

National Research Programme on Plantation Development (NRPPD)

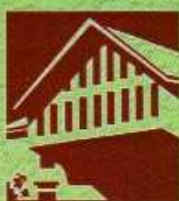
sponsored by
Department of Commerce, Ministry of Commerce and Industry,
Government of India

Discussion Paper No. 40



Towards Evolving a More Effective R&D and Extension System in Tea : A Preliminary Exploration of North India

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AND EXTENSION SYSTEM IN TEA:
A PRELIMINARY EXPLORATION OF NORTH INDIA**

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2015

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vide a platform for publishing preliminary results of the policy oriented research and it is meant for encouraging discussion and debate.

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ABSTRACT

This study is about the R&D and extension system in North Indian tea focusing on Tocklai Tea Research Institute within the innovation system framework wherein innovation is conceived as a process of learning through interaction between different stakeholders along with R&D effort which is governed by the institutional context.

TTRI has an elaborate R&D system wherein ten research divisions have been established to deal with almost all aspects of tea industry. However, it appears that the innovation system in general and the research agenda in particular has not successfully coevolved in tune with the emerging challenges. In particular, issues relating to processing, packaging and changing consumer preferences seems to have not received the attention that they deserve. Overtime, TTRI has transformed itself from a primarily estate-funded organisation to one with significant reliance on grants from the Tea Board. However, the study finds very low R&D intensity along the sharp fluctuations in the two major sources of funding (grants from Tea Board and member subscription) indicating the absence of a steady and assured support for R&D, an activity involving substantial uncertainty. Since the research system has not been able to rise up to the challenges, the emerging trend appears to be one wherein the industry's interaction with the research system is declining as is evident from the sharp decline in the number of annual scientific Committee, meetings, the number of members attending such meeting, number of training cum demonstrations held and number of participants therein and finally on the number of advisory visits. Analysis of the research agenda setting and the nature and extent of interaction with different actors in the research system tends to suggest that the nature of interaction that exists today is highly lop-sided, mainly, confining to the large planters. The small growers are totally excluded. It appears that given the lop-sided interaction, the research agenda tends to get focused excessively on the short-term considerations and challenges faced by the planters and the system is constrained to

address the long-term considerations which would also involve substantial basic research. No wonder, though the system has been able to come up with different clones overtime, a clone that evolved in 1949 still dominates the sector. There has not been any significant increase in the productivity either. The index of production per hectare of tea (with 1970 =100) has hardly shown any significant increase and in fact showed downward trend since the mid-1990s. This compares very poorly with that of natural rubber.

From the policy perspective, there is the need for substantial internal restructuring of R&D and extension activities with greater attention to processing and enabling the industry to cope with new certification standards along scaling up the R&D and extension activities. The study also underscores the need for developing stronger linkage with other knowledge producing centers and other actors, both within and outside the country. We are also inclined to infer that the interactive system has to be made more balanced wherein the role of Tea Board cannot be reduced simply to the provider of research grants. Since the Tea Board has the mandate of building an internationally competitive and vibrant tea sector it has to ensure that a long term perspective is built into the research agenda.

At a more general level, drawing from the earlier research of NRPPD, we believe that the plantation sector today is confronted with more challenges than ever before. While many of these challenges are similar across different plantation crops and mutual learning possibilities are immense, the present mode of organizing research - one institution one crop – perhaps leads to duplication of efforts. Such narrow crop level specialization has the potential danger of foregoing learning opportunities from the experience of other crops and forgoing economies of scale and scope, which is inherent in the production of innovations as well. Hence, it is high time to think in terms of bringing all these research institutes under one organization with appropriate governance structure by effectively harnessing the information and technology.

1. Introduction

Indian tea industry is currently confronted with a host of challenges at all stages of its value chain from production, processing, marketing and to trade. While some these challenges are age old others are of recent origin. The new challenges emerged from the significant changes in the international trading environment with the emergence of new competitors accompanied by the establishment of different regional trading agreements and new regulatory environment. Along with heightened international competition resulting from these changes, new issues have emerged inter alia with ecological changes including climate change and ever-increasing incidence of new pests and diseases, more importantly the need to adhere to the stringent sanitary and phyto-sanitary conditions. Added to it is the issue of old age plantations which has been persisting for some time. What is more, as will be evident from the forthcoming discussion, the index of yield – production per hectare of tea (with 1970 =100) has hardly shown any significant increase and in fact showed downward trend since the mid-1990s. This may be contrasted with the trend in natural rubber wherein the index of yield (1970=100) recorded an almost three fold increase thanks to the RRI105 variety introduced by Rubber Research Institute of India. Realizing the role of innovations in building a vibrant and internationally competitive tea sector, research and development activities have been undertaken from the late 18th century mainly at the instance of individual planters. As will be evident from the forthcoming discussion, institutional architecture for R&D and extension evolved overtime mainly at the instance of associations of large estates, who dominated the sector. The mandate was mainly to generate and disseminate technologies for the member estates. In this regard, two important tea research centres deserve attention- Tocklai Experimental Station (which was named as Tocklai Tea Research Institute recently) run by the Tea Research Association (TRA) in North India and the Tea Research Foundation (TRF) managed by UPASI in South India (57th Annual Report, Tea Board). Over the years, along with TTRI and UPASI-TRF, other actors under the Tea Board too became involved in tea research. One is the Research Centre at Kurseong (Darjeeling Tea Research and Development Centre; DTR&DC established in 1977) to cater to the needs of Darjeeling tea industry. The Tea board also provides grants-in-aid to different universities and

technical institutions¹ to undertake research on various activities not included in the programme of research of the TRA and UPASI-TRF. Further, in 1988, National Tea Research Foundation (NTRF) was established with financial contribution from the tea industry and NABARD.

It needs to be noted that in this paper our discussion is confined to the research activities undertaken by Tocklai Tea Research Institute (TTRI henceforth) for the North Indian tea plantations. In fact TTRI was the first tea research centre established in the world. Evidence tends to suggest that during early years of independence, when the R&D and extension system has been able to effectively address the needs of the industry, India had near monopoly in the world tea market.

It is generally believed that the survival of any sector in the current context of heightened international competition and ever-new challenges is governed by the learning, innovation and competence building systems for the various stakeholders involved. In the context of near stagnation/decline in productivity of tea along with declining international competitiveness and new challenges, the present study makes an attempt to examine the extent to which the existing research and extension system in tea is equipped towards addressing emerging challenges and contribute towards building a vibrant tea sector.

The present study approaches the problem at hand from the innovation system perspective, which by now has emerged as the most widely used approach in innovation studies. The innovations system approach deviates from the linear approach to technological progress (invention-innovation-diffusion) and considers innovation as an interactive and evolutionary process at micro, meso and macro level as a driving force behind competence building, growth and development. It therefore considers innovation as an outcome of interactive learning process involving different actors, which in turn is shaped by the institutional context in which they operate (Lundvall 1992, Nelson 1993; Joseph 2006; Edquist 2001)². Further, as per this approach knowledge is the most fundamental resource in the modern economy and its acquisition is an interactive learning process.

¹ These institutes are CSIR Institute of Himalayan Bio-resource Technology (IHBT) at Palampur and Himachal Pradesh Krishi Viswa Vidyala (HPKVV) in order to look into the problems of hilly area of Kangra region; Assam Agriculture University, Jorhat; and Tea Husbandry Department at North Bengal University.

²The concept has been articulated by a number of scholars at the national sectoral and regional levels. For a growing number of studies on Innovation systems the readers are referred to www.globelics.org

As per the innovation system perspective, while resources for undertaking science-based research – both human resources financial resources – are crucial, the extent of learning is also governed by the extent of interaction which in turn shapes knowledge sphere associated with the sector concerned. The knowledge sphere of a sector, in sync with the science base as understood in the traditional approach to innovation, in turn is governed by the number of actors involved along with the nature and extent of interaction between them. Thus viewed, it could be argued that larger the number of actors involved and more intensive interaction between them would help in the broadening of knowledge sphere and potential for innovation. For instance, given the science base of the sector, interaction of scientists involved R&D sector with other actors like growers, processors, traders and consumers would broaden their knowledge sphere by exposing them to varied issues. This in turn could lead to more learning and innovation provided there is a facilitating institutional context along with adequate financial and human resources to address these issues. Further, in line with the notion that ‘invention unless applied cannot be termed as innovation’, the solutions that the researcher comes up with in their research stations has to reach out the growers in the field. This gives rise to another set of interactions with the researchers and growers which would lead to use of innovation by the latter. This would finally be manifested in the outcomes related to production, processing and marketing. Learning and innovation is also construed as a co-evolutionary process where is there is the need for intuitions and innovations to co-evolve in sync with the emerging challenges.

This study is mainly based on the secondary data base drawn mainly from annual scientific reports (henceforth ASR) of the TTRI, the annual administrative reports (henceforth AAR), the annual reports of the Tea Board, Tea Statistics and Tea Digest. However, it needs to be noted that though these reports (ASR and AAR) are published every financial year; some of the earlier reports (also some of the recent reports) had gone missing due to certain unforeseen circumstances. Though we have managed to compile year-wise data from the available reports we could get access to data for all the years. For this reason, the years are not in a sequential order, nevertheless it serves our purpose by being indicative of the trends during the period under consideration. The study, in addition to the above secondary sources has drawn from consultations that we had with the TTRI scientists of different research divisions and select planters.

The remainder of the paper is organized as follows. Section two discusses the organization of R&D and extension activities within TTRI. Section three analyses the R&D and extension efforts in terms of R&D expenditure and manpower followed by section four wherein the nature of interactive learning in the tea research system is discussed. Section five discusses the outcomes of R&D and extension followed by the last section that sums up the paper and draws the concluding observations.

2. Organisational Structure of TTRI and Research Agenda setting

2.1.A Brief History

Research on tea in India started as early as in 1891 with the formation of a Joint Committee of the Indian Tea Association³ (ITA) and the Agricultural and Horticultural Society of Bengal. The committee had appointed a chemist, Mr M Kelway Bamber, who carried out extensive research on chemistry of tea, soils and manures (TTRI, 2014). After Bamber, several scientists⁴ were appointed who made significant contributions to tea production and manufacturing processes. It was on the suggestion of one of the scientists, Dr Mann, an experimental station was set up at Heelakh tea estate, Assam, in 1904 with the financial contribution of GOI, Bengal, Assam and various planters association and ITA (TRA, 1992). However, for want of labourers, the existing station had to be shifted to another site which was at Tocklai in 1911. Thus, it was after these developments which occurred during those twenty years that finally led to the establishment of Tocklai Experimental Station (TES) in 1911 at Tocklai, in the Jorhat region of Assam. For conducting field trials an experimental tea estate was established in 1914 at Borbhetta, Assam on 50 hectares of land acquired from the Government.

