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TOWARDS A SUSTAINABLE SYSTEM OF INNOVATION: THE CASE OF PLANTATION SECTOR IN KERALA

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ABSTRACT

Plantation sector in India, historically dominated by the large estates has been promoted intensively by the state given its significant contribution towards foreign exchange on the one hand its developmental role and livelihood of workers on the other. However, there has been a growing concern over the environmental implications of plantations sector on account of the deforestation, sedimentation in the reservoirs of hydroelectric projects, environmentally hostile cultural practices, waste generation in case of certain plantations and others. Hence economic sustainability of plantation sector is considered as inimical to environmental sustainability. At the same time, the changes in environment do adversely affect yield of plantation crops and therefore their economic viability. In this paper, drawing insight from the literature on innovation systems, we examined the evolving nature of interaction between economy, ecology, innovation and finds that the emerging trajectory appears to be one that promotes sustainability notwithstanding instances of institutional inertia within the sector towards evolving a sustainability oriented innovation system.

Introduction

Economic growth in a number of developing countries during the closing decades of the last century and the early decades of this century is catching up with the performance of the developed countries. At the same time, if the available evidence is any indication this has further accelerated the consumption of energy and other scarce natural resources, accumulation of greenhouse gases in the atmosphere and other environmental externalities over and above the heavy toll of environment already imposed by the developed countries. Needless to say, this has led to heightened concern over environmental implications of higher economic growth. In response to this the United Nations Conference on Sustainable Development (2012) known as Rio+20 commemorating the 20th anniversary of the 1992 Earth Submit has produced the document "The future we want". This is a renewed effort to embark on ways of "greening" the global economy and evolving institutional framework for sustainable development.

Given the growing inequality and marginalization that accompanied the high growth episodes, doubts have often been raised about its economic and social sustainability and that inclusive and sustainable development is increasingly becoming a key concern of planners and policy makers. Higher economic growth, the long cherished dream for many economies, doesn't appear to entail complimentary relation between economic, social and ecological sustainability. Indian

experience in general and that of Kerala in particular appears to be not much different; with higher rate of economic growth, the adverse effect on the environment today is more than ever before. Moreover, going by the recent empirical evidence on consumption, Kerala has emerged as one of the most unequal states in the country[1].

To the extent that the observed higher economic inequality and its associated outcomes are inexorably linked to the system of innovation and production in specific sectors of the economy, addressing the issue of sustainability (ecological, economic and social) entail a techno-economic paradigm shift that needs to be *radical*, *rapid and systemic* (Tilman 2012). It has to be radical because unsustainable technological trajectories and innovative practices need to be disrupted and replaced by new technologies and innovations in order to decouple economic development from resource consumption and carbon emissions. The need for rapid change arise because this decoupling has to take place within the next decade or two and the failure to take immediate action will overstrain the carrying capacity of critical global ecosystems and lead to much higher costs in the future. Finally the changes are to be *systemic,* as it implies changing technological regimes and combining institutional sub-systems in innovative ways.[2]

This paper makes an attempt to explore the nexus between ecology, economy and innovation (in its broader sense – covering technological, organisational and institutional) by taking the case of plantation sector in Kerala. In the context of plantation sector in India in general and Kerala in particular, while its adverse effect on environment has been an issue of perpetual concern, the issue seems to have not received adequate

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1. The estimated value of Gini coefficient using the NSS consumption data in Kerala declined from 0.35 in 1983 to 0.32 in 1993 and was comparable to that of all India average (0.31). But by 2009-10 it increased to 0.48 in Kerala as compared to the national average of only 0.36.

2. See in this context Tilman (2012) and the special issue of Innovation and Development Vol 2, no.1, 2012.

attention of scholars. Plantation sector in India, historically dominated by the large estates, has been promoted intensively by the state on account of its significant contribution towards foreign exchange[3] on the one hand its developmental role and livelihood of workers on the other[4]. However, economic sustainability of plantation sector is considered as inimical to environmental sustainability as there has been a growing concern over the environmental implications of plantations sector on account of the deforestation, sedimentation in the reservoirs of hydroelectric projects, environmentally hostile cultural practices, waste generation in case of certain plantations and others (Murugan et al 2011, James 2011, Nair et al 1989 among others). Unlike the industrial sector wherein the adverse environmental impact of their operations need not directly affect the efficiency and productivity of the units involved, in the plantation sector the adverse environmental effects of the package of practices followed (eg. degradation in soil quality resulting from heavy use of fertilizers and pesticides) will have its adverse effects on the plantation sector itself. In general the changes in environment will adversely affect yield of plantation crops and therefore their economic viability/ sustainability. Drawing insight from the literature on innovation systems, this paper analyses the evolving nature of interaction between economy, ecology, innovation and examines if the emerging trajectory is towards sustainability or unsustainability.

