SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

8.1 Introduction

The research in this dissertation is concerned with exploring national agriculture research systems at the macro and meso levels with a focus on rice research in India and Sri Lanka. While research on agriculture systems is dominated by agriculture economics, research studies in S&T policy analyses and national systems of innovation have given very little or no space to agriculture research systems from a socio-historical, sociological and organizational perspectives. Further, research on sociological aspects of science has paid very little attention to comparative studies on the organization of science, science communities and the manner in which the orientations of scientists and their research activities are structured in laboratories across national and cultural contexts (Krishna, 1987). The present dissertation is a modest contribution in this direction. The main objective of this thesis was to develop appropriate theoretical framework from historical, sociological and organisational perspectives on the National Agriculture Research Systems (NARS) in India and Sri Lanka. While the NARS in India formed a basis for exploring the dynamics of its working and structure of linkages between different actors for comparison with Sri Lankan counterpart at the macro level, the rice research and rice science community within the NARS in the two countries formed a basis for a comparative study at the meso level. The NARS in the two countries have been established on the basis of both India and Sri Lanka being British colonies, which gained independence during the same period in late 1940s. The two research institutes, CRRI, Cuttack (India) and RR&DI, Batalagoda (Sri Lanka) showed organizational similarities (in terms of formal research objectives and management model) and functional diversities. This
provided a fruitful sociological context for drawing a comparison on the organization of scientists in the two case studies of the rice research institutes that are housed within the NARS in the two countries.

The theoretical perspectives developed in the first part of this thesis formed a sound basis for empirical investigation, through the methodology discussed in the Chapter 3. Towards the construction of a theoretical framework, a number of concepts were drawn from different sources ranging from general sociology of organisations, sociology of science and the social history of science. The most influential theoretical streams that formed the basis for a meaningful approach to the analysis of this study were the perspectives drawn most centrally from the works of Haralambos and Rocheteau (system); Richard Nelson and Lundval (national systems of innovation); Galbraith, Kast and Rosenzweig (organization); Merton, Kuhn, Storer, Bridgestock and Schott (scientific communities); Parsons, Meyer, Rowen, and Evan (institutionalisation); and Ben-David, Whitely and Jagtenberg (professionalisation). The overall analysis contained in this thesis reflects a combination of historical analysis with interpretative perspectives of the present situation.

While the scope of this thesis at the meso level is limited to the case studies of two research institutes in rice concerned with organization of science and orientations of scientists, the exploration at the macro level investigates the historical and national specificities concerning the dynamics of NARS and the way in which different actors (agriculture research, education, extension, organizational and institutional mechanisms) interact and structured particularly in India. This was rather intentional to draw a comparison to the Sri Lankan NARS. Therefore, the empirical findings can be expected to have considerable practical value in drawing some policy implications for agriculture research.
8.2 Summary

The present study was undertaken to provide a comprehensive review of the historical development of agricultural research and the National Agricultural Research Systems in India and Sri Lanka in their present context, with particular reference to rice research. The study had the following broader objectives as laid down in the Chapter 1.

i) To explore how the NARS in India and Sri Lanka have evolved, organized and performed over the years.

ii) To examine the organizational structure of the agricultural research in India and Sri Lanka in the overall development of the country.

iii) To understand the structure of linkages among different actors or main components of NARS that has strengthened the system.

iv) To draw lessons, if any, from the Indian Agricultural Research System to Sri Lanka.

The specific objectives consisted of: i) to explore the thrust areas and the issues of S&T policies relating to agriculture those have shaped the growth and structure of NARS; ii) to explore the processes of institutionalisation and professionalisation of rice research in India and Sri Lanka; iii) to study the growth and organization of scientific community and understand the dynamics of linkages among research, teaching and extension in rice research; iv) to explore the role of advanced rice research technologies in the process of varietal development and how they are institutionalized; to explore how scientists are organized in the rice research laboratories in India and Sri Lanka; v) to study the institutional and organizational factors influencing the productivity of scientists in rice research laboratories; vi) to map out lessons of learning, if any, from each other’s system of rice research and organization of scientific communities; vii) to map the strengths, weaknesses and drawbacks of the NARS and make some policy orientated recommendations as relevant to the two national contexts.
The brief literature survey on the NARS of the two countries formed a solid basis for this study. The sociological perspectives of science, social history analyses and organizational studies helped to build up an analytical frame for the thesis, which have been discussed in the Chapter 2.

