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Beyond the supply chains of technology and commodity

Challenges to strengthening mango innovation systems in Andhra Pradesh, India

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Abstract

Purpose – Despite favourable agro-ecological conditions and being the largest international mango producer, India still struggles to build competence in sustainable mango production and post-harvest. The purpose of this paper is to contribute to the literature on innovation capacity development, and to explore aspects of innovation systems ideas in the analysis of mango production and marketing by small-scale farmers in the South Indian state of Andhra Pradesh.

Design/methodology/approach – This paper uses case study research methods to an analysis of the sector's recent history combined with an empirical account of systems thinking on integrating technology supply chains and commodity supply chains.

Findings – Findings suggest that the case of mango production and post-harvest in the Krishna district is a dismal one and the remedial actions to strengthen mango innovation systems in the district relate to aspects of capacity development to promote upward spiral of learning and innovation, and involve multistakeholder processes to integrate the supply chains of technology and commodity.

Originality/value – This paper, with its aim to contribute to the literature on innovation capacity development, brings together conventionally distinct bodies of literature on strengthening innovation systems and developing stakeholder capacity. The value of this paper lies on how it addresses technology supply and commodity supply issues in the analysis of competence challenges to strengthening mango innovation systems performance.

Keywords Complex systems, Innovation, Mango, High-value, National competence, Supply chain management, Learning, South Asia, India

Paper type Research paper

1. Introduction

This paper explores aspects of innovation systems ideas in the analysis of sustainable mango production and marketing by poor farmers in India, a part of the world where agro-ecological conditions are highly favourable for this type of crop (Zeven and Zhukosky, 1975). Indian subcontinent is known as the centre of diversity of mango

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with a host of cultivated and wild varieties of mangoes. In fact India has maintained over 650 mango variety accessions, exceeding 500 varieties in a single research farm in Andhra Pradesh, and is ahead of most middle and low-income countries in terms of technological innovations in horticulture and related disciplines (Vijaya *et al.*, 2003; Mattoo *et al.*, 2007). Nevertheless, despite being the largest producer of mangoes and accounting about 43 per cent of the world's production, India still struggles to build momentum in rapidly-emerging export markets. This paper argues that very probably the root of the problem lies in a dysfunctional innovation system where the patterns of interaction needed to stimulate innovation and growth are either absent or much more poorly developed than is required. In this way weak capacity to innovate has severely undermined the comparative advantages provided by otherwise favourable agro-ecological conditions for sustainable mango production and post-harvest management.

The next section reviews and summarises the relevant innovation systems literature paying particular attention to those properties felt to be central to integrated technology development and supply-chain management in smallscale agricultural production in poor countries. Then the methods section outlines how reviews of secondary material published by the Crop Post-Harvest Programme (CPHP) under the British Department for International Development (DFID)'s eleven-year Renewable Natural Resources Research Strategy between 1995 and 2006 supplements the empirical material presented in this paper, which has been derived from interviews with key stakeholder groups and direct observation in the Krishna district of southern Indian state of Andhra. Its focus is on an investigation of learning and innovation around the Vijaya Fruit and Vegetable Growers Association (hereafter referred to as Vijaya), a farmers' organisation that went through two successive restructuring periods since its establishment in 1992. For ease of exposition we call the grouping of smallholder farmers and other actors surrounding this network of mango producers in the Krishna district the "sector". Then Case study provides a short historical account of the sector's development from a relatively low point in the 1980s and setting out institutional changes that it was hoped would allow the sector to capitalise on growing export markets. Despite a number of organisational and institutional changes, innovation systems performance remained poor, but as a result of this failure, mango stakeholders turned to recognise the role of produce (e.g. premium quality and organic mangoes) and market (e.g. domestic supermarkets) differentiation strategies to capture emerging regional and domestic markets than indiscriminate integration of smallholder mango growers in the international export markets. Then the paper discusses systemic issues of interactive learning and innovation that seem to have adversely affected the sector's overall innovative systems performance, offers a series of policy relevant learning lessons, and finally draws conclusions.