The remainder of the paper is organised as follows. The second section presents the broad outlines of innovation system in Kerala's plantations sector to explore the issue at hand based on the insights from the studies on National System of Innovations (NSI). The third section presents a preliminary analysis of the emerging system of

3. As per the pioneering study on India's exports by Manmohan Singh (1964), in 1950-51 tea coffee and spices accounted for 20.8 per cent of India's total export.

4. Plantation sector is shown to be highly labour intensive, especially women labour as they account for 54 per cent of the total labour force engaged. See for details Joseph (2010) Viswanathan and Shah (2012).

innovation in Kerala's plantation sector in order to assess if the evolving nature of interactions among organisations and institutions is giving rise to relatively more sustainable outcomes. The final section presents the concluding observations and points out the need for evolving a sustainability oriented innovation system.

2. In lieu of an Analytical Framework

The recent empirical evidence on economic growth in many developing countries indicates that the road to high growth is no more an unchartered terrain for the laggards in developing world (Commission on Growth and Development 2008).Economists, regardless of the school of thought that they belong, from Adam Smith and Karl Marx to New Growth Theorists have shown that innovation in general and technological change in particular has a crucial bearing on the rate of growth of economies. Empirical evidence on the growth experience of today's developed countries and recent growth experience of emerging economies like Brazil, Russia, India, China and South Africa (BRICS), stand as a testimony to the above argument (OECD 2007). Today even the lay person is convinced of the comforts and conveniences that the technology and innovation have brought into daily life from the kitchen to office and from the farm to factory.

However, by now it is generally evident that the past episodes of high growth under globalization are unsustainable viewed in terms of any of the pillars of sustainability – environmental, economic and social. The highly energy and carbon intensive growth has led to unprecedented damage to environment resulting in global warming and its associated adverse effect leading to limits to growth thesis of club of Rome which was further reinforced by a number of influential studies and global summits.

In the sphere of economy and society, it has been shown that higher growth has been accompanied by growing inequality casting

doubt on its economic and social sustainability (Wade 2004). In India also, the high growth has not been broad based, pro-poor or inclusive and therefore not sustainable. As noted by Abhijit Sen and Himanshu (2004) the rate of decline in poverty in India has been at the lowest level during 1990s. We have also witnessed massive farmers' suicides in India that coincided with high rate of economic growth (Mishra 2006, Reddy and Mishra 2009). As observed by the Planning Commission (2008) and Vaidyanathan (2010) among others, notwithstanding an unprecedentedly high GDP growth rate of 7.7% during the 10th plan (1992-97), growth of agricultural sector that accommodated bulk of the India's labour force remained almost stagnant at two per cent and the country had to live with the largest number of poor and illiterates in the world. It also underscored the need to address the growing marginalisation of women and minorities and steep inequities at different levels. Indian experience and that of many other fast growing developing economies, therefore, tends to confirm what Schumpeter rightly maintained, aggregate statistics of GDP or industrial production can conceal as much as they reveal since they are the outcome of diverse trends in the economy.

It appears that while the recipe for high growth, which in a globalised context crucially dependent on competiveness, is presumably ready, what is missing is a credible cookbook for sustainable, both economically and environmentally, growth and competitiveness. However, despite the heightened interest on the issue at hand, our understanding on the ways to achieve sustainable growth and competiveness at best remains rudimentary. In a context wherein the focus of policy pendulum is being shifted from growth to sustainable growth one ponders if the innovation breeds growth, could it also be instrumental for sustainable growth?

While the concept of sustainability is more widely used in the context of environmental sustainability, the term in its broad sense

encompasses three dimensions – environmental, economic and social and the focus in this paper will be on the first two. The relevant point of inquiry, therefore, is whether these two dimensions of sustainability are competitive or complementary. Economists have, since long, considered a dollar worth of potato chip different from a dollar worth of microchip, implying that the product structure and sectoral composition do matter in growth (Passinetti 1981) and competiveness. Hence, to understand the micro foundations for growth and sustainability the inquiry has to be at the sectoral level which justifies the focus on plantation sector.

Viewed in a static sectoral perspective, it is rather easy to see that different sectors of the economy are not equally positioned in breeding high growth with suitability. While some sectors, given the nature of production process and higher opportunities for technological progress and innovation potential, are growth boomers, the outcome may not be complimentary in terms of economic and environmental sustainability. On the other hand, there could be other sectors wherein high growth is associated with complimentarity in terms of economic and environmental sustainability. Viewed in a dynamic sense one could have cases wherein the high growth trajectory is associated either with complimentary or non complimentary relationship between environmental and economic sustainability. This in turn would depend on the growth drivers in the economy. To the extent that innovation, the driving force behind growth in any economy is crucially dependent on the underlying innovation system Fagerberg (2005) which in turn has a crucial bearing on all the three basic considerations – growth, economic sustainability and environmental sustainability – one could safely infer that if growth needs to be sustainable the underlying innovation system also has to be one that is oriented towards sustainability. This leads to the discussion on the concept of innovation system in some detail.