The time period covered both the colonial and post-colonial period, laying much emphasis however on the period after 1980s for the study of NARS in both countries.

As for research methodology discussed in the Chapter 3, the applied social research methods were adopted by means of collecting both qualitative and quantitative data. Qualitative data were analysed by using the guidelines given by Yin (1994) and Wengraf (2001). For quantitative analysis of data, first a descriptive statistical analysis was conducted by means of simple tabulations and computing percentage values. The data were further analysed by using statistical method of t-test for significance of variance and Spearman’s correlation for agreement of attitudes of scientists between the two countries.

Since this was not a completely historically oriented study, mostly secondary data were used to review the growth of agricultural research systems in the two countries, which were presented in the Chapter 4. The overall review supported the hypotheses drawn under Level (1): NARS in general viz., (H1)- Institutional and organizational linkages between different actors (in the NARS) are as important as R&D factors in infusing dynamism.

The Chapter 5 supports the hypothesis (H1) above and (H3)- NARS in Sri Lanka is weak and less established compared to the same in India. Also, it reveals the concept of scientific communities and professionalisation of science in agriculture research under NARS remained an important feature and factor for the dynamism of NARS in India. This is important in drawing lessons to Sri Lanka, via comparison. Chapter 5 also contains secondary
data on the history and development of rice research in India and Sri Lanka, the rice research
technologies developed and conducted at present in the two countries and the strategies behind
them. It also supports that the constitution of scientific communities and
professionalisation are the important determining factors for characterizing the
weak (under developed and not well established) or strong (effective, well
established and developed) NARS in the national contexts (H2).

The overall review in the Chapter 6 supported the hypotheses drawn under Level 2: rice
science community viz., (H4)- Rice research component in Indian NARS is more
effective and strong compared to the same in Sri Lanka; (H5)- Strong or weak rice
research component in NARS is highly determined by the notion of scientific
community and professionalisation.

However, in the case of the two case studies conducted at the rice research institutes in
India and Sri Lanka, primary data were collected by means of a questionnaire survey and the
direct interviews with scientists. The qualitative and quantitative analysis of the questionnaire
survey and the interpretations therein are discussed in the Chapter 7. The results indicated that
organizational and the institutional set up in rice research has considerably influenced the
research productivity of rice scientists (H6). It may be noted that the exploration is concerned
with publications and other modes of productivity of scientists and not the rice production in
the two countries. Since India has already addressed many such issues that have negative
impact on the similar lines, the productivity of Indian rice scientists is significantly higher
than that of Sri Lankan scientists. Many of the Indian scientists strongly agree that publication
of research should be the criterion for evaluation of their work. But majority of Sri Lankan
scientists neither agree nor disagree to this. Therefore, the hypothesis that the publication of
research should be the criterion for evaluation of productivity of rice scientists (H7) is only
partially supported by the results. The contribution of rice scientists is also influenced by their
time allocation for research, their goal orientations, research climate of the institute and the
rewards and recognition they receive for their work. All these above factors collectively support the hypotheses (H6) and (H8). It was also revealed by the results that the rice scientists are subject to social control of research prevailing in the institute. They are also slightly influenced by the societal and cultural nature of the two countries. But in this case, both being neighbouring South Asian countries, there is no major difference as one finds between the West and the East.

The Chapter 7 contains the results of the qualitative analysis and interpretation of the data received from the direct interviews. The results further support the hypotheses (H1), (H2) and (H5). Also, too much centralization of research may hinder the growth and development of agricultural research in a particular country is supported by the facts presented in this Chapter. This has been the case for India in early 1990s, but many scientists agreed that the issue has now been addressed to a satisfactory level though further improvement is necessary. As for Sri Lanka, this issue is relevant only to the institutes that are coming under the DOA. The results indicated that many Sri Lankan scientists who took part in the (questionnaire) survey and the direct interviews are of the strong view that the RR&DI may be allowed to operate as an independent institute coming directly under the Ministry of Agriculture and Livestock.