Since the date of its establishment, TTRI⁵ was managed by the Indian Tea Association (ITA). However, in 1961, a severe financial crisis hit the tea industry and there were difficulties in running TTRI too. Following this crisis, in 1963, ITA ceased to manage the station. In 1964, the management was taken over by the Tea Research Association (TRA) a voluntary association of

³ ITA is an association of tea producers formed in 1881 with the objective of overall development of tea in India (TTRI, 2014)

⁴ Scientist such as Dr George Watt, an entomologist, was appointed in 1893 and Dr Harold H Mann, a scientific officer was appointed in 1899 (for more details refer to Tocklai Tea Research Institute booklet, 2014 and Tea Research Association: 1911 to 1991, 1992).

⁵ Earlier known as Tocklai Experimental Station. In 2014, it was renamed as Tocklai Tea Research Institute (TTRI).

member tea estates of North and North-East India. TRA was formed as a cooperative research body funded partly by the Council of Scientific and Industrial Research (CSIR) and the Tea Board and partly by the members of TRA through subscription (TRA, 1992). However, CSIR dissociated from TRA in 1990. At present, the Tocklai tea research institute receives grant-in-aid from the Ministry of Commerce & Industry through Tea Board, and contribution of member estates of Assam, West Bengal, Tripura, Arunachal Pradesh, Manipur, Mizoram, Sikkim, Meghalaya and Nagaland (ibid).

2.2. Present Organisational Structure

At present, TRA functions under a council of management which consists of members elected from the industry; nominees from the Ministry of Commerce, Tea Board; and ITA⁶. TTRI is embedded within the organizational structure of TRA which can be understood from figure 1.

Given such an organizational structure, the decisions regarding the conduct of research and development activities are taken through various committees. The research needs of TTRI emanates from Area Scientific Committee, Agricultural Committee, Engineering & Manufacturing Committee and North Bengal Committee. The committees mostly comprises of planters from different regions. To meet the research priorities articulated by these committees, research programmes are prepared. These research programmes are assessed by the Scientific Advisory Committee which consists of experts (scientists) of various fields to guide the further course of research⁷.

Thus the involvement of the planters (growers) in these committees is suggestive of their active participation in the decision making process of the TTRI. This is one indicator of strong interaction between the scientists and the growers (more of which has been discussed in section 5). Hence it can be expected that the research agenda would be drawn closer to growers' requirements (Kaimowitz 1990 as cited in Biggs and Farington 1991).

⁶<http://www.tocklai.net/about-tra/history/> (accessed on 14th January, 2015).

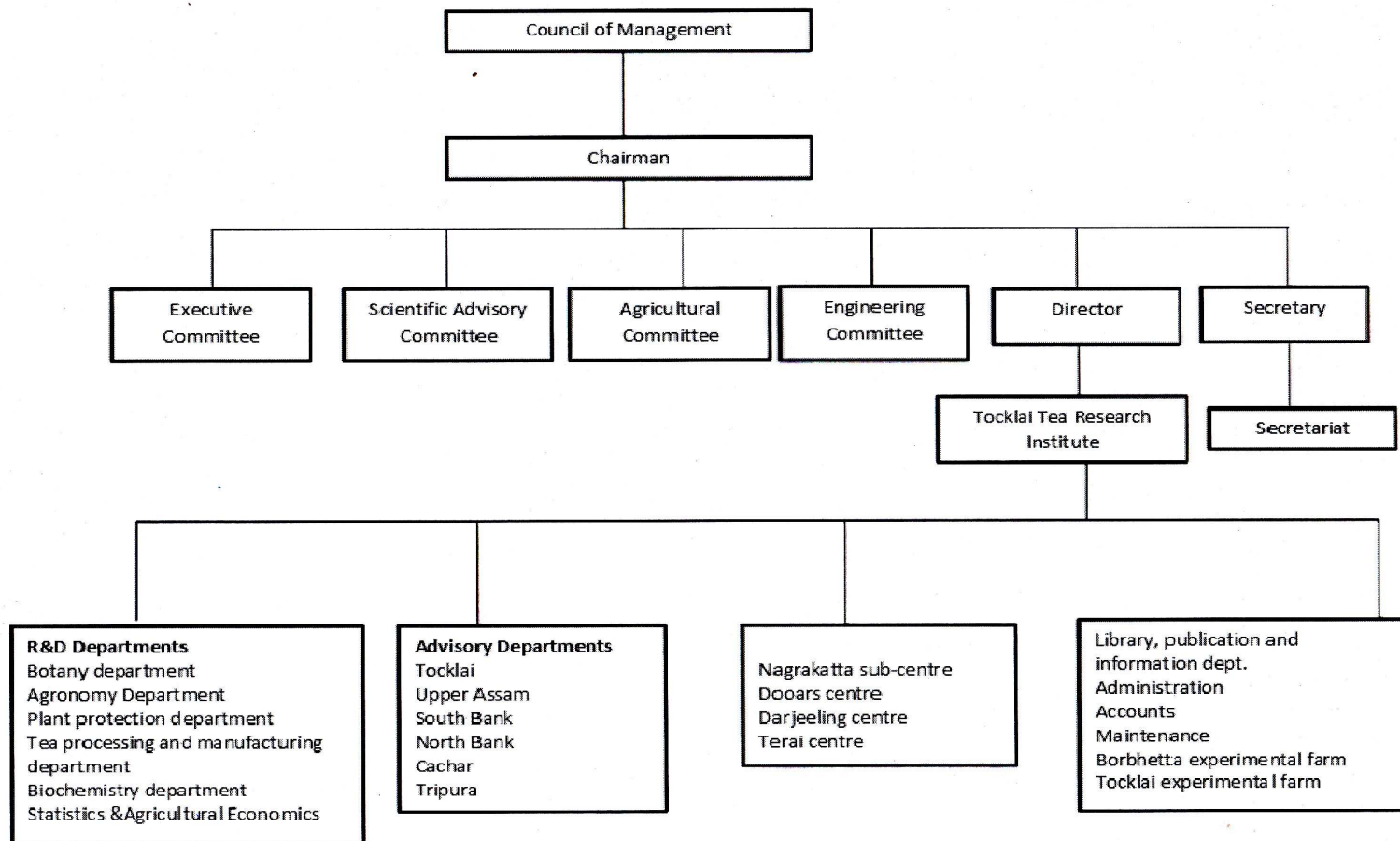
⁷<http://www.thehindubusinessline.com/todays-paper/tp-agri-biz-and-commodity/key-features/article991341.ece> (accessed on 16th February, 2015). Also based on discussion with the deputy director of TTRI, Jorhat.

Research and advisory departments

To cater to the needs of the growers, TTRI at present has six broad research departments with ten divisions under it- Plant Physiology & Plant improvement; Soils; Agronomy; Entomology; Mycology & Microbiology; Biotechnology; Biochemistry; Analytical Services; Tea Processing & Manufacturing; Agricultural Economics & Statistics (TRA, 2014). Since its inception, TTRI has been carrying out specialized research on the cultivation and manufacture of tea through its research and advisory departments. Out of these departments, agronomy, biochemistry, mycology, are the ones which had started functioning with the establishment of TTRI. Entomology unit was, in fact, in existence since 1906 in Cachar which was later shifted to TTRI in 2011.

The **agronomy department** deals with various agronomic aspects of tea culture aimed at increasing productivity and quality. This includes plant nutrition, pruning and plucking, planting and spacing, young tea management, weed control, shade management, irrigation and rehabilitation and cover crops. The importance of **biochemistry** in tea manufacture was felt since the beginning of undertaking research in tea (TRA, 1992). It undertakes biochemical studies on production and processing of tea. The **Mycology unit** deals with the identification and control of diseases affecting the tea plants while **entomology unit** carries out activities related to the bio-ecology of pest complex of tea, shade trees and ancillary crops and their control (TRA, 1992).

Figure 1: A schematic view of the organisational structure of TTRI



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Source: www.tocklai.net

However, most of these departments which had made notable contributions to varied aspects of tea cultivation seems to be suffering from its own set of issues. During the last two decades the pest scenario on tea in north east India has undergone drastic change, with tea mosquito damage assuming devastating proportions along with widespread incidence of Red spider mite. Report on Current Tea Research and Future Direction, (2010: 39) have pointed out that “close interactions with the planters in Dooars, Terai, Darjeeling and Assam have revealed that it has become extremely difficult and disproportionately expensive to control pests. They felt that Tocklai has not offered solutions to achieve the desired level of pest control”. The agronomy department too is said to have experienced a weakening of its activities since 1980, partly due to frequent transfer of senior scientist trained in agronomy to other disciplines without appointing suitable substitutes (ibid).

The other departments that came into existence in the later years were botany department, Tea processing and manufacturing department, soil and water management department. **Biotechnology department** was started in the year 1980 and is mainly concerned with non-conventional methods of tea breeding. **Botany department** was set up in 1930 and it carries out physiological, breeding, cytological, tissue culture and anatomical work. Within it the Physiology & plant breeding unit is mainly concerned with the bringing out new clones. The department also provides services to the industry by supplying of cuttings of generative clones for establishing **seed baris, certification of seed baris**, testing of seed quality, grafting demonstrations, evaluation of plant growth regulators (PGR) and specialists visits to tea estates as and when required (TRA, 1992).

Recognising the importance of soil in the successful culture of tea, the soil chemical branch came up in 1946. Later in 1987, it became **Soil and water management department** reflecting the emphasis on improved drainage and irrigation. Among these later established departments too, the tea processing and manufacturing department is observed to have suffered a serious setback from 1980s. The **tea processing and manufacturing department** was earlier known as engineering R&D department and was started in the year 1951. With the amalgamation of the tea tasting department with the engineering R&D department in 1987, the Engineering and manufacturing technology department came into existence. The department has designed and developed a list of tea machinery and has to its credit more than twenty patents (TRA, 1992).

These tea machineries were mainly developed for producing orthodox tea which was in demand during that time. However, during 1980s, there was a shift in market demand from orthodox to CTC tea, the department was not aligned to this shift, and thus this department suffered a setback. Over the years, the focus has shifted from machinery engineering to manufacturing which is, indeed, reflected in the renaming of the department. At present, the department has been renamed as tea processing and manufacturing department. It is engaged in making tea processing continuous and cost effective in terms of capital, labour and maintenance; and also to improve the quality of the end product. Further, within this department, an automated tea manufacturing unit (Model Tea Factory-MTF) had been constructed.