2. Review of relevant innovation systems literature

The idea of an innovation system is now widely used to explore the innovation process and capacities at national (e.g. Edquist, 1997; Freeman, 1987; Lundvall, 1992), regional (e.g. Asheim *et al.*, 2011; Cooke, 1992) and sectoral (e.g. Malerba, 2004; Klerkx and Leeuwis, 2008, 2009) levels. More recently innovation systems ideas have gained attention of international development researchers and practitioners (e.g. Hall *et al.*, 2002; Pant and Hambly-Odame, 2009; World Bank, 2006). At its simplest, the concept departs from earlier notions of innovation as a research-driven process of technology transfer and, instead, views it as a social process where different sources of knowledge and ideas are put into use. The concept gives centre stage to two interconnected

dimensions of innovation. First is the interaction among different players in economic and social systems, the roles they play and the way their interaction facilitates the transmission, adaptation and use of ideas, and thus enables learning and innovation for sustainable development.

The second dimension is the way the learning and innovation processes are situated in, shaped by and respond to various contexts (Lave and Wenger, 1991). These include the habits and practices – institutions – of the various actors involved in innovation; the historical, cultural and political setting that gives shapes to habits, practice and styles of innovation; and the enabling environment that includes some of these other contextual elements, but also includes policies and infrastructure as well as the market itself as a mechanism for providing incentives for entrepreneurial activity. Two other important considerations that the innovation systems framework allows one to reveal are the dynamics of the processes involved and the capacity that emerges at a systems level (Hall, 2005). So while the concept recognises the importance of certain types of relationships and linkages that mediate information flows, it also recognises that in ever-changing biophysical and social environments (climate, weather, markets, policy, technology), patterns of stakeholder linkages for learning and innovation need to change to meet new conditions and demands.

The recognition of stakeholder linkages as a systems phenomenon, however, is arguably the critical point of departure for contemporary thinking on innovation. Innovation systems thinking not only recognises the interaction of many individual parts, and the non-linearity of the outcomes of these interactions, but it also identifies that these networks of interacting elements have emergent properties. In other words these systems have properties that are more than the sum of the constituent parts and which cannot be accounted for by analysis of individual elements of the system (Hall and Clark, 2010). It is for this reason that institutional settings of actors – ways of working – are significant in innovation processes. By the same reasoning it is why science, technology and innovation policy for sustainable development is shifting towards considering stakeholder capacity development in terms of the behaviour of systems rather than in terms of quantum of research or the nature of technology transfer elements.

The concept of stakeholder capacity development is different than the way technological capabilities have usually been specified in the management literature (e.g. Lall, 1992, 2004). Nor does it really accord with how innovation capabilities have often been portrayed – that is, through major changes in the design and core features of products and production processes (Ernst *et al.*, 1998). It is more akin to the concept of dynamic capabilities (Teece *et al.*, 1997) as the firm's ability to integrate, build and reconfigure internal and external competencies to address a rapidly changing environment. It accords also with Eisenhardt and Martin's (2000) definition of dynamic capability as the processes that use resources, especially the processes to integrate, reconfigure, gain and release resources to match and even create market change.

To put the concept of stakeholder capacity development in perspective, operational and maintenance capacity development alone is less effective if it not integrated with learning-based adaptive capacities to experiment, to learn interactively and to develop adaptive capacity to innovate in response to changes in biophysical and social environments (Hambly-Odame *et al.*, 2007; Reeves and Deimler, 2011). Capacity is an emergent property of a system that comes about through the interrelationships and interactions among various elements of the system of which it is a part (Hall, 2005; Morgan, 2005). In practice, the intersection of capacity development and strengthening

innovation systems performance focuses on two critical points – managing divides among multiple stakeholders (e.g. public/private, formal/informal), and enabling processes of interactive learning and innovation (Pant and Hambly-Odame, 2006) (Figure 1).

Learning and innovation among multiple stakeholders are better facilitated through the provision of networks. Learning and innovation networks, which are often recognised as a mechanism to develop innovation capacity at various levels, can be tacit and codified; and knowledge sources can be formal organisations or informal practices in rural communities. While tacit knowledge cannot be formally expressed as it is embedded in habits and practices of knowledge practitioners, codified knowledge can be expressed and recorded in external media, such as paper or electronic media, and is transmitted over time and space. Intersecting learning types and knowledge sources, four basic types of learning networks are possible (Table I). The adaptive learning capacity through an integration of codified and tacit learning networks determines the success of knowledge mobilisation and innovation activities pertaining to a particular sector, such as in renewable natural resource and agriculture (Seufert *et al.*, 1999).