The origin of the concept: The concept of innovation system has its origin in the work of Georg Friedrich List (1841), a leading German

economist of 19th Century. It is interesting to note that, the context which induced List to write his *magnum opus* - National System of Political Economy – is strikingly similar to the current context. List's primary concern was to explore the ways and means by which a developing country (Germany of 19th century) could be enabled to catch up with a developed country (England of 19th century). He had strong reservations with Adam Smith's belief in the free trade and cosmopolitanism[5]. This is what induced List to propose the idea of infant industry protection that formed the core of impart substitution strategy adopted by many of the countries that achieved political independence after the Second World War.

However, there was another important element of the catch up strategy proposed by List. This involved investment in human capital (education) and capacity building and emphasis on knowledge acquisition and its improvement. To quote,

> "The present state of the nation is the result of accumulation of all discoveries inventions, improvements perfections and exertions of all generations which have lived before us; they form the mental capital of the present human race, and every separate nation is productive only in the proportion in which it has known how to appropriate these attainments of former generations and to increase them by its own acquirements".

While the idea of infant industry protection received much attention of development planners and manifested in the tariff barriers to protect the domestic industries, it was only by 1987 that some of the ideas of List

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5 While Adam Smith considered division of labour as the key source of improvement in the productive powers of labour, List argued that in order to explain the opulence of modern nations we must look at how work of different Labour is combined. By arguing that it not Division of Labour but "Union of labour" that actually contributes towards improvement in productive power, List highlighted the interaction between different agents involved and underscored the need to see the economy in a systemic manner.

for national capability building was articulated by Christopher Freeman (1987) while analyzing the emergence of Japan as a major economic power. He has shown how Japan has opened up a new "Technology gap" over other countries as a result of developing a national system of innovation. Thus the "National System of Political Economy of List became "National system of Innovation" in the hands of Freeman.

Development of the concept: Disenchanted with neoclassical paradigm that places analytical focus on concepts like scarcity, allocation and exchange (market) in a static context, and considering theories in social sciences as focusing devices, Lundvall (1992) and Nelson (1993) made considerable contribution towards evolving further the concept of National Innovation System (NIS). They considered knowledge as the most fundamental resource in the modern economy and its acquisition as an interactive process. The concept got enriched by drawing insights from evolutionary economics, structuralists and theories on the economics of knowledge and appreciating the dangers of considering R&D on par with innovation *ala* GDP growth with development. Common for these contributions was that they deviated from the linear approach to technological progress (invention-innovation diffusion) and regarded innovation as an interactive and evolutionary process at micro, meso and macro level as a driving force behind growth and development. Thus viewed they went beyond the narrow confines of product and process innovation and considered innovation as an interactive learning process in an evolutionary manner emphasising the inter-dependence and non-linearity wherein institutions playing the central role (Joseph 2006; Edquist 1997)[6].

Almost from the beginning, innovation system research has encompassed two different perspectives, a narrow one linking innovation

6. The 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

to science and a broader one encompassing learning, innovation and competence building (Lundvall 2007). NIS in a narrow perspective, in tune with the earlier analyses of national science systems and national technology policies (Mowery 1994), aimed at mapping indicators of national specialization and performance with respect to innovation in new products and process, research and development efforts and science and technology organisations. In contrast, the broader approach to NSI takes into account social institutions, macro economic regulation, financial systems, education and communication infrastructures and labour market conditions as far as these have impact on learning and competence building process (Gu and Lundvall 2006). It links the micro behaviour to the system level in a two-way direction. Changes at the system level are seen as outcomes of interactions at the micro level whereas the system shapes the learning, innovation and competence building at the micro level.

Drawing from the discussion so far made the innovation system in plantation sector is depicted in Fig 1. In the figure three different versions of the innovation system, very narrow, narrow and the wider version are indicated. Viewed from a very narrow perspective, innovation system in plantation will involve only the knowledge generating and diffusing organisations and the institutions[7] like the rules, laws norms and practices that govern this process and its outcomes. From a narrow perspective the innovation system will also involve the producers, both small and large, workers both in the organised large estates and informal workers, and the agents involved in the processing and marketing –both in the foreign and local markets. The actions and interaction between these actors are indeed governed by varied institutions (rules, laws, norms etc) and organisations like the planters' associations, labour unions and others.

