, Lee HB, Mei L, Jeewon R, Huanraluek N, Chaiwan N, Stadler M, Wang Y (2020), One stop shop IV: taxonomic update with molecular phylogeny for important phytopathogenic genera: 76– 100. *Fungal Diversity*. 103:87-218. <https://doi.org/10.1007/s13225-020-00460-8>

Liyanage KK, Khan S, Herath V, Brooks S, Mortimer PE, Nadir S, Hyde KD, Xu J, (2020), Genome Wide Identification of the MLO Gene Family Associated with Powdery Mildew Resistance in Rubber Trees (*Hevea brasiliensis*), *Tropical Plant Biology*, <https://doi.org/10.1007/s12042-020-09262-3>.

## **Non index (Peer-reviewed Journals)**

## 2017

Premarathna, G.N.S., Munasinghe, E.S., Rodrigo, V.H.L., Ginigaddara, G.A.S. and Bandara, A.M.K.R. (2017). Ground Level Impediments for Proper Adoption of Rubber Cultivation in Northern Province of Sri Lanka. *Journal of the Rubber Research Institute of Sri Lanka*. 97, 1-11.



Silva, T.U.K., Senevirathna, A.M.W.K., Seneviratne, P., Costa, W.A. J. M. De. andSubasinghe, H. (2017). Impact of different latex harvesting systems adopted by some growers on economic performance. *Jl. Rubb. Res. Inst. Sri Lanka*, 97, 12-20.

#### **2018**

Hettiarachchi,RP, Seneviratne, G, Jayakody AN, De Silva, E, Gunatilake, PDTC, Edirimanna, VU, Thewarapperuma, A, Chandrasiri, JAS, Malawaraarachchi GC and Siriwardana, NS (2018) Effect of biofilmedbiofertilizer on plant growth and nutrient uptake of Heveabrasiliensis nursery plants at field condition. *Journal of Rubber Research Institute of Sri Lanka*. Vol.97. (In press).

P Seneviratne, T U K Silva, K A G B Amaratunga, R P Karunasena, R K Samarasekara, L S Kariyawasam, M K P Perera, P D Pathirana and P K W Karunatilake (2018). Impact of tapping quality and harvesting practices on the sustainability of the rubber industry in Sri Lanka *Jl. Rubb. Res. Inst. Sri Lanka*,98, 45-64.

Somarathna, Y.R., Samarasinghe, I.H.K., S Siriwardena, S., D de Silva, D., and Mallikarachchi, D.V.D. Effect of nanoZnO over conventional ZnO on preservation of concentrated natural rubber latex, *Journal of the Rubber Research Institute of Sri Lanka* (2018) 98, 65-79 (DOI: 10.4038/jrrisl.v98i0.1876).

#### **2019**

Munasinghe, E. S., Rodrigo, V. H. L., Jayathilake, P. M. M., Piyasena N. M. and Iqbal, S. M. M. (2019). Livelihood capital improvements in the rubber growing community of the Eastern Province of Sri Lanka. *Journal of the Rubber Research Institute of Sri Lanka*. 98, 1-13.

#### **Non – index journals**

#### **2017**

Wijesuriya, A., Jayamali, L.B.C., Perera, A.M.M.S., Wijesuriya, B.W., (2017). Optimal plot and sample sizes for sugarcane (*Saccharum* spp. Hybrids) varietal assessment. *Sugarcane Sri Lanka* Vol 3, p25-33.

#### **2019**

Anushka P.V.A., Withanage S.P., Karunarathne.N.P.S.N.,Kudaligama.K.V.V.S. **Dahanayake T.T.D.**, Peiris H.P., (2019) Assessment and selection based on girth and yield performance of new *Hevea* genotypes generated from controlled hybridization, *Proceedings of the Seventh*

Symposium on Plantation Crop Research -Towards Achieving sustainable development goals in the plantation sector, p33-44, ISBN 978-955-9022-22-0.

Withanage S.P. (2019) MORE THAN A CENTURY OF HEVEA BREEDING IN SRI LANKA *Rubber Science* 32 (3) 227-239

**(b) Bulletin/Conferences/Seminars/Workshops/Reports**

**2017**

Attanayake, A.P., Karunanayake, L. and Nilmini, A.H.R.L. (2017). Effect of ethephon concentration on physical properties of Natural Rubber; A qualitative approach for ethephon stimulation. IRRDB International Rubber Conference IRC-2017, Jakarta, Indonesia, 18th - 20th October, 2017.

Attanayake, A.P., Karunanayake, L. and Nilmini, A.H.R.L. (2017). The role of ethephon stimulation on the strength properties of natural rubber vulcanizate. SJUP International Symposium in Polymer Science (2017). Colombo, Sri Lanka.

Balasooriya, P.W., Fernando, T.H.P.S. and Weerasena, O.V.D.S.J. (2017). Isolation of native antagonistic fungi against *Rigidoporus microporus*, the causative fungus of White Root disease from different rubber growing soils. Proceedings of the 9th IBMBB Annual Scientific Sessions. University of Colombo. OP16-27.

Gunathilaka, D.N.M Yapa P.N. and Hettiarachchi R.P (2017), Assessing the effect of arbuscular mycorrhizal fungi on the phytoremediation potential of *Eichhorniacrassipes* (Mart.) Solms (water hyacinth) on cadmium uptake. In proceedings of Applied Sciences Undergraduate Research Sessions 2017 (ASUR 2017 – 4<sup>th</sup> October, 2017) Rajarata University of Sri Lanka, Mihinthale, Sri Lanka. p 4.

Gunathilaka, D.N.M., Hettiarachchi, R.P. and Yapa, P.N. (2017). Effect of different cadmium concentrations on growth and phytoremediation potential of *Eichhornia crassipes* (Mart.) Solms (water hyacinth): In: Proceedings of Peradeniya University International Research Sessions (iPURSE 2017 – 24th November), University of Peradeniya, Peradeniya, Sri Lanka. P. 20.

Gunathilaka, D.N.M., Yapa, P.N. and Hettiarachchi, R.P. (2017). Arbuscular mycorrhizal fungi assisted cadmium removal by water hyacinth (*Eichhornia crassipes* (Mart.) Solms) in polluted soil and water. 22nd International Forestry and Environment Symposium 2017, University of Sri Jayewardenepura, Sri Lanka. P. 49.

Gunathilaka, D.N.M., Yapa, P.N. and Hettiarachchi, R.P. (2017). Arbuscular mycorrhizal fungi for increasing the phytoremediation potential of plants in heavy metal contaminated

sites: In: Proceedings of Second Global Soil Biodiversity Conference (GSBS 2-15th -19th October, 2017), Nanjing.

Gunathilaka, D.N.M., Yapa, P.N., Hettiarachchi, R.P. and Thewarapperuma, A.P. (2017). Assessing the effect of arbuscular mycorrhizal fungi on the phytoremediation potential of *Eichhornia crassipes* (Mart.) Solms on cadmium uptake. In: International Symposium on Sustainable Urban Environment (ISSUE 2017-23rd – 24th June, 2017), Tezpur University, Assam, India. P.34-35.

Ishani, P.G.N., Sankalpa, J.K.S. and Wijesuriya, W. (2017). Sri Lankan Rubber exports performance by major destinations using shift-share analysis. 11th Annual Research Forum. Sri Lanka Agricultural Economics Association, University of Peradeniya. 13p.

Jayawarna, J.C. and Edirisinghe, D.G. (2017). Use of modified solid rubber waste in dry rubber based products as a step towards sustainability. The Journal of the Plastics and Rubber Institute of Sri Lanka 16, 43-46.

Kalubovila, K.K., Nugawela, R.C.W.M.R.A., Edirisinghe, D.G. and Ranjith, S.L.G. (2017). Development of an ammonia free, environmental friendly preservative system for centrifuged natural rubber latex. Proceedings of the 16th Agricultural Research Symposium of Wayamba University of Sri Lanka. 8-9 th November, 2017.

Kudaligama, K.V.V.S., Lakshman, R.G.N., Rodrigo, V.H.L., Nugawela, A. (2017). Performance of once in three days (S/2 d3) and four days (S/2 d4) tapping systems in marginal drier Areas in Sri Lanka. Proceedings of International Rubber Conference 2017, International Rubber Research and Development Board, Grand Sahid Jaya Hotel, Jakarta-Indonesia, 18–22 October 2017. 401-412.

Kudaligama, K.V.V.S., Rodrigo, V.H.L., Randunu, R.P.S., Perera, M.K.P. and Madushani, P.D.T.L. (2017). A low frequency harvesting system exclusively for smallholder rubber growers being employed off farm. Proceedings of International Rubber Conference 2017, International Rubber Research and Development Board, Grand Sahid Jaya Hotel, Jakarta-Indonesia, 18–22 October 2017. 572-582.