Advisory services was started in the year 1938 on the recommendations of the 1935-36 Commission of Enquiry. In 1930s itself, four advisory centres one each in Darjeeling, Dooars, Cachar and at Tocklai was operational. However, the Dooars branch was reorganized and shifted to Nagarkata in 1953. There was a proliferation of advisory network with the starting of a branch at North Bank, Assam in 1957. At present, the advisory department has its extension network throughout the tea growing districts of Assam, West Bengal, Tripura and Meghalaya occupying 3.4 lakh hectares (which is approximately 74 per cent and 59 per cent of total area under tea cultivation in North India and All India respectively). This department basically deals with the transfer of technology to member tea estates and also provides feedback from the industry to the scientists (TRA, 1992).

For catering to the needs of North Bengal region, Nagarkata sub-station was later upgraded to regional R&D centre (Report on Current Tea Research and Future Direction, 2010). Then the functional research units at Nagrakata were Plant protection, Agro-Botany, Soil & Water Management, Quality & Residue Laboratory. During the initial years, scientist positions were vacant in all except plant protection. These units were being managed by Scientific Assistants and very little research work was being conducted by them (ibid). However, over the years, some additional departments such as Biochemistry have come into existence. In 2012-13, there seemed to be an improvement in the infrastructure, with the centre being headed by the Deputy Director of Research, along with advisory officers, assistant advisory officers, Botanist, assistant Mycologist, assistant Biochemist and assistant entomologist.

It appears that the organizational structure of research in TTRI is fairly broad based covering almost all the important aspects of tea industry. Nonetheless it is relevant to ask the question as to how effectively the innovation system in general and the research agenda in particular has been coevolving in tune with the emerging challenges. It needs to be noted that the research agenda in a context of heightened international competition coupled with series of consumer centric certification and their ever growing preferences culminating in new challenges has to be different from a context of monopoly power. As already noted, the tea industry today faces numerous challenges, which are unprecedented. In the sphere of production for instance climate change has given rise to new sets of issues whereas in the sphere of trade, the industry is faced with intense competition from low cost producers along with the need to adhere to highly stringent quality certifications. Today tea trade is no more the monopoly of primary producing countries but is dominated by re-exporting countries with not even a hectare of tea cultivation. Their dominance is based on their ability to systematically and dynamically cater to the ever new tastes and preferences of the consumers. From our limited enquiry, we are inclined to infer that the organization of research is yet to coevolve to enable the industry to address these new challenges. Perhaps our inability to respond timely to the new context has given space for our competitors.

3. **R&D and Extension Effort**

Research outcome depends to a great extent on the research effort being put in by the institute. Here research effort is examined in terms of physical resources such as money spent on R&D activities and manpower engaged in research and extension.

Financial resources: Financial resources at the disposal of the research institutes influence the activities undertaken by them.

As already mentioned, TTRI was formed as a cooperative research body funded partly by the Council of Scientific and Industrial Research (CSIR) and the Tea Board and partly by the members of TRA in the form of subscriptions. It was from then on that the services of the TTRI became available to the all the TRA member estates⁸. However, from 1990 onwards, CSIR withdrew its association with the TRA and in its place Ministry of Commerce (Tea Board) got

⁸ Earlier, membership was restricted to the members of the Indian Tea Association (Guide to Tocklai, 1972).

involved in the funding of the institute. Though the Tea Board is the main organization concerned with the overall development of the tea industry in India (59th Annual Report, 2012-13), research is mainly conducted by the industry itself rather than the Tea Board. The role of the Board is confined to providing grants-in-aid to the research institutes for carrying out research and extending advisory services to the tea gardens.

Despite there being data limitations⁹, the trend that emerged from the share of different sources in total income of the TRA indicates that overtime the institute has transformed itself from primarily estates-funded organisation to one with significant reliance on grant-in-aid from the Tea Board. To be more specific in the initial year, the contribution from estates was 85 per cent and that from the Tea Board was around 8 per cent. Overtime, the share of subscription¹⁰ from estates steadily declined to reach the present level of around 38 per cent and that of Tea Board increased to around 50 per cent. The lowest level of contribution from the estates was in 2006-07 (34 per cent), thereafter though it showed an upward trend to reach 47 per cent in 2008-09. This however, turned out to be short lived as the downward trend continued. R&D as an activity with its inherent characteristics of risk and uncertainty, to be effective has to be supported with adequate financial resources in a timely manner. However, the sharp fluctuations in the two major sources of funding for the institute (as is evident from Table 1) indicate the absence of a steady and assured support for R&D. This is bound to have its implications not only on the extent to which the institute could afford to address the range of issues as well as on the effectiveness of their initiatives.

The share of other income has more than doubled during the first decade of the period of analysis to reach the highest level of nearly 15 per cent in 2001-02. Since then, there has been a steady decline in their share to reach the lowest position in 2005-06 (4.5 per cent). Though there has

⁹ Regarding the grant-in-aid from Tea Board, it needs to be noted that for a particular financial year along with the actual figure corresponding to that year, the report had given the carried over amount from the previous years as well. For instance, for the financial year 1999-2000, the corresponding grant-in-aid includes the carried over amount from previous four financial years including the actual amount for that concerned year. So while getting the data on grant-in-aid from the Tea Board, we have excluded these carried over amounts and have only considered the actual amount for that financial year to avoid double counting of the amount. This kind of categorization is given for the years 1989-90 to 2004-05. However, from 2005-06 onwards, the report provides combined figure of the grant-in-aid from Tea Board for that particular year inclusive of the amount carried over from previous years. Hence, it was not possible to separate the actual grant-in-aid for years following 2005-06. As such the grant-in-aid figure reported from 2005-06 onwards are overestimated.

¹⁰ According to AAR, 2008-09, the member estates' outstanding due to TRA was Rs 5.36 crore. Of this, TRA withdrew its services to those defaulter estates owing Rs 3.01 crore.

been a revival since then, their share is yet to reach the peak level of 15 per cent. The lackluster performance of the institute in terms of raising own resources is indeed a point of concern.

Table 1: Share of different sources in the total income of TRA

Year	Total income (Rs lakh)	Share of Tea Board funding in R&D	Share of members Subscription	Share of other income*
1990-91	367.79	7.86	85.41	6.73
1996-97	503.04	18.89	71.35	9.76
1997-98	553.78	14.45	76.51	9.05
1998-99	722.70	22.14	67.14	10.73
1999-00	834.70	29.95	59.86	10.14
2000-01	748.88	36.72	50.97	12.31
2001-02	689.33	29.01	56.27	14.72
2002-03	705.80	42.5	47.73	9.76
2003-04	897.06	39.69	52.12	11.32
2004-05	921.96	35.58	56.88	7.54
2005-06	1508.46	59.35	36.11	4.54
2006-07	1479.36	57.34	34.89	7.77
2007-08	1284.15	53.42	40.19	6.39
2008-09	1143.72	45.32	46.87	7.81
2009-10	1454.65	45.46	44.27	10.27
2010-11	1760.47	49.88	43.08	7.04
2011-12	1998.33	49.63	38.8	11.57

Source: Compiled from various issues of Annual Administrative Report, TRA

Note: ‘*’ ‘other income’ includes sale of green leaf from experimental plots, sale of plants, sale of clones, sale of seeds, sale of publication, advisory service fees, testing fees, training fees.

We must hasten to add that the above conclusion needs to be taken with due caution because our analysis does not include own resources raised from externally funded projects. Going by the evidence presented in table 2 besides in-house experiments, externally funded projects are also conducted in different

Table 2: Department-wise list of funding agencies for 2011-12

Departments	Funding agencies
Soil	Tea Board, National Tea Research Foundation (NTRF), CFC, IFOAM, ICAR, C-DAC
Entomology	Tea Board
Mycology	NTRF, DRL (Tezpur), Tea Board and NTRF
Plant Physiology& Breeding	PPV&F RA, Ministry of Agriculture, GOI
Biotechnology	Tea Board, DEIT (GOI), Department of Biotechnology (GOI)
Biochemistry	Tea Board, NTRF
Tea Processing & Manufacturing Advisory	NTRF
Analytical Services	Tea Board, NTRF
North Bengal Regional R&D centre	Tea Board, NTRF

Source: Compiled from various issues of Annual Scientific Report, TTRI

departments of TTRI. The following table is for the year 2011-12¹¹. Since 2006, a total of 33 externally funded projects are being conducted at TTRI amounting to Rs 136 million (Report on Current Tea Research and Future Direction, 2010). These projects are basically of three to five years duration. The committed annual funding from these projects approximately amounts to Rs 44 million which is around 40 per cent of the total receipts from membership fees and government grant (ibid). The report highlights that it is through these externally funded projects that TRA is able to conduct bulk of its long term research activities, which would have been difficult had it been reliant only on the TRA annual budget.

Further, when we consider R&D expenditure of the institute, for majority of the years, expenditure is observed to be exceeding the total funding allotted for R&D (Table 3). This trend is perhaps indicative of

¹¹This is the recent year for which department wise details on funding agencies is provided. The years following 2011-12 just provide the list of external funding agencies but not department wise

Table 3: Trend in R&D Expenditure

Year	Total income (Rs lakh)	R&D Expenditure (Rs lakh)	Difference (Rs lakh)
1982-83	193.15	193.15	0.00
1983-84	165.88	210.94	-45.06
1984-85	356.50	283.75	72.75
1985-86	na	na	
1986-87	na	na	
1987-88	na	na	
1988-89	na	na	
1989-90	395.76	409.39	-13.64
1990-91	367.79	376.84	-9.05
1991-92	na	na	
1992-93	na	na	
1993-94	na	na	
1994-95	na	na	
1995-96	na	na	
1996-97	503.04	720.22	-217.18
1997-98	553.78	733.05	-179.27
1998-99	722.70	769.70	-47.00
1999-00	834.70	1128.66	-293.96
2000-01	748.88	863.34	-114.46
2001-02	689.33	976.22	-286.89
2002-03	705.80	944.10	-238.30
2003-04	897.06	936.08	-39.02
2004-05	921.96	1002.64	-80.68
2005-06	1508.46	1112.09	396.36
2006-07	1479.36	1137.10	342.26
2007-08	1284.15	1615.11	-330.96
2008-09	1143.72	2488.61	-1344.89
2009-10	1454.65	1881.09	-426.44
2010-11	1760.47	1979.72	-219.24
2011-12	1998.33	2457.50	-459.17

Source: Compiled from various issues of Annual Administrative Report, TRA

the contribution of the externally funded projects which we have not been able to account for due to paucity of data.

Table 4 shows R&D intensity - R&D expenditure as % of the value of tea output in North India. Except for the year 2007-08 and 2008-09 which shows a relatively higher R&D intensity of 0.30 per cent and 0.36 per cent respectively, for the years preceding and following these two years, the R&D intensity hovered between 0.19 per cent and 0.24 per cent. It is generally held that R

&D intensity in India is less than one per cent of GDP which is considered as very low by global standards. The tea sector despite the numerous challenges that it faces, the resources expended on R&D is only around one third of that at the national level. This reflects the need to increase R&D investment which would in turn help in realising the research outcomes.