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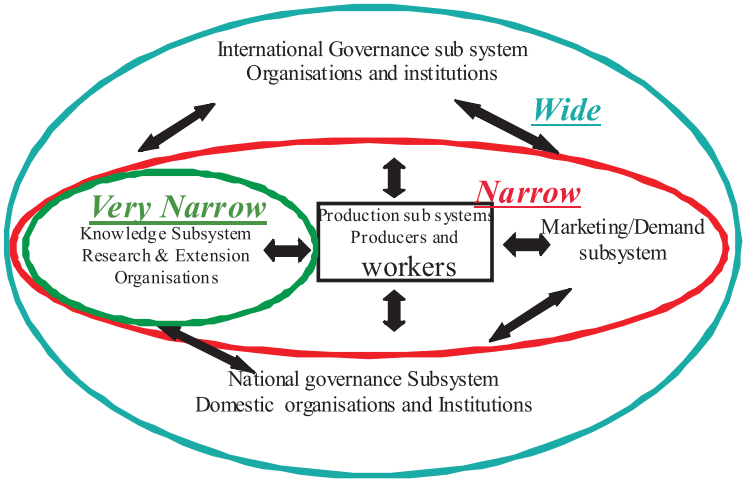
7. North (1990) says Institutions are the rules of the game in society or, more formally, are the humanly devised constraints that shape human interaction.

Fig 1. Innovation system in India's Plantation Sector



Source: Adapted from Cassiolato (2005).

When it comes to the wider conceptualization of innovation system it is also necessary to take into account the international organisations[8] (eg., WTO) and institutions (eg. multilateral agreements with bearing on plantations like the Agreement on the Sanitary and Phytosanitary Measures and national organizations (eg., commodity boards) and the organizations and institutions both at the state and national level (eg., rules on land utilisation). Going by the innovation system framework, the complementary on non-complimentary relationship between growth and the sustainability in plantation sector quintessentially will be dependent on the innovation system in plantation sector which in turn will be an outcome of the interaction between different actors involved and the institutional framework provided.

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8. North (1994, 361) says "It is the interaction between institutions and organisations that shapes the institutional evolution of an economy. If institutions are the rules of the game, organisations and their entrepreneurs are the players. Organisations are made up of groups of individuals bound together by some common purpose to achieve certain objectives.

3. Emerging Innovation System in Plantations

Plantation sector in general, involves mono crop cultivation for the market and environmentalists consider such plantations as green deserts. Tree plantations are not forests as it is a highly uniform agricultural system that replaces natural ecosystems and their rich biodiversity[9]. It is further argued that monoculture tree plantations have a two-fold impact globally: loss of biodiversity and net emitters of carbon.

Plantation sector in India in general and Kerala in particular, has been developed mostly in the ecologically fragile locations. The development of plantations in such regions, needless to say, has been at the cost of biodiversity due to large scale deforestation. The plantation sector being historically integrated with the world market, with a view to be internationally competitive has to adopt such cultural practices which involved heavy use of chemical fertilizers and pesticides. Such cultural practices are also shown to have severe adverse effect on environment and human habitation in addition to the soil erosion and other adverse environmental consequences. Similarly, in cardamom plantations, felling of trees for firewood for cardamom curing is also having similar outcomes. Apart from the highly fertilizer and pesticide intensive cultural practices, and fuel wood intensive processing methods, the survival strategies of growers in the event of drastic decline in the prices of these crops also have adverse ecological outcomes. Damodaran (20002) has shown that the coping up strategies of growers like felling of shade trees for sale in coffee plantations for sustaining the revenue flows in the event of decline in prices, have had deleterious consequences on the environment.

At the same time, the productivity and therefore the competitiveness and economic viability of plantation crops is highly

9. See for details http://news.mongabay.com/2008/0919-plantations_hance.html

susceptible to the state of environment (Nair et al 1989) and hence the climate change. Thus there is a nexus between technology, economy and environment in plantation sector. The technology driven agricultural practices and processing methods, along with innovations in the organisation of production (large vs small holdings) and cropping pattern (mono cropping *vs* mixed cropping) governed by economic considerations impacts environment while such adverse environmental outcomes in turn affect the productivity and economic viability of plantations. Here there are different trajectories possible depending on the nature of interaction between different actors and organisations involved and institutional setting within which they interact. The key issue is whether the nexus between economy, ecology and technology and innovation in Kerala's plantation innovation system as evolved over the years has been tending towards a trajectory of high growth with complimentary or non complimentary relation between economic and environmental sustainability. This calls for an inquiry into the innovations in India's plantation sector in lieu of the above issues.

Organizational Innovations[10]: Shift from Estates to Small holdings

The origins of plantation agriculture in India could be traced to the pre independence period and has been an outcome of colonization of tropical region by European countries[11] Going by the historical evidence, plantation sector in India has been initially in the hands of foreign companies (see Table 1). Later, especially after independence the ownership of these estates shifted to the large domestic players.

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10. For a discussion of various organisational innovations see Mansigh and Johnson (2012).

11. Cultivation of tea, for example, began in 1830s in Assam and North Bengal. Later cultivation shifted to Nilgiris in Southern India. Hence the first phase of the development of South Indian tea industry was confined to Nilgiris. Later Chinese tea seeds seem to have been planted in Kerala on a commercial scale in early 1850s (George and Tharakan 1985).