Within each type of learning network, knowledge conversion takes place from tacit-to-tacit, tacit-to-codified, codified-to-codified and codified-to-tacit (Nonaka, 1991; Nonaka and Takeuchi, 1995). Tacit-to-tacit conversion takes place through socialisation; tacit-to-codified conversion takes place through codification or

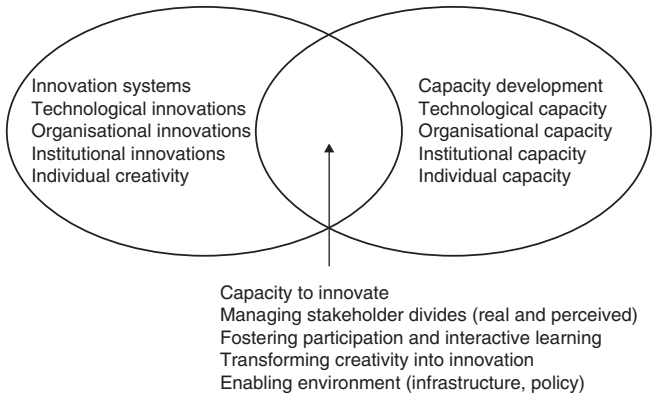

Figure 1.
Capacity to innovate

Source: Adapted from Hambly-Odame *et al*. (2007)

Table I.
Intersecting codified and tacit modes of learning with the sources of knowledge

	Codified learning	Tacit learning
Formal knowledge source	Codified learning networks of the public, non-profit private and for-profit private sectors; e.g. policy briefs, manuals, journal papers	Tacit learning networks of the public, non-profit private and for-profit private sectors; e.g. social events, tea time chat
Informal knowledge source	Codified learning networks of rural communities; e.g. rural bulletin boards	Tacit learning networks of rural communities; e.g. social events, labour exchange

externalisation of tacit knowledge embedded with people's habits and practices; codified-to-codified conversion takes place through systematisation or combination into a higher scale; and codified-to-tacit conversion takes place through decodification or internalisation to put codified knowledge into use. One or the other type of knowledge conversion takes place in a system, but an efficient system integrates all of these conversions to produce an upward spiral of learning networks. Here an upward spiral means that all four types of knowledge conversion begin at an individual, then at a group, organisational, network and system levels.

The higher the level, the more challenges collective learning, innovation and action faces as the number of knowledge actors increase exponentially, which in turn increases the diversity and differences among actors. Inefficiency in any type of knowledge conversion will trap a system into a downward spiral that reduces learning networks to the tacit learning networks of a group or small number of individuals (e.g. families and friends). Therefore, knowledge networking is an important aspect of developing organisational and institutional capacities to innovate in the natural resource and agriculture sector because it represents the collective action of organisations and individuals in response to unpredictable economic, social, climatic and environmental changes. The next section examines the case of Vijaya to illustrate how an increasingly stringent export market demand for Indian mangoes combined with weaker stakeholder capacities to innovate led to a downward spiral of learning and innovation that not only aim to serve the lower value conventional domestic and regional markets but also overlooks the possibilities of sustainable mango production and post-harvest management, through alternative practices, such as produce and market differentiation through organic mango production and fair trade practices.

3. Research methods

The empirical material for the investigation was derived from interviews with key stakeholder groups and direct observation of their habits and practices as a part of a study on agricultural innovation systems (see Pant, 2012 for details). Key informant and focus group interviews were conducted with primary stakeholders in the Krishna district, and secondary stakeholders in Hyderabad, Bangalore and New Delhi, to investigate the patterns of interaction. The interviews were also instrumental in complementing the findings in the analysis of the recent history of the mango sector, which primarily emerged from the review of the literature published over a decade or so. Key informant interviews were initiated with the Agricultural Processed Products Export Development Authority's (APEDA) officer in Hyderabad, who was a key public sector actor in the sector. The APEDA officer was asked to provide names of other persons who would be appropriate to interview, and the snowballing continued with other key informants. This method of snowballing was successful because stakeholders knew each through networks built over a decade or so.