Table 4: R&D Intensity of TTRI

Year	R&D Intensity (%)
2000-01	0.19
2002-03	0.23
2003-04	0.23
2004-05	0.19
2005-06	0.23
2006-07	0.21
2007-08	0.30
2008-09	0.36
2010-11	0.22
2011-12	0.24

Source: Calculated from various issues of Tea Statistics, Tea Board of India and Annual Administrative Report, TRA.

Note: The value of output was obtained by multiplying the Production of tea in North India by the average price at North Indian auction.

Manpower: Table 5 shows that there has been a drastic fall in the total manpower¹² employed in the TTRI over the years. It decreased from 1176 in 1983-84 to 274 in 2011-12. This sharp fall is also shown by a negative annual growth rate (-5.07 per cent) in total manpower from 1983-84 to 2011-12 (see Table6).

¹² The annual administrative report of the TRA provides data on the distribution of manpower across the different categories of personnel. The categories are given as officers, scientific assistant, technical, non-technical, helper and sub-staff. However, definition of these categories is not provided in the report.

Table5: Manpower engaged in TTRI (1984 to 2012)

Year	Total	Officers	Scientific Asstt	Technical Asstt	Non-Scientific Asstt	Helper	Sub-Staff	Labour
1983-84	1176	38	128		84	86	188	652
1987-88	549	43	116	26	90	88	155	31
1990-91	506	51	103	23	82	80	147	20
1997-98	449	59	98	22	67	61	133	9
1999-00	423	54	95	23	63	51	132	5
2000-01	404	57	89	23	60	44	126	5
2001-02	407	57	91	21	61	50	127	
2002-03	392	55	89	21	60	48	119	
2003-04	377	65	69	6	65	34	138	
2004-05	357	67	65	63	65	60	37	
2005-06	339	64	64	53	64	54	40	
2007-08	318	59	62	52	58	49	37	
2008-09	310	60	61	57	56	48	28	
2009-10	304	62	61	53	54	47	27	
2011-12	274	60	56	48	45	41	24	

Source: Compiled from various issues of Annual Administrative Report, TRA

This fall is seen to be contributed by a decrease in manpower employed under all the categories except for officers and technical assistant which shows an increase over the years. Further, from 1983-84 to 2000-01, there was a section on labour employed. This labour employed was mainly related to the two experimental estates – Borbhetta and Tocklai. However, after 2000-01, labour employed in these experimental plots seems to have been fully withdrawn. Thus this trend is indicative of a change in recruitment policy by TTRI probably to increase the scientific staff strength so that there is greater contribution to research¹³. This is further substantiated by a gradual increase in the proportion of scientists¹⁴ in total manpower over the years (see Table 6). The number of scientists employed grew at the rate of 1.35 per cent.

¹³ A study on the organizational structure of the association conducted by A.F Ferguson & Co in the year 2006 had recommended amongst others a ratio of 1:1 between scientific and non-scientific manpower.

¹⁴ We intended to consider officers as an indicator of the number of scientists involved in research activities. However, when we considered the distribution of officers across the different departments of RRII, there were departments such as Accounts, library, maintenance, medical and Kolkata office, wherein administrative officers can be expected to be employed rather than scientists. Again we cross checked with the list of TRA officers with their corresponding qualifications and posts held by them across the different divisions which was provided in the annual scientific report of TTRI and found that in the above noted departments there were no one under the designation of scientists. Hence, to arrive at the number of scientists employed we excluded officers employed in the above mentioned department from the total number of officers given.

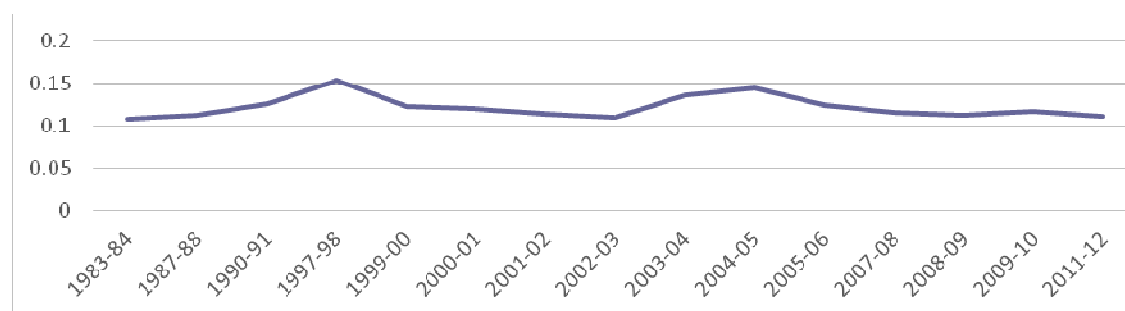
Table 6: Proportion of scientists to total manpower in TTRI

Year	Total manpower	Scientists	proportion of scientists to total manpower
1983-84	1176	35	2.98
1987-88	549	38	6.92
1990-91	506	43	8.50
1997-98	449	53	11.80
1999-00	423	47	11.11
2000-01	404	47	11.63
2001-02	407	45	11.06
2002-03	392	44	11.22
2003-04	377	55	14.59
2004-05	357	59	16.53
2005-06	339	54	15.93
2007-08	318	53	16.67
2008-09	310	52	16.77
2009-10	304	54	17.76
2011-12	274	51	18.61
CAGR (%)	-5.07	1.35	

Source: Various issues of Annual Scientific Report, TTRI

However, despite the increase in the number of scientists over the years, when we considered the proportion of scientists employed per 1000 hectare of area under tea cultivation in North India, it has remained more or less stagnant with a declining trend since 2004-5(see Figure 2).

Figure2: Proportion of Scientists employed per 1000 ha of Area under tea cultivation in North India



Source: Various issues of Annual Report, TTRI and Tea Statistics, Tea Board of India

Considering the distribution of manpower across the various research and advisory departments of TTRI, it was observed that over the decades, there has been a sharp fall in the total manpower employed, except for the plant protection department consisting of Mycology & Microbiology and Entomology divisions (see Table 7). The plant protection department is seen to have had an increase in the number of officers employed (which is equivalent to the number of scientists) from mere one in 1991 to five in 2012. Thus indicating that identification and control of pests and diseases affecting the tea plants has remained high on the agenda of TTRI. This may be probably due to the increased international regulations with regard to the reduction in the use of synthetic pesticides and maintaining the required level of Maximum Residue Limit (MRL) in recent years. In Physiology & Plant Breeding department (3 officers), Agronomy (2 officers) and Tea Processing & Manufacturing department (3 officers), the number of scientists employed has been maintained at the same level over the decade. The Statistics & Agricultural Economics unit had four officers in 1991 which drastically came down to one in 2012. Thus, economic aspects of tea also seems to have received less priority in recent years. While Soil & Meteorology department had five scientists in 1991, which fell to four in 2012. Given the issue of climate change confronted by the sector, the need to have adequate manpower in Soil & Meteorology department cannot be underestimated. In fact, as a part of a network project launched by Indian Council of Agricultural Research (ICAR), TTRI has initiated a project to study the impact, vulnerability and adaptation of tea to climate change (TTRI, 2014). Its aim is to develop a climate resilient tea production system (ibid).

Regarding financial resources for research and extension effort, it was observed that the contribution of Tea Board has decreased drastically from 2005-06 onwards and has stagnated at 50 per cent in 2010-11 and 2011-12. Funding in terms of member estates subscription too shows a fall over the years. Thus indicating the financial constraint faced by TTRI which might have led to a consequent fall in manpower across the research and advisory departments. Despite an increase in the proportion of scientists in total manpower, the number of scientists available to cater to per 1000 hectare of area under tea cultivation in North India has stagnated over the years and shows a declining trend since 2004-05. Decadal distribution of scientists across the research departments too either shows a fall or has remained the same except that in the plant protection department. In advisory department too, total number of manpower

shows a decline. Given such a downward trend in the physical resources of the institute, the research activities would be bound to suffer a serious setback.

Table7: Distribution of manpower across the various departments of TTRI

Departments	2012							1991						
	Officer	Scientific assistant	Technical	Non-technical	Helper	Sub-staff	Total	Officer	Scientific assistant	Technical	Non-technical	Helper	Sub-staff	Total
AS	3	3		2			8							
SAE	1			1	1		3	4	6	4	3		2	19
PPB	3	5		2	2	1	13	3	9		2		6	20
BT	1	1					2							
SM	4	8	1	1	1		15	5	12		2		12	31
AG	2	5		1		2	10	2	14	1	2		5	24
PP	5	8		2	1		16	1	8	1	1		4	15
BC	3	4	1	1	2		11	2	11		2		7	22
TPM	3	3	3	1	3	1	14	3	2	4	5	27	14	55
Total	25	37	5	11	10	4	92	20	62	10	17	27	50	186
ADV	5		1	2		1	9	3	8	2	4		4	21
NGR	7	6	6	4	4	2	29	7	15	2	11	8	19	62
TER #	1	3		2		1	7	2	3		2	2	4	13
DAR	1	3	1		1		6							
TRI	1						1	1			1	1	1	4
CH	2	3	2	2	1		10	1	5	1	2	1	5	15
NB	2	3	2	1	2		10	2	5		2	2	5	16
UA	2	1	1	2	3		9	3	5		2	1	2	13
STG	1						1							
Total	22	19	13	13	11	4	82	19	41	5	24	15	40	144

Source: Various issues of Annual Report, TTRI

AS- Analytical Services; SAE- Statistics & Agricultural Economics; PPB- Physiology & Plant Breeding; BT- Biotechnology, SM- Soil & Meteorology, AG- Agronomy; PP- Plant Protection; BC- Biochemistry; TPM- Tea Processing & Manufacturing; ADV- Advisory; NGR- Nagrakata; TER- Terai; DAR- Darjeeling; TRI- Tripura; CH- Cachar; NB- North Bank; UA- Upper Assam; STG- Small Tea Growers Advisory Cell

Note: '#', Manpower employed in advisory services for Nagarkatta and Terai region was available as a combined figure for 1991 which has been reported as such.

4. Interactive learning process in TTRI

TTRI being an important knowledge generating entity for the tea sector, the importance of knowledge as a resource can hardly be overemphasized. Generation of knowledge cannot take place in isolation, it requires interaction with different actors related to the tea industry and other knowledge generating entities as well. This interactive learning is crucial for the growth of the knowledge sphere of the personnels engaged in the institute which in turn would help to effectively confront the issues plaguing the tea industry.