Table 1: Concentration of area under tea in Kerala and Tamil Nadu by foreign controlled companies

	Kerala			Tamil Nadu		
Year	No. of Companies	Area under their Control (Hectares)	Area under Control as % of total Area under Tea	No. of Companies	Area under their Control (Hectares)	Area under Control as % of total Area under Tea
1925	5	19702.37	77.23	6	9427.12	59.23
1940	5	28071.58	73.69	6	15470.50	59.72
1950	5	27606.36	70.14	6	14021.10	53.05
1960	5	25248.86	63.29	6	13245.83	41.20
1970	5	22749.08	62.20	6	14778.46	41.17
1978	3	16778.54	46.90	5	10187.21	27.77

Source: Planting Directory of Southern India (Various Issues), UPASI, Coonoor as quoted in George and Tharakan (1985).

Plantations in Kerala, started with the conversion of Cardamom into plantation type agriculture along with Coffee, then moved into Tea and Rubber. It has however, been considered an instrument of modernisation in the sense that it served to open up previously underdeveloped regions to open up and create the social overhead capital and monetized primitive economies. Hence, the development of plantation sector was facilitated by the state in a number of ways that included provision of enormous surplus land and levying a very low or negligible land tax along with maintaining a very low wage rate (George and Tharakan 1985). The plantation based production arose, as argued by Hayami and Damodaran (2004), in a context wherein virgin land had to be cleared and developed and physical infrastructures such as roads, irrigation systems, bridges and other basic facilities had to be constructed. Thus the need for lumpy investment in the context of poor infrastructure development necessitated organisation of production of plantation commodities in large estates based systems. In addition, the agrarian reforms in states like Kerala is also attributed to have facilitated the perpetuation of estate based production.

In the estate based production, oriented mostly towards the world market, the economic viability depended crucially on the international competitiveness which in turn was governed by factors like yield. To enhance the productivity levels, the estate sector, very often than not, had to resort to cultural practices involving heavy use of chemical fertilizers, insecticides and pesticides. Given the larger scale of operation, organic cultural practices are unlikely to be practicable in large estates. Hence the estate based production, though viable economically, had its adverse effect on environment leading to non complimentary relationship between economic and environmental sustainability.

With the establishment of infrastructure facilities and the development of hitherto underdeveloped plantation areas and large scale migration of farmer families along with promotional measures by

Table 2: Trends in area under small (<2 ha) holdings in rubber and estates in cardamom

Year	Rubber		Cardamom			
	Area	Share of < 2 ha category	No. of Estates	% share of Total Estates	Area (Hectares)	% share of total area under Cardamom
1955-56	18289	21.81				
1960-61	38340	29.51				
1965-66	51433	31.22				
1970-71	68470	33.71				
1975-76	81938	36.51	18795*	67.53*	17144*	20.62*
1980-81	132650	47.7	19929	68.06	18216	21.21
1985-86	217150	58.79	22857	68.94	20923	21.76
1990-91	332401	83.63				
1995-96	375957	83.64				
2000-01	412574	83.29				
2005-06	455483	85.61				

Note: Figure with * refer to the year 1978.

Source: Rubber and Cardamom (spices) Statistics published by respective Commodity Boards in India.

the commodity boards, there has been a large scale participation of small holders in plantation commodities. The flexibility and economies associated with family based production has also contributed to the emergence of small holder domination in the plantation sector (Hayami and Damodaran 2004). The share of small holders in the total area under natural rubber steadily increased from 21.8 per cent in 1955-56 to over 85 per cent in 2005-06 (see Table 2). If the available evidence is any indication, during the last five years the share of holdings with less than two hectares has further increased to reach the present level of over 90 per cent. When it comes to cardamom, though authentic data is not available, the available evidence is indicative of the increasing role of small holders thought not to the extent in natural rubber.

Similar trend could be observed in case of tea, which is traditionally known for large estate based production which was facilitated greatly by yet another innovation in the form proliferation of bought leaf factories[12]. From Table 3 it is evident that the number of small growers has been growing at a compound annual growth rate of 6.88 percent while the large growers grew at 0.60 percent from 1998 to 2007. This indicates a higher proliferation of small growers compared to the large growers over the years. As a result, the share of area under small growers doubled from 14.5 percent in 1998 to 28.1 percent in 2007. It is also to be noted that the average size of holdings under small growers was only 0.79 hectare in 1998 and it increased marginally to 1.03 hectare in 2007. When it comes to production, the share of small holders has more than doubled (11.15 percent in 1998 to 26.10 percent in 2007) indicating their higher productivity.

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12. The proliferation of small growers could also be the result of shift from export to domestic market. The growing domestic market has led to switching over from quality orthodox to cheaper CTC tea for the price conscious Indian customers. Since the domestic market is price conscious, the effort of the producers will be to restrict cost at the production stage. Further, production of quality tea is not a major concern for the producers in case of CTC tea (Thappa 2012).