Liyanaarachchi, L.A.T.S., Wijesuriya, B.W., Sankalpa, J.K.S., Herath, H.M.L.K., Premalal, S. and Karunaratne, S.B. (2017). Identification of temporal trends in rainfall anomalies of different rainfall seasons in Sri Lanka using the Standardized Precipitation Index (SPI). Proceeding of 6th Young Scientists Forum, National Science and Technology Commission, Sri Lanka, 20th January 2017. 74-79.

Nayanakantha, N.M.C., Rathnayake, R.M.C.G, Panditharatne, B.M.S.S., Seneviratne, Priyani, Nakandala, S.A. and Karunathilake, P.K.W. (2017). Nitric oxide improves growth and physiological attributes of rubber (*Hevea brasiliensis*) under drought and heat stress conditions. Proceedings of the International Rubber Conference pp.277-293. Indonesia: International Rubber Research & Development Board.

P Seneviratne , M K P Perera and R Handapangoda (2017). Strategies to maintain the recommended stand in rubber clearings to improve productivity. *Bulletin of the Rubber Research Institute of Sri Lanka*. 54, 17-22.

P Seneviratne, N M C Nayanakantha, T U K Silva, R K Samarasekara and P K W Karunathilake (2017). Field wise crop estimation ensures the sustainability of rubber plantations in Sri Lanka *Bulletin of the Rubber Research Institute of Sri Lanka*.54, 23-29.

Perera, K.I.D.P. and Edirisinghe, D.G. (2017). Reclaiming of Acrylonitrile-Butadiene Rubber waste using an amino compound for oil resistant applications. Proceedings of the IIUPST 2017, University of Sri Jayewardenepura, Nugegoda, 14-15th April, 2017.

Premarathna, G.N.S., Ginigaddara, G.A.S., Munasinghe, E.S., Bandara, A.M.K.R. and Rodrigo, V.H.L. (2017). Identification of socio-economic, cultural and agronomic limitations to adaptation of rubber cultivation in Northern Province of Sri Lanka. Proceedings of 9th Annual Research Symposium, Faculty of Agriculture, Rajarata University of Sri Lanka. 12.

Rodrigo, L. (2017). Rubber a fortune in time of misfortune: Eastern cultivator. Sunday Times on 30<sup>th</sup> April 2017.

Rodrigo, V. H. L. and Munasinghe, E. S. (2019). Wonder tree from Amazon rain forest, now flourishing in Sri Lanka's Dry Zone. *Sunday Time*, February 17<sup>th</sup> 2019.

Samarasinghe I.H.K., Siriwardena S., Dhanukamali H., Raw Rubber properties of Skim/Natural Rubber Latex blended Ribbed Smoked Sheets, Proceedings of 3rd Biennial International Symposium, University of Sri Jayewardenepura Nugegoda, Sri Lanka, 2017.

Sankalpa, J.K.S., Wijesuriya, Wasana, Karunaratne, Senani and Ishani, P.G.N. (2017). Use of GIS geographically weighted regression to determine Natural Rubber productivity and their driving forces: A case study from the Kalutara district of Sri Lanka. IRRRI & IRRDB International Rubber Conference 2017, Jakarta, Indonesia, 24 p. (Abstract only)

Sankalpa, J.K.S., Wijesuriya, Wasana, Karunaratne, Senani and Ishani, P.G.N. (2017). A comparison of spatial interpolation methods in developing yield maps of natural rubber for precision crop production: A case study from smallholder rubber lands in Kalutara district of Sri Lanka. Proceedings International Statistics Conference 2017, Taj Samudra Hotel, Colombo, 129 p.

Wijesuriya, W., Rathnayaka, A.M.R.W.S.D. and Abeywardena, O.V. (2017) 'Analysis of Rainfall Data at Dartonfield, Agalawatta in the Low Country Wet Zone (WL1a): Looking at the Past 57 Years since 1964, Bulletin of the Rubber Research Institute, Vol. 54:42-48.

Wijesuriya, Wasana and Seneviratne, Priyani (2017). Preparedness of the Natural Rubber sector against adverse impacts climate change and variability. Proceedings of the Workshop

on present status of research activities on climate change adaptations (Ed. B. Marambe). 83-100. Sri Lanka Council for Agricultural Research Policy, Colombo.

## 2018

Abey Siriwardana, D.D.S.D.Z., Withanage, S.P. and Attanayake, D.P.S.T.G. (2018). Screening of drought tolerance in selected clones of *Hevea brasiliensis*. Proceedings of 17th Agricultural Research Symposium Part I, pp.91-95. 28th - 29th November 2018. Wayamba University of Sri Lanka, Makandura, Gonawila.

Balasooriya, B.M.D.C., Edirisinghe, J.C. and Seneviratne, P. (2018). Impact of perception, awareness and adoption of technologies in reducing production variability in smallholder rubber cultivations in Kurunegala district. Proceedings of the Wayamba University Research Congress, pp.56-57. Wayamba University of Sri Lanka, Makandura, Gonawila.

Balasooriya, P.W., Fernando, T.H.P.S. and Weerasena, O.V.D.S.J. (2018). Phosphorus solubilizing ability of antagonistic fungi on *Rigidoporus microporus* isolated from Sri Lankan rubber growing lands. Proceedings of the 7th Young Scientist Forum 2018. p.19. Wayamba University of Sri Lanka, Makandura, Gonawila.

Balasooriya, P.W., Fernando, T.H.P.S. and Weerasena, O.V.D.S.J. (2018). Production of toxic metabolite by native antagonistic fungi, against *Rigidoporus microporus*, the causative fungi of White Root Disease of rubber (*Hevea brasiliensis*). Proceedings of the 10th Annual Scientific Sessions, p.29. Institute of Biochemistry, Molecular Biology and Biochemistry, University of Colombo.

Dilrukshi, P.G.T., Subasinghe, S.M.C.U.P., Nayanakantha, N.M.C. and Senevirathna, A.M.W.K. (2018). Evaluation of growth performance of agarwood producing species under three shade settings in different rubber intercropping systems. Proceedings of the 23rd International Forestry and Environment Symposium, p.57. 23rd -24th November 2018. University of Sri Jayawardenapura,

Dissanayake, D.M.A.P. (2018). Strategic technology transfer methods: Experience from the smallholder rubber sector of Sri Lanka. International Workshop on Statistical Applications in Socioeconomic Research and Forum on Current Socioeconomic Issues and their Impact on Rubber Production Sector Performance. p.32. 1-5 October 2018, Rubber Research Institute of Sri Lanka.

Dissanayake, D.M.A.P., Wijesuriya, B.W., Gunarathne, P.K.K.S. and Ranawaka, R.A.D. (2018). Empowering rubber farmers in non-traditional rubber growing areas of Sri Lanka through knowledge on combating adverse impacts on environment for rubber cultivation. Proceedings of International Rubber Conference – IRC 2018, p.85. Abjidan, Cote' d Ivoire.

Fernando, T.H.P.S., Seneviratne, P., Tennakoon, B.I., Siriwardena, D. and Wijeratne, C. (2018). The battle against white root disease: An integrated approaches for success. Proceedings of the First National Symposium on Sustainable Plantation Management pp.129-139, National Institute of Plantation Management, Colombo, Sri Lanka

Gayashan, N.D.K., Nayanakantha, N.M.C., Seneviratne, P., Senevirathna, A.M.W.K., Jayasinghe, H.A.S.L. and Panditharathna, B.M.S.S. (2018). Effect of polybag size on growth and physiological attributes of rubber (*Hevea brasiliensis*) seedlings. p.20. Proceedings of 2nd International Research Symposium, Uva Wellassa University, 1st -3 rd February 2018.

Gunarathne, P.K.K.S., Dissanayake, D.M.A.P., Wijesuriya, W. and Ranawaka, R.A.D. (2018). Livelihoods of rubber latex harvesters in Kegalle District: comparative analysis of harvesting own lands versus operating on hired basis. Proceedings of the SLCARP International Symposium. p.93. Colombo, Sri Lanka.

Gunathilaka, D.N.M., Yapa, P.N., Hettiarachchi R.P and Thewarapperuma A.P. (2018) Effect of arbuscular mycorrhizal fungi on the cadmium phytoremediation potential of *Eichhorniacrassipes* (Mart.). Ground water for sustainable development, <https://doi.org/10.1016/j.gsd.2018.03.008>, ELSEVIER.

Hansamali, A.A.D., Liyanaarachchi, L.A.T.S., Karunaratne, S.B. and Gajanayake, B. (2018). Characterization of Calcic-Red Yellow Latasol of Northern Province for Coconut Cultivation: A Case Study in Palali Area of Jaffna District, Proceeding of 17 th Agriculture Research Symposium, 247-251.

Hettiarachchi RP, Dharmakeerthi RS, Seneviratne G, Jayakody AN, De Silva E, Gunathilaka T, Thewarapperuma A, Edirimanna, V, Chandrasiri JAS, Malawaraarachchi, GC (2018). Enhancing nutrient uptake of rubber nursery plants by the application of biofilmed biofertilizers. In Proceedings of Sri Lanka Council for Agricultural Research Policy International Agricultural Research Symposium. (13<sup>th</sup> – 14<sup>th</sup> August 2018), Colombo, P. 50.