On the recommendation of APEDA and subsequent stakeholders, interviews were held with mango farmers, exporters, executives of Vijaya and the members of Agricultural Market Committee (AMC), district horticulture extension officers, officers of the Andhra Pradesh Department of Marketing (DoM), and the director of the Agricultural Export Zone (AEZ) for mangoes in Vijayawada. Scientists at the Indian Council of Agricultural Research (ICAR) in New Delhi and at the Indian Institute of Horticulture Research (IIHR) in Bangalore were also interviewed. The key informant interviews were facilitated using a check-list and the interviewees were specifically

asked to draw a stakeholder map to illustrate and discuss the patterns of interaction among the public, non-profit private, for-profit private and informal sector (see Pant and Hambly-Odame, 2006).

Given the large numbers of mango farmers recommended for inclusion as key informants, mango growers were interviewed in groups employing a focus group interview technique and an interpreter as they spoke only Telugu and did not understand English and Hindi. Farmers were also asked to draw a stakeholder map representing tripartite relationships among the public, non-profit private and for-profit private sectors, putting themselves at the centre of the triangle. Since this research involved two field visits that were subsequently organised – the first during the mango flowering season and the second during harvesting – direct observation of the habits and practices of stakeholders engaged in the sector served as a strong method of data triangulation.

4. Case study

4.1 Recent history of the mango sector in the Krishna district

The Vijaya was established in 1992 in Vijayawada region of the Krishna district, in the southern Indian state of Andhra. At that time the association was made up of 16 fruit and vegetable cooperatives. The primary society membership consisted of approximately 500 small and mediumscale farmers (one to ten acres) who, between them, cultivated almost 3,000 acres of mangoes (Hall *et al.*, 1998, 2001a, b). Vijaya was a non-profit private enterprise established with two specific goals:

(1) find a better price for farmer members' produce through direct marketing without the produce being handled by middlemen, wholesalers and traders; and

(2) act as a source of technical advice and inputs to assist farmers in increasing the proportion of fruit which reaches export quality criteria.

In the same year, the Andhra Pradesh DoM, with financial support from APEDA in the Ministry of Commerce, Government of India, established a pilot facility in Gollapudi, near Vijayawada to process table mangoes for export (Figure 2). Exporters were able to use this facility for a nominal fee with Vijaya being one of the first exporters to utilise it. APEDA, DoM and Vijaya had been involved in developing a protocol for sea freight of mangoes to the Middle East and Europe. At the same time, the Natural Resources Institute, a specialised Institute at the University of Greenwich at Medway, UK, came to APEDA with a proposal to implement a component of the DFID's CPHP in India, and APEDA was more than happy to collaborate. In 1995 Vijaya began exploring the potential of European markets with assistance from APEDA. Subsidies were provided for collecting market intelligence; cost of samples and trial shipments; cost of producing promotional literature; and underwriting commercial shipments. APEDA also supported the technical capacity of Vijaya and its farmers, not only by providing 50 per cent of the costs of engaging national scientists but also in forming linkages between Vijaya and relevant sources of technical expertise both nationally and internationally.

The CPHP was implemented in three phases: first phase in 1995 for one year, second phase in 1996 for three years and third phase in 1999 with two projects, one for three years (1999-2002) and another four years (1999-2003) (Hall *et al.*, 2001b, 2003a, b; Hall, 2003). The first phase project identified constraints to implementing quality assurance (QA) systems for horticultural exports from India, defined legislative