The most important issue that came out in the Chapter 7, when the data of the direct interviews were analysed, is that the personnel policies in the Sri Lankan system relevant to scientific community, are in a very poor state. The Indian NARS has already addressed this issue to a satisfactory level with the establishment of the Agricultural Research Service (ARS) in 1975, though it needs further improvement. The introduction of ARS highlighted the fact that the opportunities for career advancement, irrespective of the occurrence of vacancies, through a system of assessment should enable each scientist competing with his or her own past rather
than with colleagues and to the acceptance of the principle that "All rights accrue from a duty well done" (Ramanujam et al, 2002). However, the recruitment and promotion of scientists were done on the above stand up to 1996 until it was replaced with the University Grant Commission (UGC) system, which is in operation now.

8.3 Concluding Remarks

Based on the overall review of this study and the hypotheses proved in the Chapters 4-7, the following conclusions could be made in two steps.

8.3.1 Specific conclusions drawn according to the hypotheses proved:

1. As observed throughout the review, proper organizational and institutional innovations give dynamism to NARS in any particular country. In the case of this particular study, it is clearly seen that such innovation moves such as AICRPs, are the reasons behind the dynamic NARS in India.

2. A strong structure of linkages among different actors (research, education and extension activities including organizational and institutional mechanisms) or components of NARS gives strength and dynamism to NARS as seen in the case of India.

3. Much centralization of research may obviously hinder the growth and development of agricultural research in a particular country because agriculture is a location specific, climatologically different and culturally biased subject.
4. The rice science community could be considered as the most important actor in the organization of rice research in the two countries. Nevertheless, it is apparent in the case of India that the government, the Ministry of Agriculture, the ICAR, senior scientific administrators in the sector along with the Directors of the two rice research institutes are also the other important actors behind the success of rice research in India. In other words, the rice research and rice scientists at the laboratory level are closely linked networked to NARS at the national level.

5. India has a strong professionalised rice science community compared to Sri Lanka. The strength of this community is largely due to the intellectual climate of relevant research groups spread around the country in institutes and agriculture universities, professional societies and their frequent meetings and seminars, availability of journals for publications, incentive structures at the laboratory and the council level to motivate scientists, arena of competition due to large groups in agriculture research and adequate research and laboratory infrastructure. It may be said that there is no comparable situation in the case of Sri Lankan counterpart. The intellectual and institutional features noted above provide some insights including the feature noted in (4) above.

6. Although there is no argument that the publication of research findings is very important to gain scientific recognition; publication is important for development of scientific identities and recognition; to avoid duplication or repetition of research; to lay a solid basis to the research world and so on, it
should not be the main and the only criteria for evaluation of contribution of rice scientists.

7. Research productivity of scientists in laboratories obviously depends on the time allocation for research by scientists, goal orientation of scientists and the research climate of a particular institution. According to the study, this is also true in the case of rice research in the two countries.

8. Rewards and recognition by the institute where they work, naturally enhances the research productivity of rice scientists.

9. Age of retirement of Agricultural Scientists in Sri Lanka may be increased up to at least 60 years as in the case of India (which is 62 years now), since Sri Lanka has considerably a fewer number of experienced scientists and since she has severe financial constraints in regard to training and HRD of scientists.

10. The morale of Sri Lankan agricultural scientists, especially those who are attached to the DOA, is low due to their low salaries, ad hoc transfers done within the institutes in the DOA, absence of proper recruitment and promotion schemes and lack of good infrastructure facilities for research.

8.3.2 General conclusions drawn on the overall review of the study

1. The agricultural research relevant to food crops in India and Sri Lanka was in similar status and was considered as marginal during British colonial period, until the two countries gained independence in late 1940s.
2. After independence, even though the governments of both countries had recognized the importance of agricultural research and development, the science/research policies in India were more consistent despite the change of governments and the implementation levels were generally satisfactory compared to the same in Sri Lanka. One can see a strong political support to science and technology by successive governments in India coupled with recurrent increase in the over all R&D investments as proportion of GDP. This has not been the case with Sri Lanka both in the overall R&D and in specific with agriculture research.