Hettiarachchi, H.A.I.U., Balasooriya, B.M.D.C. and Edirisinghe, J.C. (2018). Scale efficiency in smallholder rubber sector in Kegalle district: A data envelopment analysis. Proceedings of 17th Agricultural Research Symposium Part II, pp.330- 334, 28th - 29th November 2018. Wayamba University of Sri Lanka, Makandura, Gonawila.

Hettiarachchi, R.P., Dharmakeerthi, R.S., Seneviratne, G., Jayakody, A.N., De Silva E., Gunathilaka, T., Thewarapperuma, A., Edirimanna, V., Chandrasiri, J.A.S. and Malawaraarachchi, G.C. (2018). Enhancing nutrient uptake of rubber nursery plants by the application of biofilmed biofertilizers. Proceedings of Sri Lanka Council for Agricultural Research Policy International Agricultural Research Symposium. p.50. 13th -14th August 2018). Colombo, Sri Lanka.

Jayarathne, K.D.T., Herath, H.M.I.K. and Liyanaarachchi, L.A.T.S. (2018) Mapping of Spatial Variability of Soil Chemical Properties for Efficient Nutrient Management: A Case

Study in Red Yellow Podzolic (RYP) Soils. Proceedings of the 17th Agricultural Research Symposium, 25-26 June, 2018. Makandura, Wayamba Univesity.

Jayatissa, B.G.D.D., Liyanaaarachchi, L.A.T.S., Karunaratne, S.B. and Gajanayake, B. (2018). Assessment of the Quality of Soils of Coconut Cultivating Lands via Geographical Information Technology Approaches: A Case Study in Bandirippuwa Coconut Estate, Lunuwila, Proceeding of 17 th Agriculture Research Symposium, p 267-271.

Jayawardana H.A.R.K., Rathnasooriya P.D.S.D.O., Baddevidana R.M. and Chandrasiri J.A.S (2018), The effect of amendment of soil media with paddy husk charcoal and paddy husk ash on growth of rubber nursery plants, Proceedings of the National Symposium on Sustainable Plantation Management (NSSPM -2018), National Institute of Plantation Management Sri Lanka. 100- 107.

Jayawardana H.A.R.K and Hettiarachchi R.P (2018), What to be learnt from past studies on nutrient management in rubber, Bulletin of Rubber Research Institute Of Sri Lanka, Vol. 55, pp. 26-33.

Jeewanthi P.W., Wijesuriya W. and Amarakoon A.M.C. Identifying Changes in Rainfall Distribution using Standardized Precipitation Index (SPI): An Application in Uva Province Sri Lanka”. Proceeding of second International Conference on Climate Change 2018:5p

Jeewanthi, P.W., Wijesuriya, W. and Amarakoon, A.M.C. (2018). Identifying changes in rainfall distribution using Standardized Precipitation Index (SPI): An application in Uva Province Sri Lanka. p.5. Proceeding of Second International Conference on Climate Change. 15th -16th February 2018, Colombo Sri Lanka.

Karunaratne, N.P.S.N., Kudaligama, K.V.V.S., Abewardhane, N.N. and Madushani, P.D.T.L. (2018). Possibility of using wood of RRIC 121 rubber clone as an alternative to forest timber. Proceedings of the First National Symposium on Sustainable Plantation Management pp.77-86, National Institute of Plantation Management, Colombo, Sri Lanka.

Kirushanthi, T., Pitawala, H.M.J.C., Edirisinghe, D., Ratnaweera, D.R. and Etampawala, T.N.B. (2018). Silica from rice husk as an alternative to commercially available silica fillers in tyre compounding. Proceedings of the IRSUWU, Uva Wellassa University, p.385, 1-2 nd February, 2018.

Kondrage, Y.G., Pitawala, H.M.J.C., Thangavel, K., Edirisinghe, D. and Etampawala, T.N.B. (2018). Ceramic waste – based natural rubber composites: An exciting way for improving mechanical properties. Proceedings of the IRSUWU, p.386, 1-2 nd February, 2018. Uva Wellassa University, Badulla.

Kudaligama, K.V.V.S., Rodrigo, V. H. L., Perera, M.K.P. and Madushani, P.D.T.L. (2018). Low intensity harvesting systems assured improved financial benefits to growers and harvesters. Latex harvesting & physiology session. Handbook of the International Rubber Conference 2018, International Rubber Research and Development Board, Abidjan, Cote de

Ivory, 22nd -23rd Oct 2018.

Kudaligama, K.V.V.S., Rodrigo, V.H.L., Perera, M.K.P. and Madushani, P.D.T.L. (2018). Low intensity harvesting systems assured improved financial benefits to growers & harvesters. Proceedings of the International Rubber Conference, p.72. 22-24th October 2018, National Institute of Plantation Management, Abidjan, Ivory Coast.

Liyanaarachchi, L.A.T.S., Herath, H.M.L.K., Wijesuriya, B.W. and Karunaratne, S.B. (2018). Occurrence of Dry Spells in Different Rainfall Seasons in Puttlam District of Sri Lanka: An Application of Markov Chain Model, Kuliyaipitiya, Sri Lanka: Wayamba International Conference, p 112.

Liyanaarachchi, L.A.T.S., Herath, H.M.L.K., Wijesuriya, B.W. and Karunaratne., S.B. (2018). Identification of Extreme Changes and Temporal Trends in Rainfall in the Coconut Triangle of Sri Lanka, Proceeding of Wayamba Research Congress 2018, Senet Research and Higher Degrees Committee, p 62 -63.

Malshan, P.D.C., Herath, H.M.I.K., Liyanaarachchi, L.A.T.S. (2018). Land Suitability Assessment Using GIS Applications for Efficient Soil Management: A Case Study of Dummalapitiya Estate on Red Yellow Podzolic Soil. Proceedings of the 17th Agricultural Research Symposium, 25-26 June, 2018. Makandura, Wayamba University of Sri Lanka, 2, 71-74.

Munasinghe, E. S. and Rodrigo, V. H. L. (2018). Rubber cultivation shows positive impact on rural livelihood in the Eastern province of Sri Lanka. Dissemination of Research Findings - Private Sector Engagement for Sustainable Development in Sri Lanka: Evidence-Based Policy and Practice. Sri Lanka Institute of Development Administration. 41- 44.

Munasinghe, E.S. and Rodrigo, V.H.L. (2018). Rubber cultivation shows positive impact on rural livelihood in the Eastern province of Sri Lanka. Dissemination of Research Findings - Private Sector Engagement for Sustainable Development in Sri Lanka: Evidence-based Policy and Practice. pp.41-44. Sri Lanka Institute of Development Administration, Sri Lanka.

Munasinghe, E.S., Rodrigo, V.H.L., Jayathilake, P.M.M. and Piyasena, N.M. (2018). Rubber cultivation shows positive impact on rural livelihood in the Eastern province of Sri Lanka. Proceedings of the Second International Agricultural Research Symposium 2018. p.126. Sri Lanka Council for Agricultural Research Policy.

N M C Nayanakantha, B M S SPanditharathna, D L N de Zoysa and P Seneviratne (2018). Comparison of black and transparent polybags for growth and bud grafting performances of rubber (*Hevea brasiliensis*) seedlings under sub-optimal climatic conditions *Bulletin of the Rubber Research Institute of Sri Lanka* 55, 16-20.

N M C Nayanakantha, E U M De Z Dissanayaka and P Seneviratne(2018). Growth and bud grafting performance of selected clonal seedling rootstocks of rubber (*heveabrasiliensis*) *Bulletin of the Rubber Research Institute of Sri Lanka* 55, 34-44



Nadeeshani, A.A.A., Palihakkara, I.R. and Kudaligama, K.V.V.S. (2018). Variation of some physiological and growth parameters in commonly grown young Hevea clones in WL1a agro ecological zone in Sri Lanka. Proceedings of the First National Symposium on Sustainable Plantation Management, pp.47-55. National Institute of Plantation Management, Colombo, Sri Lanka.

Nakandala, S.A., Nayanakantha, N.M.C., Seneviratne, P., De Alwis, M.N. and De Zoysa, D.L.N. (2018). Morphological and physiological responses of immature plants of Hevea brasiliensis to micro-irrigation. Proceedings of International Rubber Conference and IRRDB Annual Meeting, p.53. 2018, Abidjan, Côte D'Ivoire.

Nakandala, S.A., Seneviratne, P., Iqbal, S.M.M., Weerasinghe, K.D.N. and Pathirana, P.D. (2018). Irrigation systems for rubber nurseries. *Bulletin of the Rubber Research Institute of Sri Lanka* 54, 1-5.

Nanayakkara, E.N.N., Attanayake, A.P., Wijesinghe, H.G.I.M. and Seneviratne, A.M.W.K. (2018). Effect of ethephon stimulation on physic-mechanical properties of carbon black filled natural rubber vulcanizate. p.395, International Research Symposium, February 1-3 rd , Uva Wellassa University, Badulla.