Interaction of TTRI with research institutes and universities

The period from 1911 to 1977 is said to have witnessed extensive research activities at Tocklai which had helped tremendously in the development of the Indian tea industry (Phukan, 2011). The reason for this is traced to two important trends related to the interaction of the scientists and other actors. The first was the scientists working very closely with the planters to understand their problems. The other was the scientists being abreast of the latest happenings in the field of scientific research through their association with the scientists of renowned research institutes and universities of the world (ibid). We will first discuss the latter interaction and then come to the interaction of the scientists with the planters in the later section. These institutes of repute that was mentioned earlier were Cambridge University, Sheffield University and Rothamstead Station of Britain. Thus Tocklai has a long history of collaborative research basically made possible by the active involvement of the London Scientific Advisory Committee (LSAC) of the TRA. The LSAC was formed in 1935-36 on the recommendation of Commission of Enquiry appointed to look into the working of the Institute and to indicate necessary changes for orientation of the research programme (TRA, 1992). This interactive learning with the planters and other experts helped them to formulate their own research ideas and find solutions to the problems faced by the planters and accordingly disseminate it through the network of advisory services (Phukan, 2011). However, in the later decades mainly during the 1980s and 1990s is said to have seen least collaborative research. In mid 1990s, work on pesticide residue only was carried out in association with the British Government (ibid). Among others reasons, this may perhaps can be seen as a consequent effect of the transferring of the functions of the London

Advisory Committee to the Scientific Advisory Committee (SAC)¹⁵ in India. It had witnessed the transfer of project work being carried out in other collaborating countries to India, for instance, the work on chemistry of made tea which was carried out in U.K was transferred to Central Drug Research Institute, Lucknow (ibid). However, after undertaking research work in isolation for more than two decades, Tocklai started collaborative work with Kyoto University of Japan, ITC Netherlands, Cranfield University, U.K, Southampton University, and South African University. It is also a part of the Inter-governmental group on Climate Change, FAO (TTRI, 2014).

Regarding, interaction of TTRI with regional research institutes, cooperation with UPASI dates back to as early as 1925. This was in the form of a scientific officer of UPASI getting trained at Tocklai for a year. It was during that time, collaborative and complimentary research projects were drawn up between UPASI and TRA where three joint consultation panels were formed on production, plant protection and tea technology (TRA, 1992). However, in recent years, nothing much has been mentioned about any projects being undertaken in collaboration with UPASI-TRF, perhaps indicating absence of any form of collaboration between these two institutes.

Interaction of TTRI with planters

With regard to agriculture, studies have pointed out that though the role of research institutes in producing innovations has increased over the years, the importance of field experience, gained by farmers through their own experimentation, in inspiring innovations cannot be ignored (Sunding and Zilberman, 2000; Biggs and Clay, 1981; Biggs and Farrington, 1991). Hall et al., (2004) have mentioned that in contrast to the conventional linear notion of relationship between research and economic production, innovation is observed to take place chiefly as a result of iterative relationships between those engaged in knowledge creation (research) and those engaged in knowledge application (economic production).

In case of tea, TTRI being the main organisation responsible for the generation of innovation, it can be termed as 'producer of knowledge'. The member estates of TRA for whom these innovations are generated are the 'consumers of knowledge'. In the generation of innovations, there is an intense interaction between the 'producers of knowledge' and the 'consumers of

¹⁵ The SAC consists of eminent scientists in India selected by the council of management of the TRA to advise on the R&D work undertaken at Tocklai.

knowledge'. Along with the involvement of planters in research agenda setting which was also observed in our earlier discussion, their interaction with the scientists is manifested in several other forms as well. Broadly, it can be categorised as group interaction consisting of group meetings and training courses, personal interaction consisting of advisory visits, and other form of interaction such as publications and services rendered to member estates (see Table 8). Two-way mode of interaction includes group meetings, individual visits, training courses and services whereas publications are one-way mode of interaction. Here we are restricting ourselves to two-way mode of interaction. Based on the availability of data, within two way interaction, we are focusing on group interaction in the form of Area Scientific Committee meetings and Training cum demonstration programmes and personal interaction in the form of advisory visits.

Table 8: Different forms of interaction between the TTRI and the growers

Form of interaction	Details
Group meetings	1) Tocklai Biennial Conference 2) Biennial Joint Area Scientific Meet 3)Area Scientific Committee Meetings(quarterly meets of each of the 9 committees) 4) Seminars 5) Symposia 6) Tea Tasting Sessions 7) Special Seminars
Training courses	On topics ranging from tea cultivation, field management practices, manufacturing
Individual visits	1) Advisory routine visits 2) Advisory special calls 3) Specialist visits
Publications	1) Annual Scientific Report 2) Two and A Bud (Half-yearly journal) 3) Tea Encyclopedia 4) Memoranda (monographs) 5) Conference Proceedings 6) Advisory Bulletins (quarterly) 7) Special Bulletins 8) Occasional Papers 9) Advisory Leaflets
Services	1) Soil testing 2) Pest and disease identification 3) Estate clone certification 4) Trouble shooting advice on manufacture 5) Pesticide residue testing 6) Quality analysis of microbial biocides samples

Source: Compiled from Annual Scientific Report, 1978-79 and other issues of ASR

Before getting into the details of these different forms of interactions, we will discuss about the member estates who, given their membership with TRA, are the direct beneficiary of the research outputs brought out by the TTRI. (See Table 9) When we consider the number of TRA member estates over the years, it has increased from 524 estates in 1971-72¹⁶ to 710 in 2012-13 at the rate of mere 0.23 per cent. This meagre rate of increase in the number of TRA member

¹⁶The period 1971-72 is considered here since it was in 1964 that TRA took over the management of Tocklai.

estates have to be seen in the overall scenario of total tea estates in India¹⁷ which had experienced a decline at the rate of 0.21 from 1971-72 to 2007-08 and the total tea estates in North India which registered a growth rate of mere 0.23 per cent. The percentage of TRA member estates in total estates in India was as high as 57 per cent in 2000-01 which had fallen to 39 per cent in 2007-08. However, TRA members comprise a large percentage of the tea estates operating in North India. It was 47 per cent in 1971-72 which increased to 73 per cent in 1996-97¹⁸. Since membership in TRA is voluntary, it implies that about 73 per cent of the estates in North India are eligible to avail the research outputs generated by the TTRI.

Group Interaction

a) Area Scientific Committee (ASC) Meetings: Among the group meetings, one of the primary forms of group interaction between the TTRI and the growers is through the Area Scientific Committee meetings. To ensure closer and more frequent interaction between the scientists at TTRI and the planters, Area Scientific Committees (ASCs) were formed in the 1966 mainly for addressing the problems of different tea growing regions. Initially, it started across the regions of Assam with five ASCs- three in South Bank, two in North Bank and one in Cachar. Later during 1972-73 it increased to nine ASCs covering the other regions of North Bengal (i.e. Dooars, Terai and Darjeeling) as well. However, at present, there are eight ASCs covering the entire North East India. Each of these committees consists of six to eight members of senior planters of the area (Joint Area Scientific Committee Meeting, April 2nd to 3rd, 1993). These ASCs broadly provide suggestions on “a) ways and means in which advisory services can be improved and b) areas of research considered to be of importance to specific region” (TRA, 1992: 176). The ASC meetings are held twice a year. Along with the ASC meetings, the committees also arrange seminars on varied subjects (ASR, 1973-74). These seminars/workshops are held on varied topics such as package of field management and practices of early season, cold weather practices, plucking and spraying, plant protection and post drought, early weather practices and manufacturing, drought management. Figure 3 shows that there has been wide fluctuations in the number of such meetings and seminars held over the years since the formation of ASCs. The

¹⁷ Total tea estates in India comprises the estates in North India and South India.

¹⁸ With respect to the number of growers, this kind of categorisation for small and large growers by region i.e. North India and South India is not available from 2000 onwards. Only the data on total number of growers are available. Hence we had to restrict ourselves to the year 1996-97.

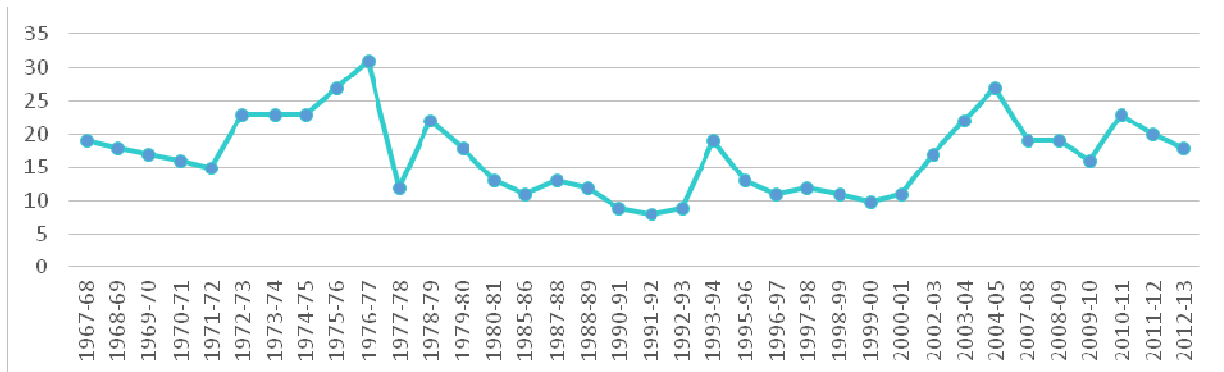
sharp increase in the number of meetings held during the early 1970s is mainly due to the formation of ASC in the tea growing regions of North Bengal such as Dooars, Terai and Darjeeling. However, the number of meetings held is observed to have come down during the 1980s and 1990s. Despite an increase after 2000-01, this trend could not be sustained after 2007-08 except for 2010-11.