3. The landmark for agricultural R&D took place in both countries in between mid 1960s and mid 1970s with the application of new technologies during green revolution. During this period India gained self-sufficiency in rice production while Sri Lanka became closer to self-sufficiency.

4. Though the institutionalization of agricultural research had begun during the British colonial period, India had made a remarkable progress in building agriculture universities, specialized agriculture research laboratories and an extension system with a network of linkages between different segments of a large country after the independence compared to Sri Lanka. From a sociological perspective, it may be also said that the close and easy linkages between science and politics in the post independence period acted as a catalyst in giving boost to science and technology agenda, particularly agriculture. This feature is evident not only in strategic sectors of research such as atomic energy, space research and defense but in accomplishing what are known as 'green' and 'white'
revolutions in India. The accomplishments of Dr Kurien (father of milk revolution in India) at NDDB and the milk cooperatives is another good example of positive science and politics linkage. This feature is now continued in soft-ware and ICT revolutions. India created a ministry with a cabinet rank minister for ICT to give a boost to this emerging field and as early as 1980s created a Department of Biotechnology. Despite some shortcomings and problems the 'science-politics alliance' played an important role in the case of India (see Krishna 2001).

5. India is much ahead in professionalisation of agricultural research and has a well-established agricultural science community compared to Sri Lanka. This achievement has not been a sudden one but gained over the years, as a result of consistent S&T policy insights in agricultural development. The small number of agriculture scientists, particularly in rice science and limited number of research groups with under developed intellectual features of journals, professional societies, reward structures both at the macro and laboratory level and above all inadequate infrastructure in research laboratories in the case of Sri Lanka poses several problems.

6. India has a well-organized National Agricultural Research System under the umbrella of ICAR within the single Ministry of Agriculture while Sri Lanka has a poorly organized National Agricultural Research System within six cabinet ministries causing poor coordination in agricultural research. The above feature coupled with scientific leadership heading the NARS in India with considerable research and policy autonomy has enabled the system to evolve some crucial institutional and organizational mechanisms to forge
linkages between different actors of the innovation system (AICPS for example) and introduction of incentive systems over a period of time. One of the important features of NARS in India is also the inputs she receives from sociological, economics and statistical research for which some specialized institutions are created within the NARS systems. Some 300 scientists are employed in these social science activities in addition to those involved in the extension system.

7. Due to structural weakness and lack of legitimacy and authority, the functions of CARP as an inter-ministerial organization for coordinating agricultural research (functions expected to be similar to ICAR) has not been so far successful.

8. The structure of linkage among research, education and extension in the agriculture sector is well structured and strengthened with recurrent institutional mechanisms in India compared to Sri Lanka. Central Institutes and Agricultural Universities have well been welded together into a symbiotic working partnership through All India Coordinated Research Projects. No such institutional mechanism is there in Sri Lanka including specialized agriculture universities such as in India.

9. The inadequate funds, inadequate research infrastructure and poor coordination among research institutes, universities and scientists are the major stumbling blocks for Sri Lanka for R&D in agriculture.¹

¹ See Swaminathan, 2002 for details
Lack of proper personnel policies relevant to the scientific community in the agriculture sector has demoralized the Sri Lankan agriculture scientists, which has severely affected the efficient functioning of NARS in Sri Lanka. Authorities in the Sri Lankan NARS should pay attention to the ARS (1975) in the Indian NARS, as discussed elsewhere in the chapter and draw lessons from the same.

The institutionalisation, organization, and professionalisation of rice research is much ahead in India along with a well established rice science community with majority of rice scientists having PhDs in a much wider variety of fields compared to Sri Lanka.

What is also of relevance here is the fact that in developing countries likes Sri Lanka and other South Asian economies; food security (also health security) is of paramount importance. Food security actually means establishing national technological capabilities in agriculture research and in modern biological sciences such as biotechnologies and genetics. In the post-WTO regime these capabilities cannot be fully transported and imported as earlier in the form of technology transfer and need to be evolved nationally and locally. Also in agriculture and modern biological sciences technological capabilities means establishing basic research base and promoting agriculture science communities and establishing advance research groups in universities. Unfortunately there is no shortcut other than promoting basic research and establishing science communities in agriculture in agriculture based economies. This is indeed an important lesson from the Indian case of NARS.
12. The research productivity of rice scientists in India measured by means of research output (research publications, patents, awards etc.) is significantly higher compared to the Sri Lankan rice scientists implying that the contribution of Indian scientists to rice research is higher.