Nayanakantha, N.M.C., Madushani, K.A.U., Seneviratne, P., Panditharathna, B.M.S.S., De Z. Dissanayaka, E.U.M. and Karunarathna, B. (2018). Seed priming with nitric oxide enhances storage life, germination and seedling attributes of rubber (Hevea brasiliensis). pp.6-7. Proceedings of the SLCARP International Agricultural Symposium, 13-14 August, Colombo.

Nayanakantha, N.M.C., Madushani, U., Karunarathna, B., Panditharathna, B.M.S.S. and Seneviratne, P. (2018). Priming with nitric oxide donor sodium nitroprusside enhances germination and storage life of recalcitrant rubber (Hevea brasiliensis) seeds. p.4. Proceedings of 2nd International Research Symposium, Uva Wellassa University, February 1-3.

Nayanakantha, N.M.C., Panditharathna, B.M.S.S., Seneviratne, P. and De Z. Dissanayaka, E.U.M. (2018). Effect of selected clonal seedling rootstocks on growth and budgrafting performance of rubber (Hevea brasiliensis). pp.22-26. Proceedings of the National Symposium on Sustainable Plantation Management, 10th March, National Institute of Plantation Management, Athurugiriya.

Nayanakantha, N.M.C., Panditharathna, B.M.S.S., Nakandala, S.A., Karunathilake, W. and Seneviratne, P. (2018). Exogenous nitric oxide donor sodium nitroprusside improves growth and physiological attributes of rubber (Hevea brasiliensis) under abiotic stress conditions. p.15. Proceedings of the 5th International Conference on Agriculture, 16-17th August 2018, Colombo.

Nayanakantha, N.M.C., Panditharatne, B.M.S.S., Nakandala, S.A., Karunathilake, W. and Seneviratne, P. (2018). Exogenous Moringa oleifera leaf extract as a biostimulant improves growth and physiological attributes of rubber (*Hevea brasiliensis*) under sub-optimal climatic conditions. p.54. Proceedings of the Symposium of RESCON 2018, 9-10th November 2018, PGIS, Peradeniya.

P.K.K.S. Gunarathne, D.M.A.P. Dissanayake, W. Wijesuriya and R.A.D. Ranawaka (2018). Livelihoods of Rubber Latex Harvesters in Kegalle District: Comparative Analysis of Harvesting Own Lands versus Operating on Hired Basis. In Proceedings of the SLCARP International Symposium, Colombo, Sri Lanka.

Priyani Senevirathne and G A S Wijesekara(2018). Improved root morphology in young budded rubber plants *Bulletin of the Rubber Research Institute of Sri Lanka*55, 53-59.

Priyani Seneviratna and G A S Wijesekara Coconut husks to reduce the top soil requirement in young budding rubber plant production while solving tap root coiling at the base *Bulletin of the Rubber Research Institute of Sri Lanka*54, 30-33.

Rathnayaka, A.M.R.W.S.D., Wijesuriya, N.D. and Wijesuriya, W. (2018). ‘Appropriate methods in Rainfall Analysis; Detecting monotonic and sequential trend in rainfall data at Dartonfield. *Bulletin of the Rubber Research Institute, Bulletin of the Rubber Research Institute, Vol. 55:60-68.*

Rodrigo, Lakshman and Munasinghe, Enoka (2018). Sri Lankan experience in rubber cultivation in non-traditional areas. Programme Book of the International Workshop on Statistical Applications in Socioeconomic Research and Forum on Current Socioeconomic Issues and their Impact on Rubber Production Sector Performance. p.29. 1-5 October 2018, Rubber Research Institute of Sri Lanka.

Rodrigo, V. H. L. and Munasinghe, E. S. (2019). Rubber cultivation in North and East in Sri Lanka: journey as yet and way forward. Proceedings of the International Rubber Conference 2019, International Rubber Research and Development Board, Nay Pyi Taw, Myanmar, 30th Sept-1st Oct 2019. 46.

Rodrigo, V.H.L. and Munasinghe, E.S. (2018). Carbon trading; rubber green to greener products! *The Journal of Plastic and Rubber Institute of Sri Lanka* 17, 52-54.

Samaraweera, K.C., Wijesinghe, H.G.I.M., Etampawala, T.N.B., Edirisinghe, D.G. and Seneviratne, A.M.W.K. (2018). Silica extracted from rice husk ash as an effective reinforcing filler for natural rubber composites. Proceedings of the IRSUWU, p.394, 1-2 nd February, 2018. Uva Wellassa University, Badulla, Sri Lanka.

Samindi, H.A.N.R., Attanayaka, D.P.S.T.G., Nagahawatta, D.P. and Withanage, S.P. (2018). Analysis of the promoter region of the rubber elongation factor gene (ref) of *Hevea brasiliensis* Muell. Arg. cv RRIC 121. Proceedings of 17th Agricultural Research Symposium

Part I, pp.61-65, 28th -29th November 2018, Wayamba University of Sri Lanka, Makandura, Gonawila.

Silva, M.K.R., Fernando, T.H.P.S., Tennakoon, B.I. and Umesha, B.V.A. (2018). Evaluation of the antagonistic effect of the diethyl ether extracts of local plant species on *Rigidoporus microporus*: the causal organism of white root disease of rubber. Twenty third International Forestry & Environment Symposium 2018, p.32. 23rd -24th November 2018, University of Sri Jayawardenapura.

Silva, M.K.R., Fernando, T.H.P.S., Tennakoon, B.I. and Umesha, B.V.A. (2018). Optimization of the protocol to assess the effectiveness of solvent extracts of prospective antagonistic plant species against White root disease of rubber. Seventh Symposium of the Young Scientists Forum, pp.140-145, National Science and Technology Commission, Sri Lanka.

Wanninayakea, PCU, Yapa, PN, Malaviarachchi, MAPWK, Hettiarachchi, RP(2018). Phosphorus and cadmium in soil, roots and seeds of maize (*Zea mays* L.) as affected by the application of phosphorus fertilizers and soil amendments. In Proceedings of the applied Sciences Undergraduate Research Session (ASURS 2018), Faculty of applied Sciences, Rajarata University of Sri Lanka.

Weerasinghe, P.K.P., Karunaratne, S.B., Wijesuriya, W. and Herath, H.M.L.K. (2018). Monitoring and forecasting of meteorological droughts in Sri Lanka: Spatio - temporal bayesian modelling approach. Proceedings of 17th Agricultural Research Symposium Part II, pp.360-364, 28th -29th November 2018, Wayamba University of Sri Lanka, Makandura, Gonawila.

Wijayarathna, D.N., Lokupitiya, E. and Silva, T.U.K. (2018). Development of a relationship between a drought index and its impacts on rubber yield in wet zone. Proceedings of 74<sup>th</sup> Annual Session, Sri Lanka Association for the Advancement of Science, December 2<sup>nd</sup> - 8<sup>th</sup>. 2018. Colombo, Sri Lanka. Pp 27.

*Wijayarathne, D.N., Lokupitiya, E. and Silva, T.U.K. (2018). Ratio between potential evapotranspiration and precipitation as a drought index and its impact on rubber yield in Sri Lanka. Proceedings of 2<sup>nd</sup> International Conference on Climate change 2018. <https://climatechangeconferences.com/wp-content/uploads/2018/06/ICCC-2018-Book-of-Abstracts.pdf>*

Wijebandara, D.M.D.I., Dissanayake, D.M.P.D., Serasinghe S. and Liyanaarachchi, L.A.T.S. (2018). Soil Fertility Status of Non-Traditional Coconut Growing Soils in Sri Lanka. The 2<sup>nd</sup> Conference on Bioresources, Energy, Environment and Materials Technology (BEEM2018), Gangwon Province, Korea. 2018, PP02 -162.

Wijesuriya, Wasana (2018). Statistical insight improves the interpretability of data generated through participatory approaches: experiences from the smallholder rubber sector of Sri Lanka. IRRDB International Rubber Conference, p.93. Ivory Coast.

## 2019

Anura Dissanayake, A., Ishani, P.G.N., Gunarathne, P.K.K.S., Ranawaka, R.A.D., Sankalpa, J.K.S., Seneviratne, P. and Wijesuriya, W. (2019) 'Strategies to prevent evading from rubber planting: Introducing Gliricidia as a fuel wood in smallholder rubber lands of Sri Lanka', International Rubber Conference 2019, Myanmar

Anushka, P.V.A., Withanage, S.P., Karunaratne, N.P.S.N., Kudaligama, K.V.V.S., Dahanayake, T.T.D. and Peiris, H.P. (2019). Assessment and selection based on girth and yield performance of new Hevea genotypes generated from controlled hybridization. Proceedings of the 7th Symposium on Plantation Crop Research, "Towards achieving sustainable development goals in the plantation sector. (Eds. V.H.L. Rodrigo, B.W. Wijesuriya, D.G. Edirisinghe and N.M.C. Nayanakantha), Rubber Research Institute of Sri Lanka, Dartonfield, Agalawatta, Sri Lanka. Vol.1, Pp.33-44, 4-5 November.