Table 3: Number, Area & Production of Tea for Small and Large Growers (1998- 2007)

(Area in hectares and Production in million kg)

Year	Small Growers (Up to 10.12 ha)			Large Growers (Above 10.12 ha)		
	Number	Area	Production	Number	Area	Production
1998	86517	68598 (14.5)	97.46 (11.15)	1598	405428 (85.5)	776.65 (88.85)
1999	97267	83152 (17.0)	133.94 (16.22)	1600	407048 (83.0)	691.99 (83.78)
2000	110396	97598 (19.4)	154.21 (18.21)	1614	406768 (80.6)	692.71 (81.79)
2001	115025	101345 (19.9)	163.59 (19.16)	1634	408461 (80.1)	690.34 (80.84)
2002	126167	106154 (20.6)	178.09 (21.24)	1634	409678 (79.4)	660.39 (78.76)
2003	127366	109198 (21.0)	180.66 (20.57)	1661	410400 (79.0)	697.47 (79.43)
2004	127366	110787 (21.2)	201.96 (22.62)	1661	410616 (78.8)	691.01 (77.38)
2005	139041	142985 (25.7)	231.29 (24.45)	1672	412626 (74.3)	714.68 (75.55)
2006	141544	154099 (27.2)	249.71 (25.43)	1673	412921 (72.8)	732.09 (74.57)
2007	157504	162431 (28.1)	257.46 (26.10)	1686	416027 (71.9)	728.97 (73.90)
Compound Annual Growth Rate (%)	**6.88**	**10.05**	**11.40**	**0.60**	**0.29**	**-0.70**

Source: Thappa (2012) Various issues of Tea Statistics, Tea Board.

Note: Figures in brackets indicates the shares of small and large growers in the total area and production of tea.

In the light of the observed shift from large estate based production to one that is dominated by the small holders, the crucial issue relates to the differential implications of scale of operation and pattern of cropping on environmental and economic sustainability. There is significant differences in the economics of estate based production as compared to small holder production with crucial bearing on environment. While estate production is based on mono crop cultivation, it is unlikely to be viable option for the small holders. This is because, unlike the large estates, cropping by the small holders is driven by their livelihood considerations. Given the fact that the prices of most plantation crops are known to be volatile (Anoopkumar 2012), mono crop cultivation may not be helpful to ensure a sustainable livelihood for the small holders for whom agriculture is the only source of income. In such a context, to insure against the price risk arising out of the volatility in the price of these crops, the small holders are bound to resort to mixed cropping in contrast to mono cropping by the large estates. To the extent that mixed cropping is more environmentally friendly than mono cropping, the emergence of small holder domination in the plantation sector is likely to mitigate the conflict between economic and environmental viability in plantation sector (Risks associated with production, environment and markets).

Here it may be of some relevance to consider the extent to which the organisations and institutions that promote plantation sector take into account the environmental benefits associated with mixed crop cultivation. The subsidised replanting/new planting scheme implemented by all the commodity boards can be considered as an example. Replanting and new planting subsidy is offered to the small holders by all the commodity boards since there is a gestation lag between planting and harvesting of these crops. The crop is also characterised by a yield cycle that involves broadly four phases; initial pre-bearing phase followed by an early harvesting phase wherein yield is positive and increasing with high variability. During the third phase (may be called

peak bearing phase) yield reaches the highest level followed by the last phase wherein the yield declines. Since the age structure of the plant has a crucial bearing (along with other factors) on the yield and production, timely replanting is needed to maintain the age profile of the plantations in such a way that the share of old-aged plants is minimised. The planting subsidy scheme is a major institutional innovation by the commodity boards to induce the growers to undertake timely replanting and to bring in new area under cultivation. The planting subsidy, both for replanting and new planting, is a fixed amount that is disbursed *ex post* in installments depending on the crop characteristics like the gestation lag and cost of production.

The disbursement of such subsidies is governed by certain planting protocol (rules) specified by these boards. For instance, in case of Rubber Board, known to be highly efficient among the commodity boards in accomplishing what they are expected to accomplish, the subsidy schemes for replanting and new planting appears to be inimical to mixed cropping. A major stipulation by the Rubber Board, given its mandate to increase production and productivity, is that the grower should resort to mono crop culture. Hence, for reasons like spreading risk or other reasons the grower choosing mixed cropping will be excluded from the subsidy scheme. Hence it appears that, though the holding structure as evolved over time has the potential to make the plantation sector complimentary in terms of its economic and ecological sustainability, the existing institutional inertia appears to stand in the way of its transition to long term sustainability.