13. India is much ahead in development and application of new and advanced rice research technologies compared to Sri Lanka and thereby the contribution of scientific community to rice research is higher compared to Sri Lanka.

14. Sri Lanka is still experiencing difficulties due to lack of consistent S&T policies in agriculture. Therefore, inconsistent S&T policies in agriculture and poor implementation of currently available policy recommendations are the major issues that hinder the R&D in agriculture in Sri Lanka.

15. Presence of effective structure of linkage among research, teaching and extension; the State Agricultural University system; proper personnel policies consistent with the feelings of the scientists; efficient coordination of research; commitment of hierarchical authorities; and devotion of scientists keeping the basic principle in mind that "all rights accrue from a duty well done" are some of the major lessons to be drawn from the Indian NARS to Sri Lanka.
8.4 Recommendations and some S&T policy implications

The specific conclusions arrived in accordance with the relevant hypotheses tested and on the basis general conclusions presented on the overall comparative research on the NARS in the two countries – the study was able to identify some important issues to be considered as recommendations and S&T policy implications coming out of this research. These are as follows:

- The available evidence in this study suggests that Sri Lanka should increase its investment on R&D in general from its current amount of less than 0.2% of GDP (compared to India’s 0.9 per cent of GDP) to a satisfactory level in spite of the country’s financial constraints prevailing at the moment. India is targeting to raise the amount to at least 2% in the last year of the 10th Plan (2006-2007).

- To strengthen the effective coordination among the relevant government departments (DOA, DEA, DAPH etc.), research institutes (RRI, TRI, CRI, SRI, NARA etc.) and universities (Faculties of Agriculture), the Council of Agricultural Research Policy (CARP) may be upgraded by giving legitimacy and authority to function as an inter-ministerial organization for proper coordination of agricultural research in the system.

- Immediate attention may be paid to the establishment of effective linkages of structure among research, education and extension in agriculture in Sri Lanka by bringing the relevant government departments (DOA, DEA, DAPH etc.), research institutes and universities (Faculties of Agriculture) together, through countrywide coordinated research projects similar to AICRIPs in India.
Absence of at least one agricultural university in Sri Lanka may be one reason for this poor linkage and one possibility could be upgrading the Faculty of Agriculture, University of Peradeniya to a level of an agricultural university. However, feasibility of such a proposal is in question due to prevailing financial constraints for R&D, lack of resource personnel and research infrastructure in the country.

- The NARS should be administered in such a way that it must be scientist-centered and not post centered\(^1\), for effective and efficient functioning. The Indian system has fortunately focused on this issue.

- The lack of proper personnel policies and incentive or reward structure in the NARS in Sri Lanka is another issue that deserves utmost immediate attention. Reference may be made in this regard to the ICAR Hand Book on the Agricultural Research Service (1977). The main objectives for the establishment of the ARS has been summarized by Ramanujam et al. in 2002 (please see the Annex 8.1).

According to the ARS\(^2\) initiated by the ICAR in October 1975, it enables a young scientist entering a research career to get the highest salary possible in public services without changing his or her field of specialization and without shifting to managerial and administrative posts merely for receiving a better salary. This should help to 'de-glamourise' management posts and leave such positions only in the hands of those who have real aptitude and the ability in the field of co-ordination and research management.

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\(^1\) As endorsed by Prof. M.S. Swaminathan/ Chairman, MSSRF, Chennai (direct interview).

• Coupled with the issue mentioned above, the personnel policies within the S&T policy frame should be such that the authority may identify scientists with aptitude for leadership and management and they may be given training relevant to various issues on organization and management. Regular training programmes to other staff members at different levels may also be introduced.