Arachchi, N.N.M., Attanayake, A.P., Seneviratne, A.M.W.K. and Wijesinghe, H.G.I.M. (2019). Reduction of enzymatic discolouration of Natural rubber latex by using antioxidant and Moringa oleifera leaf extract. International Research Symposium, 7-9 February. P.55.

Attanayake, A.P. and Weerasinghe, M.U.D.S. (2019). Study on raw rubber and rheological properties of RRISL 203 clone: Superior clone for sustainable rubber industry. Proceedings of the International Rubber Conference 2019. International Rubber Research and Development Board, Nay Pyi Taw, Myanmar, 30th Sept-1 st Oct 2019. P.103.

Balasoorya, B.M.D.C., Edirisinghe, J.C., Seneviratne, P. and Piyasena, N.M. (2019). Status of farmer awareness and adoption of recommended technologies in the smallholder rubber sector in Kegalle district. Proceedings of the Wayamba University Research Congress. Senate Research and Higher Degrees Committee, Wayamba University of Sri Lanka Pp.95-96.

Dissanayake, Anura., Ishani, P.G.N., Gunarathne, P.K.K.S., Ranawaka, R.A.D., Sankalpa, J.K.S., Seneviratne, P. and Wijesuriya, W. (2019). Strategies to prevent evading from rubber planting: Introducing Gliricidia as a fuel wood in smallholder rubber lands of Sri Lanka. Proceedings of the International Rubber Conference 2019. International Rubber Research and Development Board, Nay Pyi Taw, Myanmar, 30th Sept-1 st Oct 2019. P.72.

Fernando, T.H.P.S., Siriwardena, D., Wijerathna, C., Nishantha, N., Balasoorya, Poorna and Nishantha, Buddika (2019). Field screening of RRISL recommended test rubber clones against *Corynespora* leaf fall disease. Proceedings of the 7th Symposium on Plantation Crop

Research, “Towards achieving sustainable development goals in the plantation sector. (Eds. V.H.L. Rodrigo, B.W. Wijesuriya, D.G. Edirisinghe and N.M.C. Nayanakantha), Rubber Research Institute of Sri Lanka, Dartonfield, Agalawatta, Sri Lanka. Vol.1, Pp.127-134, 4-5 November.

Gunarathne, P.K.K.S., Dissanayake, D.M.A.P. and Wijesuriya, Wasana (2019). Adoption of the rubber harvesting technologies in the smallholder rubber sector: A case study in Ratnapura district of Sri Lanka. Proceedings of the International Rubber Conference 2019. International Rubber Research and Development Board, Nay Pyi Taw, Myanmar, 30th Sept-1 st Oct 2019. P.93.

Gunarathne, P.K.K.S., Dissanayake, D.M.A.P., Ranawaka, R.A.D. and Wijesuriya, Wasana (2019). Training induced adoption changes in rubber harvesting technologies in rubber smallholdings in the Kegalle district of Sri Lanka: Comparative analysis of lands harvested by owners versus operating on hired basis. Proceedings of the 7th Symposium on Plantation Crop Research, “Towards achieving sustainable development goals in the plantation sector. (Eds. V.H.L. Rodrigo, B.W. Wijesuriya, D.G. Edirisinghe and N.M.C. Nayanakantha), Rubber Research Institute of Sri Lanka, Dartonfield, Agalawatta, Sri Lanka. Vol.2, Pp.135-144, 4-5 November.

Hettiarachchi, R.P., Chandrasiri, J.A.S., De K.E. Silva, Edirimanna, V. Thewarapperuma, A., Gunathilake, T., Malawaraarachchi, G.C., Kulathunge, K.M.M.E.K., Gayan, M.W.H. and Siriwardana, N.S. (2019). Effectiveness of coir and rubber latex based slow release fertilizer on growth of immature rubber (*Hevea brasiliensis*) and soil nutrient availability. Proceedings of the 7th Symposium on Plantation Crop Research, “Towards achieving sustainable development goals in the plantation sector. (Eds. V.H.L. Rodrigo, B.W. Wijesuriya, D.G. Edirisinghe and N.M.C. Nayanakantha), Rubber Research Institute of Sri Lanka, Dartonfield, Agalawatta, Sri Lanka. Vol.1, Pp.21-29, 4-5 November.

Hettiarachchi, R.P., Edirimanna, V., Gunathilake, T., Kulathunge, K.M.M.E.K., Gayan, M.W.H., Malawaraarachchi, G.C., Baddevidana, R.M. and Rathnasooriya, P.D.S.D.O. (2019). Slow release fertilizers to enhance soil nutrient levels and plant growth of immature rubber (*Hevea brasiliensis*). Proceedings of the International Symposium on Sustainable Soil Management (ISSSM) Soil: Underpinning Life and Environment. (Eds. R.S. Dharmakeerthi, U.W.A. Vitharana and W.S. Dandeniya) Soil Science Society of Sri Lanka. Pp.4-7. 5-6 December 2019.

Ishani, P.G.N., Wijesuriya, W. and Sankalpa, J.K.S. (2019). Can poverty be reduced through improvement in technical efficiency in the smallholder rubber sector: Case study from Kegalle district of Sri Lanka. Proceedings of the 7th Symposium on Plantation Crop Research, “Towards achieving sustainable development goals in the plantation sector. (Eds. V.H.L. Rodrigo, B.W. Wijesuriya, D.G. Edirisinghe and N.M.C. Nayanakantha), Rubber

Research Institute of Sri Lanka, Dartonfield, Agalawatta, Sri Lanka. Vol.2, Pp.145-153, 4-5 November.

Jayawardana H.A.R.K., Rathnasooriya P.D.S.D.O., Baddevidana R.M. and Chandrasiri J.A.S.(2019), the effect of paddy husk charcoal and paddy husk ash on growth of Rubber (*Hevea brasiliensis*), Journal of National Institute of Plantation Management, 1:114-123.

Jayawardana RK, Hettiarachchi RP, Gunathilaka T, Thewarapperuma A, Rathnasooriya S, Baddevidana R, Gayan H. (2019) Natural and Synthetic Mulching Materials for Weed Control in Immature Rubber Plantations. American Journal of Plant Biology. Vol. 4, No. 4pp. 114-117. doi:10.11648/j.ajpb.20190404.20

Karunaratne, N.P.S.N., Kudaligama, K.V.V.S., Fernando, L.T.B.K., Abewardhana, N.A., Madushani, P.D.T.L., Perera, M.K.P., Seneviratne, P. and Rodrigo, V.H.L. (2019). Effectiveness of commercially available selected waterbased and oil-based ethephon formulations as a yield stimulant of rubber (*Hevea brasiliensis*). Proceedings of the 7th Symposium on Plantation Crop Research, "Towards achieving sustainable development goals in the plantation sector. (Eds. V.H.L. Rodrigo, B.W. Wijesuriya, D.G. Edirisinghe and N.M.C. Nayanakantha), Rubber Research Institute of Sri Lanka, Dartonfield, Agalawatta, Sri Lanka. Vol.1, Pp.105-114, 4-5 November.

Karunaratne, N.P.S.N., Kudaligama, K.V.V.S., Fernando, L.T.B.K., Madushani, P.D.T.L., Rajapaksha, R.M.A.C., Kumara, A., Seneviratne, P. and Rodrigo, V.H.L. (2019). Effect of different types of ethephon on yield and related factors of *Hevea brasiliensis* harvested with S/2 d4 system during wintering season. Proceedings of the International Rubber Conference 2019. International Rubber Research and Development Board, Nay Pyi Taw, Myanmar, 30th Sept-1 st Oct 2019. P.112.

Kirushanthi, T., Pitawala, H.M.J.C., Edirisinghe, D., Ratnaweera, D.R. and Etampawala, T.N.B. (2019). Development of polyurethane based composite using plastic waste of PET bottles and agro waste. Proceedings of the International Research Conference, Uva Wellasa University, p.457, 7-9 February 2019.

Kudaligama, K.V.V.S., Fernando, L.T.B.K., Fernando, T.H.P.S., Lakmini, W.G.D., Somasiri, H.P.P.S., Karunaratne, N.P.S.N., Fernando, K.M.E.P., Attanayake, A.P., Rodrigo, V.H.L. and Seneviratne, P. (2019). Effectiveness of a locally developed ethephon formulation on yield and related latex physiological factors of *Hevea brasiliensis*. Proceedings of the 7th Symposium on Plantation Crop Research, "Towards achieving sustainable development goals in the plantation sector. (Eds. V.H.L. Rodrigo, B.W. Wijesuriya, D.G. Edirisinghe and N.M.C. Nayanakantha), Rubber Research Institute of Sri Lanka, Dartonfield, Agalawatta, Sri Lanka. Vol.1, Pp.95-103, 4-5 November.

Kudaligama, K.V.V.S., Fernando, L.T.B.K., Fernando, T.H.P.S., Lakmini, W.G.D., Somasiri, H.P.P.S., Karunaratne, N.P.S.N., Attanayake, A.P., Rodrigo, V.H.L. and Seneviratne, P.