Table 9: Percentage of TRA member estates in Total tea estates in India and North India

Year	TRA member estates	Total estates in India	% of TRA estates in total estates	Total estates in North India	% of TRA estates in Total estates in North India
1971-72	524	1817	28.84	1112	47.12
1972-73	513	1825	28.11	1111	46.17
1973-74	564	1836	30.72	1116	50.54
1974-75	601	1837	32.72	1119	53.71
1975-76	652	1837	35.49	1118	58.32
1976-77	697	1585	43.97	1103	63.19
1977-78	771	1587	48.58	1105	69.77
1978-79	787	1598	49.25	1115	70.58
1979-80	802	Na		Na	
1980-81	781	1597	48.90	1121	69.67
1982-83	609	1418	42.95	1008	60.42
1983-84	779	1452	53.65	1040	74.90
1984-85	610	1488	40.99	1077	56.64
1985-86	672	1471	45.68	1054	63.76
1991-92	758	1491	50.84	1050	72.19
1992-93	782	1503	52.03	1060	73.77
1993-94	833	1512	55.09	1067	78.07
1994-95	826	1620	50.99	1179	70.06
1996-97	855	1624	52.65	1179	72.52
2000-01	915	1614	56.69	na	
2004-05	572	1661	34.44	na	
2005-06	629	1672	37.62	na	
2006-07	646	1673	38.61	na	
2007-08	659	1686	39.09	na	
2010-11	802	Na		na	
2012-13	710	Na		na	
CAGR (%)	0.74	-0.21		0.23	

Source: Compiled from various issues of Annual Scientific Report, TTRI; Tea Statistics, Tea Board of India

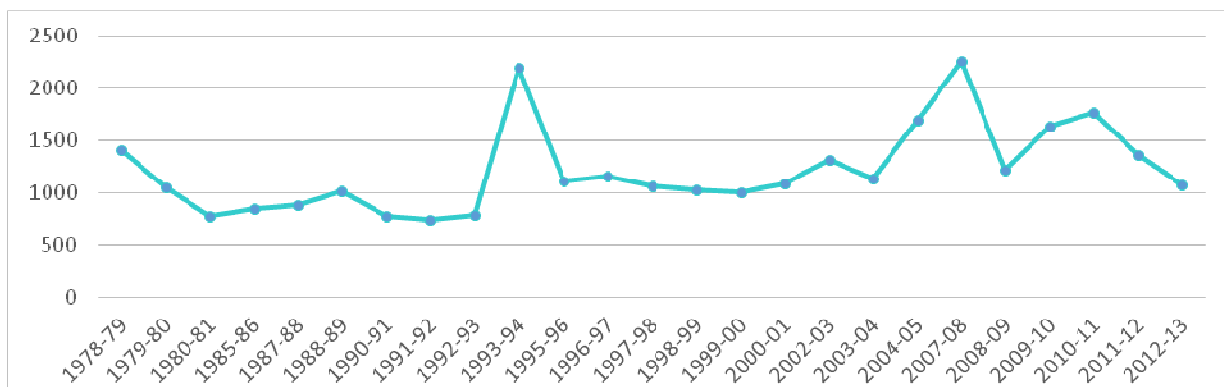
Figure 3: Trend in the Number of Annual Scientific Committee Meetings and Seminars held over the Years



Source: Compiled from various issues of Annual Scientific Report, TTRI

The decrease in the number of ASC meetings and seminars held is indeed reflected in the fall in the participation of the number of planters in these meetings and seminars (see Figure 4). Hence, ASC meetings despite being as an important forum for exchange of ideas between the planters and the scientific staff seem to have waned over the years.

Figure 4: Trend in the Number of Participants in ASC meetings and seminars



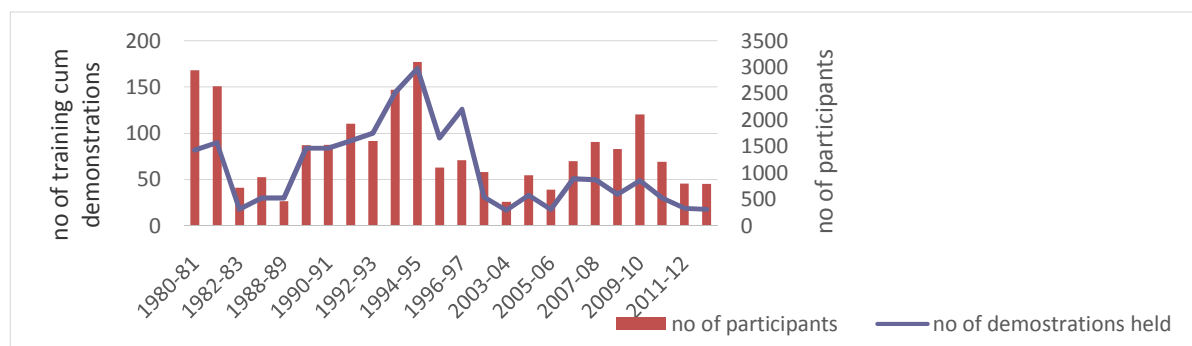
Source: Compiled from various issues of Annual Scientific Report, TTRI

Note: Years considered here is on the basis of the data available on number of participants. While for certain year information on number of meetings held was available but the number of participants in those meetings were not mentioned. For such cases we have not considered that particular year for the sake of uniformity in the data compiled.

b) Training cum demonstrations: At the grass root level, training of supervisory staffs of tea estates is undertaken through field demonstration along with group discussion. This training is expected to help them properly perceive the technical information received from the Manager, hence, resulting in better implementation of various programmes in the field and factory.

Figure 5 shows that except for the late 1980s and mid-1990s, there has been a fall in the number of training cum demonstrations held by TTRI and correspondingly there was a drop in the number of participants in these programmes.

Figure 5: Number of Training cum Demonstrations held and Number of Participants therein



Source: Compiled from various issues of Annual Scientific Report, TTRI

Personal Interaction

Advisory Visits: Advisory visits undertaken as part of the extension service are one of the forms of personal interaction, which comprises routine visits and need-based or special visits to member estates. Routine visits are paid to each estate twice to thrice a year. During these visits, advice is given on time-specific problems on various aspects of tea husbandry. If there are any lapses which might have gone unnoticed or unattended by the estate manager and are affecting the productivity, the advisory officer points it out to them during such visits. Further, these officers helps the managers in planning their programmes for future developmental work. Through such visits, data banks on further research and extension activities are also established and it also helps in assessing the regional response to any new technique/input and rate of adoption. Need-based or special visits are undertaken to attend to problems not covered in

routine visits and demand for such visits increases in instances of natural calamities like drought, flood or hail storm, sudden out-break of pest or disease among others. The number of advisory visits would help us to capture the demand for the services of TTRI from the member estates.

Table 10¹⁹ shows that a majority of the TRA member estates (95 per cent to 93 per cent) were covered during these advisory visits mostly during 1975-76 and 1976-77. However, it showed a decrease from 1978-79 and had fallen sharply to 61 per cent in 1983-84. Due to data unavailability, we could not discern the recent trends for the entire region covered by TTRI. Nevertheless, when we considered North Bengal region, in recent years, all the member estates in the region (100 per cent) are observed to be covered through these advisory visits.

Table 10: Percentage of Estates Visited for Advisory services out of TRA member estates

Year	No of Estates Visited	TRA Member Estates	% of Estates visited out of TRA Estates	Year	No of Estates visited in North Bengal	No of TRA Member Estates in North Bengal	% of Estates visited out of TRA Estates
1971-72	373	524	71.18	1989-90	163	202	80.69
1972-73	412	513	80.31	1991-92	216	233	92.70
1973-74	439	564	77.84	1994-95	254	254	100
1974-75	507	601	84.36	2007-08	200	200	100
1975-76	619	652	94.94	2010-11	261	261	100
1976-77	648	697	92.97				
1977-78	671	771	87.03				
1978-79	699	787	88.82				
1979-80	665	802	82.92				
1980-81	658	781	84.25				
1983-84	474	779	60.85				

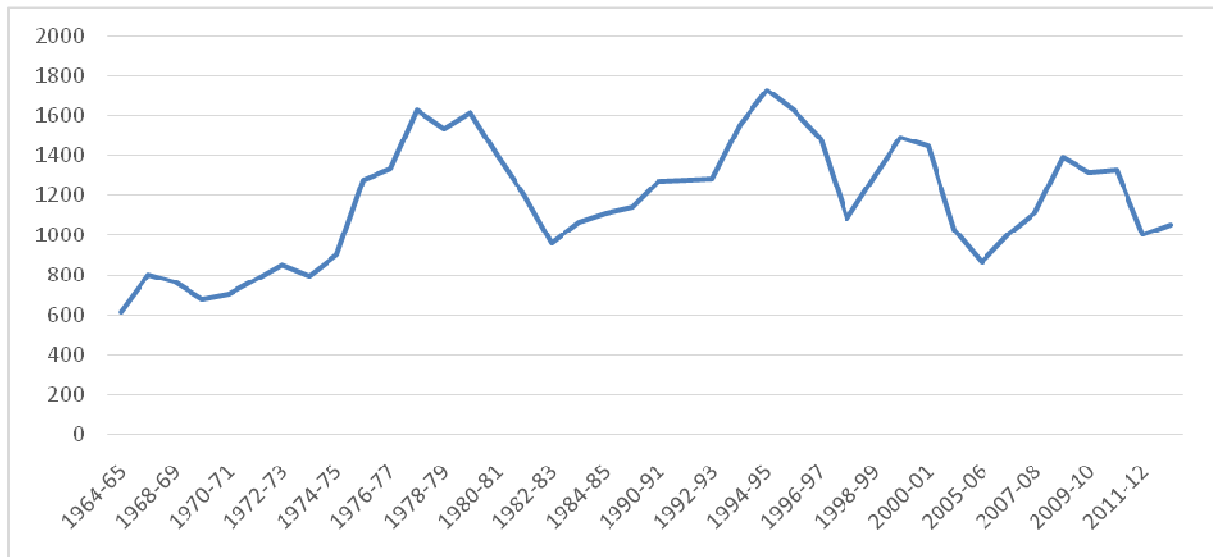
Source: Compiled from various issues of Annual Scientific Report, TTRI

Coming to the frequency of visits to these tea estates, Figure 6 shows that though the number of advisory visits paid had increased from mere 616 in 1967-68 to 1057 in 2012-13, it has

¹⁹It needs to be noted here that the latest time period for which the data on number of tea estates visited for providing advisory services is available is for the year 1983-84. However, for North Bengal region, the number of estates visited is given for the latest period of 2010-11 and also few years preceding that. Hence the same has been compiled in Table to get an understanding of the number of estates availing the facility of advisory visits out of the total TRA member estates.

experienced sharp fluctuations over the years and since the mid-1990s there has been a downward trend.

Figure 6: Number of Advisory visits paid to the TRA member estates



Source: Compiled from various issues of Annual Scientific Report, TTRI

From the above discussion, it can be inferred that interaction between the growers and TTRI, both personal interactions and group interaction, in terms of ASC meetings and seminars; and training cum demonstrations has not been showing any increase but a decline especially since the mid-1990s.

Interaction of TTRI with small growers

Though it is not the mandate of TTRI to cater to render services to the small growers, on the initiative of the Tea Board, as a part of the advisory Department, Small Tea Growers Advisory Cell (STGAC) was initiated in TTRI from 2004-05 onwards. STGAC was started by the Tea Board with the required budgetary support under the 10th Plan. Before the formation of this cell, there was no formal mechanism for delivering services to the small growers²⁰.