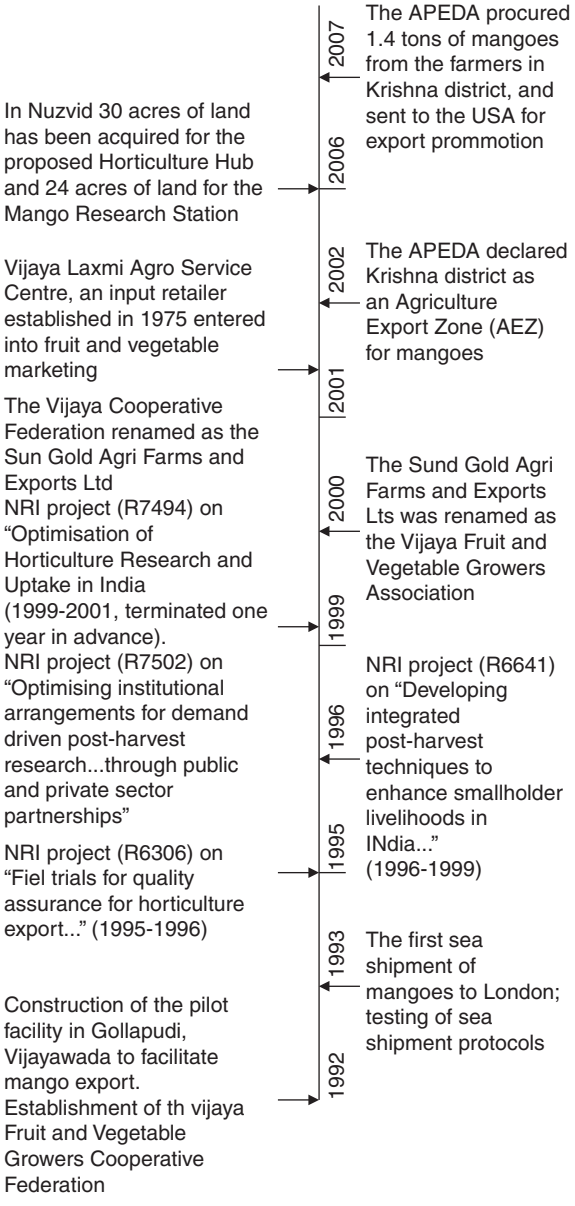

Figure 2.
Timeline of major events related to mango export promotion in the Krishna district

requirements to export fresh horticultural produce to Middle East, identified changes in European legislation affecting horticultural exports and gathered information on QA for Francophone countries. The second phase aimed at developing an integrated package of treatments for successful mango export. Several sea shipments of mangoes were sent to London and South East Asian markets without, however, any encouraging success (Hall *et al.*, 2001b). The problems during these initial phases were basically

identified as technical in nature and included recommendations for the regulation of temperature and carbon dioxide in the refrigerated containers. In fact, constraints were more institutional than technological *per se* – for example, there was a complete disconnect between organisation involved in technology development (public sector R&D bodies who themselves operated in "silos") on the one hand and private sector entrepreneurs and their affiliates, and smallholder mango growers on the other (Hall *et al.*, 2001a, b, 2002). As a result, the project ended its second phase with a revised focus on institutional issues in subsequent interventions.

The two projects in the third phase were as follows: first, technical and management systems for horticultural export by fostering suitable public-private partnerships, and second, institutional arrangements for ensuring that in the future public sector R&D would benefit resource-poor mango growers (Hall *et al.*, 2001b). Although these projects recognised the interdependence of technical and institutional issues, the focus was still on technical matters than institutional change. Despite these projects being effective enough to catalyse some discussion on innovation systems thinking in agriculture – as well as its relevance to the mango export sector – these projects failed to persuade Indian stakeholders to deviate from the "business-as-usual" habits and practices of working within their own silos.

In an effort to create an upward spiral of learning and innovation networks, exploit stringent export market demands and meet expectations of fellow mango growers, Vijaya then began to experiment with its organisational structures and processes. Interviews revealed that in 1999 Vijaya was renamed as the Vijaya Sun Gold Agri Farms and Exports Ltd, a public limited company. In fact, "Vijaya Sun Gold" was already the brand name for its mangoes, but this had been used thus far without legal protection. In 2002 Vijaya was again restructured as an Association of Fruit and Vegetable Growers representing 217 individual members in order to revitalise collective action in mango export. The proprietor of one of Vijaya's subsidiaries, Vijaya Laxmi Agro Service Centre (hereafter Vijaya Laxmi), mentioned that its activities were later diversified to include marketing of agricultural produce in response to the unsuccessful institutional experiment with Vijaya. However, what was significant was that the mango export sector, including Vijaya Laxmi, managed most of this by using the tacit and informal learning networks of families and friends.

Another significant milestone in 2002, as interviewees proudly mentioned, occurred when APEDA declared Krishna district as an AEZ for mangoes adopting the concept of regional innovation developing clusters of mango research and development infrastructure. Additional land was acquired to develop an integrated packing house in Nuzvid, a town that is relatively closer to mango-growing areas than Gollapudi. Another piece of land was also acquired to strengthen the activities of the Mango Research Station in Nuzvid, as a subsidiary of the Acharya NG Ranga Agricultural University (ANGRAU). However, this shift in location for infrastructure development, while existing infrastructure in Gollapudi remained underutilised, was largely due, it is claimed, to political interests than influenced by the regional innovation systems thinking in international development.