(2019). Effectiveness of a new ethephon formulation on latex micro diagnosis and yield potential of *Hevea brasiliensis*. Proceedings of the International Rubber Conference 2019. International Rubber Research and Development Board, Nay Pyi Taw, Myanmar, 30th Sept-1st Oct 2019. P.111.

Kudaligama, K.V.V.S., Rodrigo, V.H.L. and Lakshman, R.G.N. (2019). Effect of early tapping on yield and related factors of rubber grown in non-traditional areas of Sri Lanka with an emphasis on financial benefits. Proceedings of the International Rubber Conference 2019. International Rubber Research and Development Board, Nay Pyi Taw, Myanmar, 30th Sept-1st Oct 2019. P.114.

Madushika, K.P.I., Wijesinghe, H.G.I.M., Edirisinghe, D.G. and Senevirathna, A.M.W.K. (2019). Influence of partial replacement of carbon black with areca nut husk fibre on properties of natural rubber composites”. Proceedings of the International Research Conference, 7-9 February, Uva Wellassa University.

Munasinghe, E.S., Rodrigo, V.H.L., Jayathilake, P.M.M., Piyasena, N.M. and Iqbal, S.M.M. (2019). Livelihood capital improvements in the rubber growing community of the Eastern Province of Sri Lanka. Proceedings of the 7th Symposium on Plantation Crop Research, “Towards achieving sustainable development goals in the plantation sector. (Eds. V.H.L. Rodrigo, B.W. Wijesuriya, D.G. Edirisinghe and N.M.C. Nayanakantha), Rubber Research Institute of Sri Lanka, Dartonfield, Agalawatta, Sri Lanka. Vol.1, Pp.123-134, 4-5 November.

Nakandala, S.A., Nayanakantha, N.M.C., Seneviratne, P., De Alwis, M.N. and De Zoysa, D.L.N. (2019). A study on different micro-irrigation techniques for mitigating water stress of immature rubber (*Hevea brasiliensis*) plants. Proceedings of the 7th Symposium on Plantation Crop Research, “Towards achieving sustainable development goals in the plantation sector. (Eds. V.H.L. Rodrigo, B.W. Wijesuriya, D.G. Edirisinghe and N.M.C. Nayanakantha), Rubber Research Institute of Sri Lanka, Dartonfield, Agalawatta, Sri Lanka. Vol.2. Pp.13-20, 4-5 November.

Nayanakantha, N.M.C., Nakandala, S.A., Karunathilake, W., De Alwis, M.N., De Zoysa, L.N. and Seneviratne, P. (2019). Moringa oleifera leaf extract as a biostimulant on growth and other physio-chemical attributes of rubber (*Hevea brasiliensis*) under drought and heat stress conditions. Proceedings of the 7th Symposium on Plantation Crop Research, “Towards achieving sustainable development goals in the plantation sector. (Eds. V.H.L. Rodrigo, B.W. Wijesuriya, D.G. Edirisinghe and N.M.C. Nayanakantha), Rubber Research Institute of Sri Lanka, Dartonfield, Agalawatta, Sri Lanka. Vol.1, Pp.95-103, 4-5 November.

P.K.K.S. Gunarathne, D.M.A.P. Dissanayake and **WasanaWijesuriya** (2019). Adoption of the rubber harvesting technologies in the smallholder rubber sector. International Rubber Conference 2019, Myanmar.

P.K.K.S. Gunarathne, D.M.A.P. Dissanayake, R.A.D. Ranawaka and **Wasana Wijesuriya** (2019). Training Induced Adoption Changes in Rubber Harvesting Technologies in Rubber Smallholdings in the Kegalle District of Sri Lanka: Comparative Analysis of Lands Harvested by Owners versus Operating on Hired Basis, Proceedings of the Seventh Symposium on Plantation Crop Research, 2, pp. 135-144.

Rathnayaka, A.M.R.W.S.D., Samita, S. and Wijesuriya, W. (2019). Occurrence of extreme rainfall events in rubber growing areas. Proceedings Faculty of Agriculture Undergraduate Research Symposium, FAuRS-2018, University of Peradeniya, p.160. Rodrigo, V.H.L. and Munasinghe, E.S. (2019). Rubber cultivation in North and East in Sri Lanka: journey as yet and way forward. Proceedings of the International Rubber Conference 2019. International Rubber Research and Development Board, Nay Pyi Taw, Myanmar, 30th Sept-1 st Oct 2019. P.46.

Rodrigo, V. H. L. and Munasinghe, E. S. (2019). Rubber cultivation in North and East in Sri Lanka: journey as yet and way forward. *Proceedings of the International Rubber Conference 2019*, International Rubber Research and Development Board, Nay Pyi Taw, Myanmar, 30<sup>th</sup> Sept-1<sup>st</sup> Oct 2019.

Rodrigo, V. H. L. and Munasinghe, E. S. (2019). Wonder tree from Amazon rain forest, now flourishing in Sri Lanka's Dry Zone. *Sunday Times*, February 17<sup>th</sup> 2019.

Rodrigo, V.H.L., Wijesuriya, B.W., Edirisinghe, D.G. and Nayanakantha, N.M.C. (2019). Towards achieving sustainable development goals in the plantation sector. Proceedings of the Seventh Symposium on Plantation Crop Research, Rubber Research Institute of Sri Lanka. Vol. 1. (ISBN 978-955-9022-22-0).

Rodrigo, V.H.L., Wijesuriya, B.W., Edirisinghe, D.G. and Nayanakantha, N.M.C. (2019). Towards achieving sustainable development goals in the plantation sector. Proceedings of the Seventh Symposium on Plantation Crop Research, Rubber Research Institute of Sri Lanka. Vol. 2 (ISBN 978-955-9022-23-7).

Ruwani Kalpana Jayawardana, Rasika Hettiarachchi, Thushara Gunathilaka, Anoma Thewarapperuma, Surani Rathnasooriya, Rangika Baddevidana, Helaru Gayan. Natural and Synthetic Mulching Materials for Weed Control in Immature Rubber Plantations. *American Journal of Plant Biology*. Vol. 4, No. 4, 2019, pp. 114-117. doi:10.11648/j.ajpb.20190404.20

Samarasinghe, I.H.K., Edirisinghe, D.G., Walpalage, S. and Egodage, S.M. (2019). Effect of nitrosamine safe diisopropyl xanthogen polysulfide accelerator on cure and static mechanical properties of natural rubber compounds. Proceedings of the 7 th Symposium on Plantation Crop Research, "Towards achieving sustainable development goals in the plantation sector. (Eds. V.H.L. Rodrigo, B.W. Wijesuriya, D.G. Edirisinghe and N.M.C. Nayanakantha),



Rubber Research Institute of Sri Lanka, Dartonfield, Agalawatta, Sri Lanka. Vol.2, Pp.105-114, 4-5 November.

Sampath, W.D.M., Edirisinghe, D.G. and Egodage, S.M. (2019). Effect of recycled polyethylene (rPE) on properties of titanate coupling agent treated natural rubber (NR)/Low-Density Polyethylene (LDPE)/rPE composites. Proceeding of 3 rd ICSTR Dubai - International Conference on Science and Technology Research. 26-27 February.

Sampath, W.D.M., Egodage, S.M. and Edirisinghe, D.G. (2019). Effect of recycled polyethylene (rPE) on properties of titanate coupling agent treated natural rubber (NR)/low density polyethylene (LDPE)/rPE composites. Proceedings of the 3rd ICSTR Dubai – International Conference on Science & Technology Research, 26- 27 February, 2019, Flora Grand Hotel, Deira, Dubai, United Arab Emirates, p. 14.

Sampath, W.D.M., Perera, I.D., Edirisinghe, D.G. and Abhayawardhana, V.G.M.J. (2019). Effect of waste polyethylene on properties of methyl salicylate treated natural rubber/low density polyethylene/waste polyethylene composites. Proceedings of the 7th Symposium on Plantation Crop Research, “Towards achieving sustainable development goals in the plantation sector. (Eds. V.H.L. Rodrigo, B.W. Wijesuriya, D.G. Edirisinghe and N.M.C. Nayanakantha), Rubber Research Institute of Sri Lanka, Dartonfield, Agalawatta, Sri Lanka. Vol.2, Pp.97- 104, 4-5 November.

Seneviratne, Priyani, Prathibha, W.A.V., Nayanakantha, N.M.C., Dissanayake, U. (2019). Effects of size and color of polybags on growth of rubber (*Hevea brasiliensis*) seedlings and budded plants under nursery conditions. Proceedings of the International Rubber Conference 2019. International Rubber Research and Development Board, Nay Pyi Taw, Myanmar, 30th Sept-1 st Oct 2019. P.55.