²⁰ Though it needs to be noted that during April 2000, under the Tea Board sponsored programme, three workshops each of one-day duration was organised by Tocklai for the small growers of North Bengal. In this workshop officers from Darjeeling and Terai had participated along with 225 small tea growers (ASR, 2000-01).

For running the STGAC, TTRI has been receiving budgetary support from the Tea Board from 2004-05 onwards. (See Table 11) The trend shows that expenditure has been in excess of the grant received from the Tea Board for running the cell. However, funds were available only till the year 2007-08 (Annual Administrative Report, TRA 2007-08).

Table 11: Grant Received & Expenditure under 10th Plan project “Small Tea Growers Advisory Cell”

Year	Grant from Tea Board (Rs lakh)	Expenditure (Rs)
2004-05	21.50	23.87
2005-06	38.00	46.15
2007-08	63.69	90.92

Source: Various issues of Annual Administrative Report, TRA

Note: 2006-07 data was not available, hence not included here.

This lack of funding perhaps have manifested in the cutting down of manpower in STGAC. In 2004-05, when this cell was started manpower employed was 7. Out of 7, one was an officer heading the cell, other five were deputed from different departments to small tea growers’ cell and one was non-technical staff (ASR, 2004-05 and AAR, 2004-05). Two of the junior advisory officers were placed at Dikom, TRA’s Upper Assam advisory centre and one field assistant at TRA’s Terai branch. As per the project proposal approved by the Tea Board, the small growers’ area of operation for the cell was distributed across the districts of Assam, West Bengal and Bihar. In Assam, it covered the districts of Tinsukia, Dibrugarh, Sivasagar, Jorhat and Golaghat. The districts of Cooch Bihar, Jalpaiguri, Darjeeling and Uttar Dinajpur in West Bengal and Kisanganj district in Bihar were covered under the cell. Table 12 shows that from 2004-05 to 2007-08, the total number of manpower employed in the cell was 3, however, from 2008-09 onwards, it decreased to 1.

Table 12: Number of Manpower employed in Small Tea Growers Advisory Cell

Year	Officers	Non-Technical	Total
2004-05	2	1	3
2005-06	2	1	3
2007-08	2	1	3
2008-09	1		1
2009-10	1		1
2011-12	1		1

Source: Various years Annual Administrative Report, TRA

Note: In 2004-05, though it was mentioned in the report that five persons were deputed to the small tea growers' cell. The report had not included it in the data provided on manpower. So it has been reported in the table as such.

Given the increasing number of small growers over the years²¹, it would be not be difficult to discern that one manpower would be incapable of rendering services to these section of growers. Thus the cell seems to be almost non-functional at present due to lack of grant from Tea Board and perhaps consequent inability to maintain the required number of manpower. This would imply that there would hardly exist any interaction between the TTRI and the small growers. Thus, further restricting the knowledge sphere of the researchers from getting exposure to issues faced by the small growers which, could possibly be different from those faced by the planters.

To sum up, the literature on innovation both in industry and agriculture has underlined the need for increased interaction between producers and users of knowledge as a prerequisite for fostering innovation. Viewed in this perspective, we have a case of tea industry, which depicts a picture of highest level of interaction between users and producers of knowledge as the research agenda here is primarily shaped by the concern of the growers. However, the implications of this extreme form of interaction wherein research is driven mainly by the short-term considerations of growers perhaps at the cost of long term perspective needs further exploration. As we have already noted though the public funding (from Tea Board) has emerged as the major source of financial resource. However, its own role in shaping the research agenda in tune with the long term survival of the industry is limited. If this is the case, this has to be a point of concern. What is more, the observed trend is one wherein despite being a user driven innovation system the

²¹ Total number of small growers spread across the fourteen districts of Assam is 68459. Out of which only 4966 were registered with Tea Board in 2012.

users' own participation in the interactive learning process has come down leading to declining sphere of learning and interaction. This also perhaps gets reflected in the limited coevolution to address the new challenges and exploit new opportunities. This is especially manifested in the systems inability to address the specific needs of the small growers, which by now has emerged as a major player in the tea sector accounting for over 32 per cent of total production.

5. Research Outcome

The R&D and extension effort and interactive research process can be expected to be manifested in the research activities undertaken by TTRI over the years. These research activities of TTRI can be broadly classified as 'development of new clones', 'agro-management practices', 'machinery' and 'others' (see Table 11). Table 13 is indicative of research personnel at TTRI being actively involved in all aspects of tea cultivation and processing. It can be observed that TTRI had come out with varied technologies ranging from biological technology such as clones, chemical technology such as fertilisers, pesticides and herbicides, mechanical technology such as processing machinery and managerial technology such as improved agro-management practices related to pruning, plucking, manuring and planting of shade trees.

Table13: Decade-wise Research Activities of TTRI

Activities	1949	1950-59	1960-69	1970-79	1980-89	1990-99	2000 till date
Development of new clones	Release of TV1, TV2 and TV3	Release of TV4, TV5, TV6, TV7, TV8 and TV9.	Release of clones TV10 to TV17	Release of clones TV18 to TV24; Biclinal seeds and their release	Release of clones TV25, TV26, TV27 and TV28; Introduction of polyploidy clones	Release of clone TV29; New biclinal seeds and clones	Release of tea cultivars, Lengree 51 and Lengree 56 for drought affected areas; TV 31 clone released to the industry based on multilocational trials; TTRI 1 and TTRI 2 clones released to industry in September 2014
Agro-management practices	Introduction of annual prune; Improved pest control measures, drainage, Clonal propagation of tea from single nodal cuttings,	Introduction of herbicide; Standardisation of tipping level at 5 leaves	Balanced NPK manuring; Introduction of longer pruning cycle; leguminous shade tree; Planting pattern and plant	Introduction of micronutrient; Potash application basis; Drainage improvement; Young tea management; Better	Plant growth regulators for crop productivity; Introduction of tissue culture in tea; Irrigation and drainage; Improved	Biopesticides, Trichoderma, Package for Helopeltis control; Drip irrigation; Tissue culture technique;	Development of simple technique for top replacement by cleft-grafting; Introduction of <i>Anadenanthera peregrina</i> , a new leguminous shade tree; a new technology for producing enriched vermicompost, microbial control of termite pests

	importance of legume as shade		density; Recommendation of herbicides	pest control methods	pest control measures through IPM	Conservation of tea germplasm	
Machine ry		Developed Rotorvane	Developed continuous tray drier, rotorvane attachment, rotorvane cone attachment, rotorvane improved; developed Borbora leaf conditioner machine		Developed Boruah Continuous Roller and Boruah Continuous Roller improved; developed tea breaker cum stalk separator and green leaf storage system.		modified rolling table for Darjeeling
Others						Establishment of pesticide residue testing laboratory; Establishment of laboratory for heavy metal testing	Comparison of remote sensing imageries for four pilot areas with topographic maps of 1912-13 giving information on overall drainage systems; a process technology for improvement of brightness of liquor by controlled withering; development of jute-based alternative packing material; a process for developing tea tablet and soft drinks based on tea by-products; Experiments related to climate change

Source: Compiled from Various issues of Annual Scientific Report, TTRI

Note: This is not an exhaustive list of the research activities undertaken by TTRI. This compilation is indicative of the broad areas of research undertaken by TTRI over the years.

It can be observed that TTRI has been developing and releasing new clones every decade starting from 1949 till date. This technological innovation is said to have marked the beginning of a revolution in clonal selection and vegetative propagation of tea. Altogether, 211 clones and 14 seed varieties had been released to the tea industry for commercial planting (TTRI, 2014). These clones are grouped into three categories.

Standard clones: TV2, TV3, TV4, TV5, TV6, TV7, TV10, TV11, TV12, TV13, TV14, TV16, TV17, TV20, TV24, TV27, AND TV28 have above average yield & quality with high yield potential of about 3000-3500 kg made tea/ha.

Yield clones: TV8, TV9, TV15, TV18, TV19, TV22, TV23, TV25, TV26, TV29 AND TV30 have average quality but high yield with yield potential of 4000 kg made tea/ha and above.

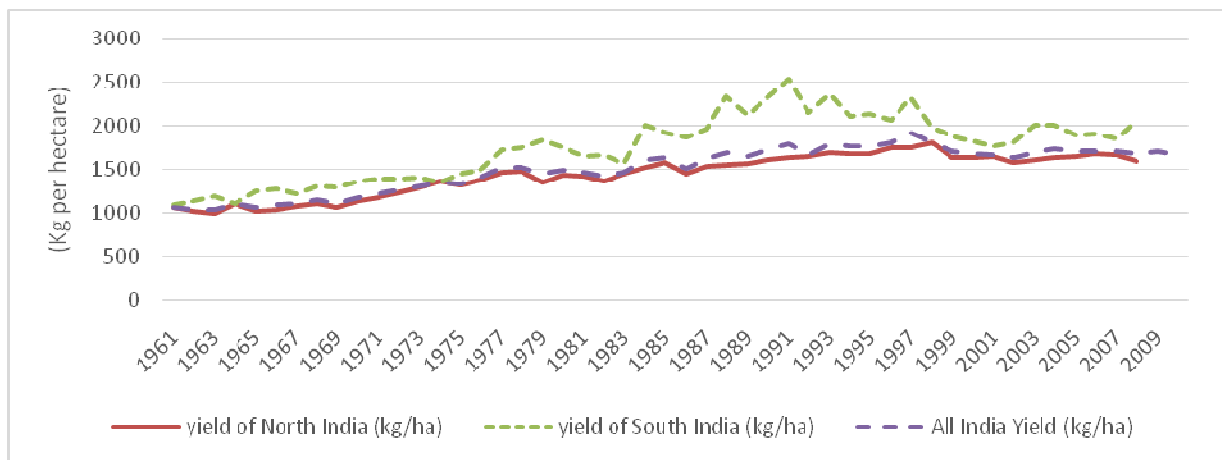
Quality clones: TV1 and TV21 have high quality but average yield with yield potential of about 2500-2800 kg made tea/ha.

However, despite the introduction of several clones²², it has been mentioned that TV1, which was the first clone released by TTRI, continues to dominate the tea industry of North East India even now (Hazarika, 2011). Given the yield potential of all the three categories of clones, the actual yield of tea in North India and All India is seen to be around approximately 1600 kg per ha (see Figure 7). This is well below the yield potential of not only standard clones and yield clones but quality clones as well. The yield of tea in North India and All India is seen to be in tandem with each other while yield of South Indian tea plantations is higher, hovering at approximately 2000 kg per hectare. In fact, the yield of tea in North India and All India is observed to have stagnated from the end of 1990s onwards.

This lower yield in tea is even more striking, when we compare the yield index of tea (1970=100) with that of another plantation crop, natural rubber (see Figure 8). While the yield index of natural rubber (1970=100) recorded nearly threefold increase (276 to be exact) that of tea marginally increased to reach the level of 162 by mid 1990s and there after showed a downward trend with the present level being only 141.