Technological Innovations

In case of small cardamom, increased small holder domination notwithstanding, a recent study (Murugan et al 2011) has shown that intensification of small cardamom farming in the Cardamom Hill reserves have the major detrimental impacts on ecosystem. The new variety of cardamom (Njallani) that was introduced in the late 1980s has contributed

to almost four fold increase in yield. But this variety is also highly susceptible to varied diseases, pest and insects in addition to being highly responsive to the intense use of fertilizers (Joseph and George 2010). To illustrate, there are over 17 diseases that affect the cardamom plant from the nursery stage to estate level and as many as four major pests are found affecting the cardamom plants (see Joseph 2012) What is more, despite the establishment of an elaborate research and extension system by the Spices Board there is a proliferation of consultants in cardamom cultivation and the growers are very often guided by the advice provided by the fertilizer/pesticide dealers (Joseph 2011). The result has been an almost 3 fold increase in the use of both nitrogen and phosphorus fertilizer as well as pesticides (4-5 fold increase in number of spray rounds).

The shade regulation practice of growers is shown to have resulted in the reduction in forest canopy cover by about 40 percent (Murugan et al 2011).Traditionally cardamom has been grown in the rain forests under the forest cover. However, the current agricultural practices for intensive cardamom production involve deliberately maintaining ecosystems in a highly simplified, disturbed, and nutrient rich state. To maximise cardamom yields, varieties are carefully selected by planters to suit to altered local growing conditions created by pruning and lopping of forest canopy on a regular basis (Murugan et al 2011). Shade regulation, however, is a highly labour intensive activity and adds to cost of cultivation. To address this issue, there is the need for reorienting research to evolve new varieties that could be grown with high yield without shade regulation. This, issue, however, is yet to receive the attention of the researchers that it deserves indicative of the institutional inertia.

Use of firewood for cardamom curing also leads to felling of trees and deforestation. While significant progress has been achieved towards alternative curing technologies, and reducing the use of firewood in

traditional curing houses, there is a need for further institutional initiatives to arrest the deforestation induced by cardamom curing. As of now the electricity tariff charged by the Kerala State Electricity Board (KSEB) for the cardamom curing devises is on par with industrial tariff. It should be noted that with lower electricity tariff use of firewood would be minimized leading more tree cover, more rains and more water in the reservoirs. Here again the institutional inertia appears to be a major constraint.

Institutional Innovations

There are certain salutary institutional changes at the global level that affect the domestic plantation sector. Though these are often treated as non tariff barriers by the developed countries on developing countries, they are likely to have the effect of facilitating economic and environmental sustainability. The Agreement on the Application of Sanitary and Phytosanitary Measures (the "SPS Agreement") entered into force with the establishment of the World Trade Organisation on 1 January 1995 is an example for this. The Agreement concerns the application of food safety and animal and plant health regulations. According to the agreement, all the countries should adopt measures to ensure that food is safe for consumers, and to prevent the spread of pests or diseases among animals and plants. These sanitary and phytosanitary measures can take many forms, such as requiring products to come from a disease-free area, inspection of products, specific treatment or processing of products, setting of allowable maximum levels of pesticide residues or permitted use of only certain additives in food. In a context wherein the developed importing countries of plantation crops like cardamom are strictly implementing these measures, the producers are forced to adhere to these standards and that it will call for significant changes in the existing agricultural practices. It is a welcome sign that the organisations concerned like Spices Board are today intensively promoting organic farming and research agenda of scientists are being

shifted towards evolving cultural practices with reduced inputs of chemical fertilizers and pesticides.

To offset the adverse effect of complying with the environmental standards and there is another institutional innovation at the global level. This relates to the Kyoto Protocol which mandates the rich and industrialized countries to reduce their collective carbon dioxide emission to at least 5.2% below their 1990 emissions levels between 2008-2012. Given the high cost associated with the domestic actions required to meet the Kyoto compliance targets, the Kyoto Protocol established three market mechanisms (flexible instruments) to help these countries meet their GHG emissions reduction target cost effectively. They are: International Emission Trading (IET), Joint Implementation of emission reduction projects (JI) and Clean Development Mechanism (CDM). The developed countries can purchase Assigned Amount Units (AAU) on the basis of IET or Emission Reduction Units (ERU) on the basis of JI projects from another developed country. Both IET and JI can be operated only among the developed countries.

The third mechanism, CDM encourages projects by developed countries in the developing and the least developed counties that do not have GHG emission reduction restrictions under the Protocol. The CDM aims at brining funding from developed countries for environment-friendly projects that are in tune with the sustainable developmental needs of the people in the developing countries in the tropics and subtropics that will earn the developed countries what is called Certified Emission Reduction (CER) credits or carbon credits, that can be used by the investing developed countries to partially offset its Kyoto protocol targets. Several analyses show that given the low costs of projects implemented in developing countries under the CDM, this will be the preferred market instrument unlike JI or IET which can be operated only between developed countries.