Silva, M.K.R., Fernando, T.H.P.S., Wijesundara, R.L.C., Nanayakkara, C. and Tennakoon, B.I. (2019). Recent trends in disease occurrence in the non-traditional rubber – growing areas of Sri Lanka. Proceedings of the 7th Symposium on Plantation Crop Research, “Towards achieving sustainable development goals in the plantation sector. (Eds. V.H.L. Rodrigo, B.W. Wijesuriya, D.G. Edirisinghe and N.M.C. Nayanakantha), Rubber Research Institute of Sri Lanka, Dartonfield, Agalawatta, Sri Lanka. Vol.1, Pp.135-143, 4-5 November.

Sivanathan, N. Wijesuriya, W., Kuruppu, I.V. and Herath, H.M.L.K. (2019). Forecasting drought incidence in Sri Lanka: Application of ARIMA and exponential smoothing models. Proceedings of 18th Agricultural Research Symposium 2019, Wayamba University of Sri Lanka. Pp.105-109.

Somarathna, Y. R., Samarasinghe, I.H.K.,Siriwardena, S., De Silva, D. &Mallikarachchi, D.V.D. (2019) Application of nano-scale zinc oxide and tetramethylthiuramdisulphide as an

effective preservative system for concentrated natural rubber latex. Proceedings of the International Conference on Science and Technology, Singapore, Pp. 6.

Somarathna, Y.R., Samarasinghe, I.H.K., Siriwardena, S., De Silva, D. and Mallikarachchi, D.V.D. (2019). Application of nano-scale zinc oxide and tetramethylthiuram disulphide as an effective preservative system for concentrated natural rubber latex. International Conference on Science and Technology, National University of Singapore, Singapore, 15-16 March, Pp.6-7.

Sudusingha, Y.C.Y., Warnajith, A.K.D., Illeperuma, R.D., Sandamali, P.K.N.N. and Siriwardena, S. (2019). A new protocol for reuse of processing water during milling process of crepe rubber manufacture. Proceedings of the 7th Symposium on Plantation Crop Research, "Towards achieving sustainable development goals in the plantation sector. (Eds. V.H.L. Rodrigo, B.W. Wijesuriya, D.G. Edirisinghe and N.M.C. Nayanakantha), Rubber Research Institute of Sri Lanka, Dartonfield, Agalawatta, Sri Lanka. Vol.2, Pp.95-103, 4-5 November.

T.T.D.Dahanayake, S.Fukai and S.Geekiyanage (2019).In vitro plant regeneration of selected Anthurium accession from Sri Lanka. National Symposium on Floriculture Research, Sri Lanka :3p

Wanninayakea, PCU, Yapa, PN, Malaviarachchi, MAPWK, **Hettiarachchi, RP (2019)**. Effect of phosphorus fertilizers and soil amendments on cadmium accumulation in maize (*Zeamays L.*) seeds. In proceedings ofInternational Research Symposium on Pure and Applied Sciences, Faculty of Science, University of Kelaniya, Sri Lanka 25-26 October 2019.

Wijesuriya, Wasana., Herath, H.M.L.K., Ishani, P.G.N. and Sankalpa, J.K.S. (2019). Forecasting of rubber prices in the Sri Lankan market using Multiple Temporal Aggregation (MTA). Proceedings of the International Rubber Conference 2019. International Rubber Research and Development Board, Nay Pyi Taw, Myanmar, 30th Sept-1 st Oct 2019. P.118.

## 2020

Bandara, B.P.D.M., Elvitigala, D.A.S., Withanage S.P. and Attanayake D.P.S.T.G., (2020) In-silico Characterization of ref gene from *Hevea brasiliensis* and Identification of High and Low Rubber Yielding Trees for ref gene Expression Studies. Proceedings of 19th Agricultural Research Symposium Faculty of Agriculture and Plantation Management, Wayamba University

Gunasekara S. D. T. S., I. R. Palihakkara and Withanage S. P. (2020) Study toward the Development of Relationship between Ref Gene Expression and Yield Potential of *Hevea*

Clones International Journal for Research in Applied Sciences and Biotechnology Volume-7, Issue-5 (September 2020) 98-105

Mifdha, M.F.F., Balasooriya, B.L.W.K. and Withanage S.P. (2020) Characterization of Selected Hevea Genotypes from the 1995 Hand Pollination Progeny. Proceedings of 19th Agricultural Research Symposium, Faculty of Agriculture and Plantation Management, Wayamba University

B. Kiriwaththuduwa, A. Wijesuriya, T.D. Silva, S.W. Ranwala and W. Wijesuriya (2020). Characterization of conserved Sugarcane (*Saccharum* spp.) Germplasm for Parental Selection in Directional Breeding of Economically Important Traits, Proc. 32<sup>nd</sup> Annual Congress of PGIA, 10p.

Mendis BILM, Palihaderu PADS, Satharasinghe DA, Premarathne JMKJK, Dissanayake AS, Rajapaksha IH, Karunanayake P, Senarath U, Wijesuriya W, Swee YK, Ho WY, Dias WKRR (2020). Stress across Different Social Demographic Groups in Suburban Areas of Sri Lanka, 133rd Anniversary International Medical Congress 86, Colombo.

Rodrigo, V. H. L. and Munasinghe, E. S. (2020). Rubber cultivation for enhancing the environmental and social resilience to climate change in drier climates of Sri Lanka. Proceedings of the International Workshop on Natural Rubber Systems and Climate Change, Digital platform. 23rd-25th June 2020.

T.T.D.Dahanayake, S.Fukai and S.Geekiyana (2020). An attempt on an alternative transformation method: Seedling transformation of rice (*Oryza sativa* L.) and Anthurium (*Anthurium andraeanum*. Linden Ex Andre) using 35S:VlmybA2 and 35S:Gus. 17<sup>th</sup> Academic sessions, University of Ruhuna, Sri Lanka : 11p

T.T.D.Dahanayake, S.Fukai and S.Geekiyana (2020). Effect of seedling transformation of *Anthurium andraeanum* Linden Ex Andre using *Agrobacterium tumefaciens* carrying genes 35S:Gus. Proceedings of the 9th YSF symposium: 174-176 p

T.U.K. Silva, P. Seneviratne, A.M.W.K Senevirathna, W.A. J. M. De Costa and H. Subasinghe (2020). Influence of some latex flow dynamics associated with different latex harvesting systems on latex yield of different clones of rubber (*Hevea brasiliensis*, Muell. Arg.). International Symposium on Agriculture and Environment, 14th February 2020, University of Ruhuna, Sri Lanka. p 23.

Wijesuriya Wasana. (2020). Preparedness of the Sri Lankan Rubber Sector to minimize the impact of Climate Change. Natural Rubber Systems and Climate Change, Open Digital Workshop, 23-25 June 2020.

Silva, T.U.K. “රබර් වගාවේ ඵලදායීතාවය ඉහළදැමීම සඳහා වැඩි දියුණු කල හැකි සාධක කිහිපයක බලපෑම”. Volume 29, Rubber Puwath, Rubb. Res. Inst. Sri Lanka.

වමිල් නයනකාන්ත (2020). රබර් වගාවේ ඵලදායිතාවය අඩු වීමට සෘජුවම බලපාන පොත්ත වියලීමේ /තැම්බීමේ (TPD /Brown Bast) සිත්ච්චෝම තත්වය වලක්වා ගත හැකි ද? රබර් පුවත්,29,4 - 45

ඩබ්. ඩී මංජුල අල්විස් (2020) සියක් වසක රබර් වගාවෙන් අප ප්‍රයෝජන ගත්තේද? රබර් පුවත් 30, 47 - 49.

ඩබ්. ඩී. මංජුල අල්විස් (2020). රබර් වගාව, රබර් පැළ තවත් සහ බද්ධකරුවා, 30 ,44 -46

පී. සෙනෙවිරත්න ,ආර්. පී කරුණාසේන සහ වසන්ත කරුණාතිලක (2020) .තාක්ෂණිකව වැඩි දියුණු කරන ලද කිරි පිහිය භාවිතය වාසිදායක ය .රබර් පුවත් , 29, 20 - 24

පී. සෙනෙවිරත්න සහ ජී. ඒ .එස් විජේසේකර (2020). රබර් ශාකයේ අතු උත්තේජනය දැන් වඩා පහසුවෙන් කර ගත හැකියි .රබර් පුවත් , 29 , 1 - 5

පී. සෙනෙවිරත්න,සී. නයනකාන්ත, ආර්. සමරසේකර සහ සදමාලි වට්ටල (2020). කොළ නිවාඩු කාලය තුල කිරි කැපීම නැවැත්වීම වාසිදායකය.රබර් පුවත් ,30, 10-14

**-END-**

## **Annex 09 - Trainings for staff on new and emerging technologies**

- Fire technology
- Technology for operation of RPA instrument
- TG/FTIR hyphenation
- Tyre technology

## **Annex 10 - Trainings for stakeholders**

Training on main thrust areas including nursery management, Planting & maintaining of plants, intercropping practices, clone identification, harvesting techniques, rain-guard application, sealant preparation, raw rubber processing, waste management, and latex/dry rubber-based compounds / product developments, etc.