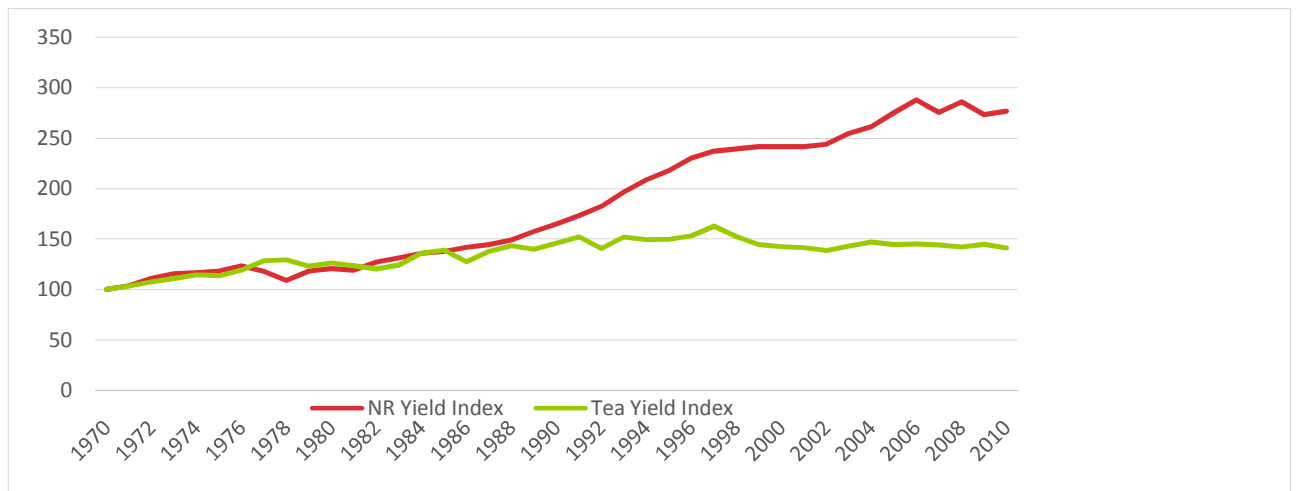
²² It is well accepted that adoption of clones would be influenced by the topography and agro-climatic conditions prevailing in the garden and the mandate of the member gardens. Whether their mandate is to increase quantity or quality, accordingly they would decide to adopt from any of these different varieties of clones. Despite this, the most widely adopted one is TV1 which was the first clone released by the institute.

Figure 7: Trend in the Yield of tea in North India, South India and All India level



Source: Various issues of Tea Statistics, Tea Digest, Tea Board of India

Figure 8: Trend in the Yield Index of Tea and Natural Rubber



Source: Calculated from Various issues of Tea Statistics, Tea Board of India and Indian Rubber Statistics, Rubber Board of India

While research on tea production is important for increasing the yield of tea, research on tea manufacturing is equally important for maintaining the quality of made tea and cater to ever changing tastes of consumers while adhering to numerous international standards. On interaction with few planters, it was understood that the TTRI was involved mostly in research on

production aspect, however, not much support was obtained by the planters with regard to processing and manufacturing of made tea. In this regard, given the increased concern for maintaining the quality of made tea as well as the increasing market demand for diversified products, the need to undertake research on manufacturing which would help in value addition and product diversification can hardly be ignored. This trend may indeed be reflective of the sharp fall in manpower experienced by the tea processing and manufacturing department over the years which might have had an adverse effect on the research activities related to tea manufacturing.

Thus what could be observed from the preceding discussions is that the institute seems to be trapped in a sort of vicious circle wherein due to financial resources not able to increase commensurately with the ever increasing challenges, the manpower employed across the research and advisory departments seems to have experienced a consequent decline. Added to it, personal interaction between the growers and TTRI as well as group interaction (in the form of Annual Scientific Committee meetings; training cum demonstration programmes) has also been on the decline since 1980s and 1990s. This can be expected to have an adverse effect on the research activities being conducted by the institute. This plausibly is manifested in instances such as lower yield which would again lead to a fall in the resources of the institute (for instance, fall in membership subscription on account of lower price realization by the planters and consequent withdrawal of planters from membership on account of unpaid dues). This would again affect the knowledge sphere of the researchers as their exposure to varied conditions through interaction with the planters would decrease along with a fall in financial resources at their disposal and the cycle would continue.

6. Concluding Observations

It is widely recognized that innovation in general and R&D and extension which contributes to innovation in particular play a significant role in determining productivity and profitability along with international competitiveness especially in the current context of globalization. R&D and extension activities in tea sector have a long history. It is unique not only in terms of its long history but also in terms of the key role that the users of knowledge - the planters - play in shaping the nature and direction of R&D and extension activities. Going by the pivotal role of industrial-academia interaction that the literature considers as central for fostering innovation,

the research system in tea is expected to deliver impressive results. However, going by the available evidence, the existing system appears to be not adequately equipped to help tea industry addressing the emerging challenges in the sphere of production, processing, marketing and trade. What is more, unlike in natural rubber, there has been hardly any significant increase in the production per hectare of tea planted in the country. Against this backdrop, the present study made a preliminary attempt in analysing the R&D and extension system in tea using the innovation system framework wherein innovation is conceived as involving interactive learning of different stakeholders governed by the institutional context along with the R&D effort in terms of R&D manpower and R&D expenditure.

Drawing from the secondary information and interaction with scientists in TTRI and planters, we have come up with some preliminary conclusions having a bearing on informed policy making. TTRI has an elaborate R&D system wherein ten research divisions have been established to deal with almost all aspects of tea industry. However, it appears that that the innovation system in general and the research agenda in particular has not successfully coevolved in tune with the emerging challenges. The study noted that given the multitude of challenges that the industry is confronted with, the R&D effort, either in terms of financial resources or manpower is grossly inadequate. In a country where R&D intensity is a little less than one percent, which is too low as compared to other countries, the R&D intensity is not even one third of the national R&D effort. Over time, TTRI has been transformed from a primarily estate-funded organisation to one with significant reliance on grants from the Tea Board. Yet, there have been sharp fluctuations in the two major sources of funding (grants from Tea Board and member subscription) for the institute indicating that even the meager R&D funding has not been available on sustained manner. Needless to say, absence of a steady and assured funding for research would have undermined the ability of the institute to undertake meaningful research on a sustained basis.

Analysis of the research agenda setting and the nature and extent of interaction with different actors in the research system tends to suggest that the nature of interaction that exists today is highly lop-sided, mainly, confining to the large planters. The small growers are totally excluded. It appears that given the lop-sided interaction, the research agenda tends to get focused excessively on the short-term considerations and challenges faced by the planters and the system is constrained especially by the inadequate R&D inputs to address the long-term considerations

which would also involve substantial basic research. The lop-sided nature of interaction with the resultant weak interaction with other knowledge producing centres along with limited provisions for skill upgradation of scientists appears to have stood in the way of evolving a vibrant R&D and extension system. The tea processing in the has witnessed hardly and innovation for decades. Though the system has been able to come up with different clones overtime, a clone that evolved in 1949 still dominates the sector. There has not been any significant increase in the productivity either. The index of production per hectare of tea (with 1970 =100) has hardly shown any significant increase and in fact showed downward trend since the mid-1990s. This compares very poorly with that of natural rubber. Since the research system has not been able to rise up to the challenges, the emerging trend appears to be one wherein the industry's interaction with the research system is declining as is evident from the sharp decline in the number of Annual Scientific Committee meetings, number of members attending such meeting, number of training cum demonstrations held and number of participants therein and finally on the number of advisory visits. This gives space to private consultants.

The policy prescription that emerged from the discussion may be seen at two levels. To begin with, at the level of TTRI, there is the need for substantial internal restructuring of R&D and extension activities. Greater attention needs to be given to processing, packaging and catering to the changing tastes of consumers. Many recommendations in this direction have been made by Rahman committee (2010) which are being implemented. However, we reiterate the need for scaling up the R&D and extension activities and ensure adequate and assured financial support for the same. The study also underscores the need for developing stronger linkage with other knowledge producing centers and actors, both within and outside the country. TTRI also cannot afford to keep away from its responsibility of generating the future scientists by more actively engaging them in teaching and research. We are also inclined to infer that the interactive system has to be made more balanced wherein the role of Tea Board cannot be reduced to provider of research grants alone. To the extent that Tea Board has the mandate of building an internationally competitive and vibrant tea sector, it has to ensure that such concerns are adequately incorporated in the research agenda for the long term survival of the industry. Finally, we underline the need for appreciating the difference between basic research and applied research. The former, being a public good, has to be fully publicly funded while the burden of industry associations shall be reduced to applied research.

At a more general level, drawing from the earlier research of NRPPD, we believe that the plantation sector today is confronted with challenges more than ever before. While many of these challenges are similar across different plantation crops, the current system of one crop – one institute leads to duplication of efforts. In a context of resource constraint, for reaping economies of scale and scope from the available resources, it may be high time to think in terms of bringing all these research institutes under one organisation with appropriate governance structure and effectively harnessing the information and technology. This however, is an issue that needs further work.

Acknowledgements

The authors acknowledge all the scientists in Toklai Tea Research Institute for sparing time for responding to all our enquiries and providing us with needed information. Thanks are due to the TTRI library staffs for being helpful in gathering the required information. We are also thankful to different planters who shared their experience which was a major source of learning for us. Interaction with Dr Biswajith Bera, Shri M Dasgupta, Shri Gangan Boriah, and Dr Pradip Baruah was especially useful. The preliminary findings were presented in the Tea board before the Deputy Chairman and other senior officers. We are thankful for their much helpful feedback.

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About National Research Programme on Plantation Development (NRPPD)

This research programme, established with the support of the Ministry of Commerce and Industry, Government of India, envisages to help transforming the plantation sector in India to be internationally competitive and sustainable – economically, environmentally and socially - by;

Undertaking Policy oriented Research – on all aspects of plantation economy at the regional, national and international levels

Promoting Policy advocacy – at the regional national and international level - to influence particularly the National and State level policies

Facilitating Networking – of all relevant stakeholders and

Help Capacity building - of all concerned at the regional and national levels.

The programme works under the overall guidance of a Steering Committee, chaired by the Chairman, CDS. The Steering Committee comprises of the Chairpersons of Coffee Board, Rubber Board, Tea Board, Spices Board, Joint Secretary/Director in Charge of Plantations in MoC, Director CDS and an expert on plantation sector. Chair Professor of the Programme is the Convenor. A Research Advisory Committee chaired by the Director CDS has been set up to provide guidance to the research being undertaken by the programme.

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