One significant approach to tackle climate change is through the growth and sustainable management of trees and forests, which naturally remove carbon dioxide (CO_2) from the atmosphere as they grow and store the carbon in their wood, roots, leaves and bark, which contain around 50% carbon by dry weight. Though this process exists in all types of trees and forests some tree species and forest types absorb and store carbon more effectively than others. Due to their relatively fast growth, tree plantations are very efficient carbon absorbers, with the added benefit of producing forest products that continue to store carbon and can reduce the need to use fossil fuels in energy production, a significant source of CO_2. The role CER credit in removing CO_2 from the atmosphere is widely recognised, and it can be traded in carbon markets within and outside the country. Thus any carbon captured in the plantation sector in India like natural rubber or Cardamom may be eligible to trade through a variety of carbon brokers[13].

4. Concluding Observations

This paper makes a preliminary attempt towards exploring the nexus between ecology, economy and innovation (in its broader sense – covering technological, organisational and institutional) on sustainable development of plantation sector in Kerala. Plantation sector in India, historically dominated by the large estates, has been promoted intensively by the state given its significant contribution towards foreign exchange on the one hand its developmental role and livelihood of workers on the other. However, there has been a growing concern over the environmental implications of plantations sector on account of the deforestation, sedimentation in the reservoirs of hydroelectric projects, environmentally hostile cultural practices and waste generation in case of certain plantations. Hence, economic sustainability of plantation sector is considered as inimical to environmental sustainability. At the

13. See for more details Jacob James (undated) The Kyoto Protocol and the Indian Natural Rubber sector available at http://rubberboard.org.in/articles.asp?id=11

same time, the changes in environment do adversely affect yield of plantation crops and therefore their economic viability. In this paper, drawing insight from the literature on innovation systems, an attempt has been made to analyse the evolving nature of interaction between economy, ecology and innovation. It has been posited that the emerging trajectory appears to be one that promotes sustainability notwithstanding instances of institutional inertia within the sector towards evolving a sustainability oriented innovation system.

The most important welcome change emanates from the shift from estate based cultivation to the domination of the small holders. While estate production is based on mono crop cultivation, it is unlikely to be viable option for the small holders. Unlike the large estates, cropping pattern adopted by the small holders is driven by their livelihood considerations. Given the fact that the prices of most plantation crops are highly volatile due to greater integration with the world market, mono crop cultivation may not be appropriate to ensure a sustainable livelihood for the small holders for whom agriculture is the major source of income. In this context, in order to insure against the price risk arising out of the volatility in the prices, the small holders are bound to resort to mixed cropping instead of mono cropping by the large estates. To the extent that mixed cropping is more environmentally friendly than mono cropping, the emergence of small holder domination in the plantation sector is likely to mitigate the conflict between economic and environmental viability. However, such environmental benefits are yet to fully recognised by the organisations that promote plantation sector as they insist that only mono cropping will be eligible for state support. Hence, it appears that, some organisational innovations in the form of changes in the size structure has the potential to make the plantation sector complimentary in terms of its economic and ecological sustainability. The exiting institutional inertia appears to stand in the way and calls for further institutional innovations towards evolving a sustainability oriented innovation system.

In the case of small cardamom, increased small holder domination notwithstanding, the intensification of farming in the Cardamom Hill reserves has major detrimental impacts on ecosystem. However, certain salutary institutional changes at the global level in the recent past like Agreement on the Application of Sanitary and Phytosanitary Measures (the "SPS Agreement") of WTO appears to have the effect of help evolving a sustainability oriented innovations system. In a context wherein the importing countries are strictly implementing these measures, the producers are forced to adhere to these standards and organisations concerned like Spices Board are today intensively promoting organic farming and the research agenda of scientists is being shifted towards evolving cultural practices with reduced inputs of chemical fertilizers and pesticides.

Shade regulation and felling of trees for cardamom curing are other activities by which cardamom cultivation contributes towards environmental degradation. Traditionally cardamom has been grown in the rain forests under the forest cover. However, the current agricultural practices involve creation of growing conditions involving pruning and lopping of forest canopy on regular basis. Shade regulation, however is a highly labour intensive activity and adds to cost of cultivation. To address this issue, there is the need for reorienting research to evolve new varieties that could be grown with high yield without shade regulation. This, issue, however, is yet to receive the adequate attention of the researchers. While significant progress has been achieved towards alternative curing technologies, and reducing firewood in traditional curing houses, there is the need for further institutional initiatives to arrest the deforestation induced by cardamom curing by making available electricity at reasonable cost. Research on increasing energy efficiency in cardamom curing is another area that needs to be focused.

The institutional interventions towards bringing about sustainability oriented innovation and production system is likely to

increase the cost of production and adversely affect the economic viability. To some extent these adverse effects can be offset by exploiting the provisions of the Kyoto protocol. On the whole, while certain institutional innovations at the national and international level evolved over the years have the potential of making the plantation agriculture relatively more sustainable, further institutional innovations, especially at the national level, are called for to make plantation sector sustainable.

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