• The NARS could attempt to stop the brain drain of scientists to the developed countries. India has been successful in minimizing this aspect to a satisfactory level by introducing progressive personnel policies. In the case of Sri Lankan NARS, immediate attention is needed. In this regard, it is worth looking at the research findings of Krishna and Khadria (1997) relating to the similar aspects, but relevant to all fields of science in India. Further, Indian experience in biotechnology and in other areas such as ICT has clearly demonstrated that strengthening scientific communities and promoting professionalisation in specific fields of research coupled with appropriate S&T infrastructure and incentive structures, brain drain could be arrested to a large extent. Increasing the professional base also contributes to brain gain as in the case of ICT and biotechnology professionals coming back from US and starting enterprises in Bangalore and Hyderabad regions of India.

• Though this particular study concentrated mainly on the scientific community, the services of the members of the Technical Service may also be recognized since they provide the kind of support that can enhance the per capita output of research scientists. As suggested in the Handbook of Technical Services of ICAR (1978), they may be directed to undertake the activities such as dissemination of research results through publication and help to organize field and laboratory facilities in an efficient manner.

• The study revealed that the percentage of allocation of funds for RR&DI is hardly enough for R&D in the institute. It is, therefore, recommended that the percentage of allocation of funds from the vote of the DOA may be increased since rice is the priority crop and the staple food in Sri Lanka. Or else the RR&DI may be upgraded to an independent institute coming directly under the Ministry of Agriculture and Livestock. However, the feasibility of such a move should be carefully looked into, so as to minimize the isolation of rice research.

• The proportion of scientists in the NARS in Sri Lanka without PhD qualification is large, which hinders the ability of the system taking up independent research. Since of late, opportunities for postgraduate training of young staff abroad have decreased. Therefore, the government should explore the possibility of adopting more and more ‘split programmes’ to train scientists up to PhD level at good foreign universities and international agricultural research institutes.

    Since India is very much advanced in the agricultural research and has very good universities and research institutes that offer PhD programmes, the Sri Lankan government may explore such possibilities and encourage scientists to receive training in India up to PhD level. This move will be cost effective compared to sending scientists to the Western countries. The most important issue here is, that for research in agriculture, India would be more relevant to train Sri Lanka agricultural scientists. Also, the cost will be further reduced dramatically if split programmes are worked out. This can be taken up as part of the S&T collaboration under the SARC.

• The external reviews of S&T organizations in the NARS are of much importance for efficient functioning of the system. Such reviews periodically done by ICAR in India have given a new dimension to the agricultural research management in the country. The CARP
in Sri Lanka also has introduced external reviews of the S&T organizations in the NARS recently and it is important for CARP to continue this programme. The recommendations made by such reviews must be followed up by the institutes.

- It is important for NARS in any country to have a monitoring mechanism for measuring the return from the investment on agricultural research\(^1\) for efficient functioning. Indian NARS has already established such a mechanism via ICAR. For building this skill, strengthening economic and social science related research assumes significance.

- It is also important to expose scientists working in the system to acquire new knowledge and share information on science and technology in agriculture, at international level to improve their research capabilities. Their participation at such events may be encouraged by both countries.\(^2\) The policy adopted by the National Science Foundation in Sri Lanka for providing financial support for travel abroad has given encouragement to many agricultural scientists.\(^3\)

- Attention may be paid by the authorities of the NARS to strengthen the mission oriented basic research so that there is a regular flow of technology, which can ensure production of more food through productivity enhancement.

India has already taken necessary steps towards this by developing advanced research technologies in the field of biotechnology.\(^4\) As discussed in the Chapter 5, India is doing well on the similar lines in regard to rice research. But it was revealed in this study, that in

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\(^1\) Views and recommendations expressed by Prof. M.S. Swaminathan/ Chairman, MSSRF, Chennai (direct interview).

\(^2\) Views expressed by the majority of scientists in India and Sri Lanka (direct interviews).

\(^3\) Views expressed by the majority of Sri Lankan scientists (direct interviews).

\(^4\) Developing country researchers and policy makers should avoid being overwhelmed by the benefits of biotechnology that are so elegantly outlined in the literature. Substantial efforts will have to be made in analyzing how these developments are going to affect current products, processes and economies, see Mooney (1984) for details.
spite of having research laboratories with advanced facilities in the central research institutes, general universities and some SAUs, Indian NARS still has some institutes especially SAUs that are doing biotechnology research without much facilities, as the financial support given by the respective state governments is poor. Therefore, the Indian NARS may workout for suitable S&T policies as to increase the facilities in those SAUs or to centralize laboratories, which are doing advanced rice research technologies.