## **Annex 11- Questionnaires given for obtaining views of different Stakeholders**

### **a) Questionnaire for the Rubber Research Board members**

1. Is the Board representing all sectors of the rubber industry including smallholders, input providers and policy makers? If not why?
2. Are you satisfied with the performance of RRISL? If not, what are the areas that should be improved?
3. Do you involve/ facilitate in Research Program planning and Progress review of RRISL and guide the researchers?
4. Are you satisfied with the Technology transfer system and advisory and extension of the RRI?
5. How do you strengthen the Technology Transfer system for both upstream and downstream activities?
6. What are the problems of recruiting scientific staff and approving amended draft of Scheme of Recruitment?
7. What are the procedures you have undertaken to retain experienced scientists at RRISL and how do you motivate the officers?
8. Have you considered implementing recommendations given in the report of the 'External Review of Research and Development of RRISL for 2010 -2016' prepared by Dr. P Waidyanatha et.al.

**b) Questionnaire for the Estate Managers/ Nursery Managers/ Smallholders**

1. What are the problems you face in rubber production, processing and marketing?
2. What do you propose to overcome those problems?
3. Are you satisfied with the Technology Transfer service of Rubber Research Institute (RRISL)? If not, give reasons.
4. Are you satisfied with the analytical services of RRISL?
5. What kind of support do you need from RRISL?
6. Are you aware of the new clones and technologies developed by RRISL?
7. What are the difficulties you face when adopting new technologies?
8. How do you communicate with RRISL? What are the steps do you suggest to improve communication?
9. Do you give support for RRISL field trials on testing new clones and technologies? What are the problems you encounter in supporting those trials?
10. What are the areas where you need new technologies developed?
11. What are your training needs?

**c) Questionnaire for the Rubber products (latex based/ wood based) Manufacturers**

1. What are the problems you face in rubber products manufacturing and marketing?
2. What do you propose to overcome those problems?
3. Are you satisfied with the Technology Transfer service of Rubber Research Institute (RRISL)? If not, give reasons.
4. Are you satisfied with the analytical services of RRISL?
5. Are you aware of the services offered by the Finite Element Analysis & Simulation Center (FEAS) of RRI? Whether you have used this facility?
6. What kind of support do you need from RRISL?
7. Are you aware of the new technologies developed by RRISL?
8. What are the difficulties you face when adopting new technologies?
9. How do you communicate with RRISL? What are the steps do you suggest to improve communication?
10. What are the areas where you need new technologies developed?
11. What are your training needs?

**d) Questionnaire for the Extension Officers of Rubber Development Department/Thurusaviya Fund**

1. What kind of advisory services you provide for the rubber growers?
2. What are the problems you encounter in transferring technologies?
3. What do you propose to overcome those problems?
4. Do you work in collaboration with the officers of Advisory Service Dept. (ASD) and researchers of RRISL? Do you discuss the problems of your clients with the researchers?
5. Are you satisfied with the cooperation and new technologies developed by the scientists of RRISL to overcome the problems faced by your clients?
6. What are the research areas that should be strengthened?
7. Any overlaps /duplicate of activities you find with the services offered by ASD? Please list those.
8. Do you advise on marketing?
9. Do your field officers get sufficient training on new technologies developed by RRISL?
10. Do you have sufficient field officers for effective technology transfer?
11. What are your training needs?
12. What are your proposals to strengthen the services offered to growers?

**e) Questionnaire for the University Researchers**

1. Are you conducting research related to the Rubber Industry?
2. What are the research areas that should be strengthened by collaborative research with RRISL to improve the Rubber Industry in Sri Lanka?
3. Do you have collaborative research with RRISL scientists? Do you encounter any problems in collaborative research?
4. Do you conduct Technology Transfer and/or Marketing research?
5. What kind of model you propose to improve Technology transfer and Marketing in Rubber Industry?

f) **Questionnaire for Funding Agencies (SLCARP, NSF, NRC)**

1. Are you engaged in operating a procedure/ database to get access the updated scientific literature for the researchers working in State Organizations?
2. Have you conducted any Performance/External Reviews of Rubber Research Institute (RRI) in the past?
3. If yes, have you monitored implementation of the recommendations given?
4. Do you fund research projects of RRI?
5. Do you prioritize research areas on rubber when funding? If yes, what are the criteria for prioritization?
6. Briefly describe the progress monitoring procedure of research projects of RRI funded by you.

g) **Questionnaire for Relevant Ministry Officials**

1. Do you facilitate/ involve in Research Program planning and Progress review of Rubber Research Institute (RRI) and guide the researchers on changes of Govt. policies?
2. Are you satisfied with the performance of RRI? If not, what are the areas that should be improved?
3. Why the Ministry (MPI) is funding special research projects in addition to the projects carried out with the funds of the normal budget?
4. Do you monitor the progress of RRI in implementing Rubber Master Plan?
5. What are the problems of recruiting scientific staff for RRI?
6. Are you satisfied with the present Technology Transfer system for the Rubber industry? What are your plans to strengthen the Technology Transfer system for both upstream and downstream activities of the Rubber Industry?
7. Do you find any overlaps with advisory and extension activities carried out by Advisory Services Dept. of RRI, RDD and Thurusaviya?
8. If yes- what would you propose to avoid duplication and to strengthen the advisory and extension system to deliver better service to the sector



## **Annex 12 - Schedule of Visits and Virtual Meetings held by the Review Team for obtaining relevant information**

### **Day 01 – 24.03.2021 (RRI, Dartonfield, Agalawatte)**

<b>Time</b>	<b>Program</b>
09.30am - 10.30 am	Presentation on review process by Dr. N. Ahamed, Acting Director of NASTEC for officers of RRISL and the review team.
10.30 am - 11.30am	Presentation on general overview of RRI by Dr. P. Senevirathne, Deputy Director (Biology)
11.30 am - 02.00 pm	General discussion with the officers participated for the meeting on performance review of RRISL.
02.00 pm – 03.00 pm	Lunch
03.00 pm – 04.30 pm	Meeting with the Chairperson of Rubber Research Board, Prof. S. Ranwala.

### **Day 02 – 08.04. 2021 (RRI, Dartonfield, Agalawatte)**

<b>Time</b>	<b>Program</b>
9.00 am – 11.00 am	Visit to Soil & Plant Nutrition Department
11.00 am – 01.00 pm	Visit to Plant Pathology & Microbiology Department
01.00 pm - 02.00 pm	Lunch
02.00 pm – 03.30 pm	Visit to Plant Science Department
03.30 pm – 04.30 pm	Visit to Adaptive Research Unit

**Day 03 - 22.04.2021(RRI, Dartonfield, Agalawatte)**

Time	Program
08.30 am – 10.00 am	Discussion with officers of Agricultural Economics & Biometry units
10.00 am - 11.30 am	Visit to Administration Department
11.30 am – 01.30 pm	Visit to Accounts Department
01.30 pm - 02.30 pm	Lunch
02.30 pm – 04.00 pm	Discussion with Additional Director & Deputy Director (Biology)
04.00 pm – 05.00 pm	Discussion with Additional Director, Dr. Lakshman Rodrigo

**Day 04 – 12.05 2021****Virtual meetings through Zoom app. technology Operated through NASTEC**

Time	Program
11.00 am – 11.30 am	Discussion with staff of Biochemistry & Physiology Department (Couldn't connect with the Head of the Department)
11.30 am – 12.00 noon	Discussion with Network Administrator
12.00 noon – 12.40 pm	Discussion with Civil Engineer of Works Department
12.40 pm – 01.30 pm	Discussion with Estate Manager, Dartonfield
02.00pm – 03.15 pm	Discussion with the Head of Genetics & Plant Breeding Department
03.15 pm- 04.15 pm	Discussion with the staff of Advisory Department & Training Centre

**Day 05 - 21. 05. 2021****Virtual meetings through Zoom app. technology operated through NASTEC**

Time	Program
09.00 am – 10.00 am	Discussion with DDR (Biology) , Dr. Priyani Senevirathne
10.00 am – 11.00 am	Discussion with DDR (Technology), Dr. Susantha Siriwardena
12.30 pm – 01.00 pm	Discussion with Internal Auditor , Ms. Shyamali
02.00pm – 03.15 pm	Discussion with Research Officer, Ms. Dhammika Balasuriya of Sub-Station, Polgahawela.

**Day 06 - 28. 07. 2021****Virtual meetings through Zoom app. technology operated through NASTEC**

Time	Program
09.00 am – 10.30 am	Discussion with Nursery Managers of RDD
10.30 am – 12.00 am	Discussion with representatives of Rubber Smallholders

**Day 07 - 09. 08. 2021****Virtual meetings through Zoom app. technology operated through NASTEC**

Time	Program
09.00 am – 10.00 am	Discussion with Secretary General, Sri Lanka Rubber Secretariat

## **Factual Verification Meetings**

<b>Date</b>	<b>Program</b>
28.10.2021	Meeting of the Review Panel at NASTEC office to discuss the suggestions given by RRI staff and members of the RRB
24.11.2021	Factual verification meeting with RRI staff
29.12.2021	Factual verification meeting with RRB

### 13. Photographs