However, in the case of Sri Lanka, S&T policies relevant to this aspect may be taken carefully, considering the financial constraints for agricultural research, lack of resource personnel and infrastructure facilities in the country. As revealed in this study, what is important to Sri Lanka at the moment is, to increase rice production to gain self-sufficiency.

Market studies have shown that Sri Lanka has a potential to export, when there is excess rice, to West Asia and the developed western nations (TAP, 1989). Since it appeared that there is a growing demand from the western nations, for locally grown red rice with a high nutritional value, especially the United States, special breeding efforts including areas using biotechnology research may be useful. However, this market need can be met only if post harvest practices and rice milling standards are improved to produce quality red rice developed using new technologies. Attention to institutional and organizational features identified in the study of Indian NARS is an important aspect because such features are not unrelated to economic objectives in agriculture production.

- In the case of Sri Lanka, staggered preparation of many policy documents and statements by different ministries and institutions servicing agricultural S&T contribute to unfocussed development.¹ This study reiterates the fact that NASTEC, NSF and CARP should be

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¹ As observed by Senanayake (2000).
actively associated in S&T policy formulation relevant to agriculture on a continuing basis\(^1\) to build up an efficient NARS in Sri Lanka.

8.5 Suggestions for future work

This study concentrated on overall review of the development of the National Agricultural Research Systems in India and Sri Lanka taking a historical, sociological and policy approach for interpretative analysis. In the empirical investigation of case studies, though it collected primary data on the general NARS mainly by direct interviews, it focused on rice research in the two countries for collection of data through a questionnaire survey. Further, there were other aspects, which were suspended in the empirical research of this study given the limitations of an individually based, time bound and financially restricted comparative PhD project involving two countries. In the light of these remarks, some suggestions for further research are listed below.

The questionnaire survey of the case study limited its focus only on the scientists who were working in the head office of the CRRI (Orissa) and RR&DI (Batalagoda) in the two countries. However, as mentioned in the thesis, the two institutes have sub-research stations under them. Due to the time constraints and difficulty of getting questionnaire collected, the study was not extended up to that extent. Further research may include the sub stations as to study whether there is a difference in the attitudes of scientists at the head office and the scientists at the sub stations, on the lines investigated.

A more detailed examination could be pursued of the status and differences between the senior and junior scientists in relation to the laboratory based socialization processes and mechanism of socialization.

View expressed by majority of senior scientific administrators in Sri Lanka (direct interviews).
India has two rice research institutes, CRRI in Orissa and DRR in Hyderabad. A comparative study on the similar lines could be extended. CRRI being the older one, established in 1946 and the DRR being a project (AICRIP) established in 1965 and elevated to a research institute in 1988 provide good grounds for comparison within the country.

Within the framework of NARS, a comparative study may be conducted on a different crop such as plantation crops. The orientations of research and attitude of scientists in regard to commercial crops would be different which may give an interesting outcome.

Since all the S&T organizations in Sri Lanka, dealing with agricultural research do not come under umbrella of a parent organization like ICAR in India, a similar comparative study may be conducted between two research institutes coming under different ministries. In such settings, it could be expected that the immediate institutional context be more directly exposed to political, social and economic contexts.

As discussed and observed in the Chapter 2, the NARS in a particular country could also be considered as a sub set of a larger system of technology innovation such as National System of Innovation (NSI). As Lundvall (1992) sees it, on the one hand, the NSI is an institutional set up affecting all parts and aspects of economic structure that supports and directs processes of innovation and learning. On the other hand, it includes organizations and institutions involved in searching and exploring such as government R&D departments, universities and public research institutions (main actors). The innovation system framework offer more inclusive way of thinking about the actors and the institutional context in which the generation, diffusion and use of new knowledge takes place. According to Sulaiman and Hall (2002), this system of actors and processes not
only includes research and extension, but also technology users, private companies and non-governmental organizations (NGOs). Therefore, it is proposed that the study of NARS could be further extended to explore as NSI and cover other aspects at the micro level, which were beyond the scope of the present study.