Despite all these interventions, however, the mango sector in Andhra Pradesh has failed to succeed not only in high-value export markets but also to meet sustainable development goals. Clearly, part of the challenge has been the failure to meet different types of market demands at play. First, in countries like the UK, USA and Japan consumer demand for quality is stringent. Importers are concerned with

QA issues, such as shelf-life, pesticide residue and insect pest and disease infestation. For example, the USA has made it obligatory for imported Indian mangoes to be irradiated (exposing mangoes to a kind of radiation that kills insects and pathogens). It was estimated during the interview with export development officials that in 2007, APEDA acquired 1.4 tonnes of mangoes from Krishna district and sent them to the USA as a promotional scheme. Before shipping them off, they were subjected to post-harvest processing in the Gollapudi market yard and then to an irradiation facility in Maharasthra, a neighbouring Indian state where cobalt ray irradiation facility for mangoes is currently available. ANGRAU conducts research on irradiation dosages for a few selected mango varieties. Similarly, vapour heat treatment (VHT) of mangoes to eliminate fruit flies is mandatory on mangoes being exported to Japan. Another excitement expressed by mango stakeholders during the interviews was that in 2006, Japan lifted its 20-year ban on imports of Indian mangoes under an agreement that the fruit would be subjected to VHT before shipping. These empirical findings confirm the published literature that clearly the focus has been more on technological innovation and economic growth than social equity to the smallholder mango growers and environmental protection.

4.2 The stakeholder structure

Now this case study, using the results of the field research, turns its focus to outline stakeholder structure around the mango sector before moving to an analysis of stakeholder interaction. Here the stakeholder structures are described as public and private sector bodies subdivided also according to whether they are for-profit or not-for-profit. Informal sector producers are also treated as a separate category.

(i) The public sector

The state agricultural university research stations and specialised fruit research centres of the ICAR conduct mango research activities. The IIHR in Bangalore, and the Central Institute for Subtropical Horticulture, Lucknow, are the major ICAR institutes with mango research activities. The Central Food Technology Research Institute, Mysore, which is under the Council for Scientific and Industrial Research, conducts research on post-harvest technology of various commodities including mango. Bhabha Atomic Research Centre (BARC) of the Ministry of Science and Technology in Mumbai funds research on nuclear science, including its application in horticultural export promotion. For example, ANGRAU conducts research on irradiation of selected mango varieties to determine appropriate dosages of irradiation with funding from BARC.

Scientists from the ANGRAU and ICAR institutes, along with extension staff from the state Department of Horticulture, meet in biannual workshops to determine long-term research priorities. The major research-extension linkage activities include publications, the hiring of researchers as consultants for extension programmes, meetings and conferences, inviting scientists for farmers training and informal information exchange.

Some public agencies have attempted to help extend linkages beyond R&D. The state Ministry of Food Processing Industries and the state DoM, along with its network of AMCs, are the state-level agencies that facilitate linkages for marketing of agricultural produce. The national agencies in this category include the National Cooperative Development Corporation and APEDA. As mentioned in the previous section, UK-based agency NR Institute worked with Indian mango stakeholders on a series of projects on supply-chain management during the 1990s. In collaboration

with APEDA and DoM, NR Institute helped stimulate linkages beyond R&D by identifying legislative requirements for importing countries and facilitating trial sea shipments of mangoes to London and Singapore. However, these initiatives were less effective in establishing sideward linkages with the informally operating but dominant supply-chain actors, specifically the powerful wholesalers and their commission agents.

(ii) Non-profit private sector

Vijaya is the only non-profit private organisation working on mangoes in Krishna district. Although stakeholders in Vijaya claim they have an intermediary role as advisors to mango growers, they were neither involved in facilitating inputs and information access nor in the marketing of mangoes. Outside of an annual general meeting, Vijaya rarely functioned. As described in the previous section, the institutional experiments of Vijaya, although intended to create an upward spiral knowledge spiral, unfortunately trapped them in a downward spiral.

(iii) For-profit private sector

The family-run company Vijaya Laxmi trades mangoes to domestic and regional markets using the facility at Gollapudi market yard. In rare instances this entrepreneur reaches as far as South East Asian and Middle Eastern markets. In addition, there are several commission agents who work on behalf of merchants from northern India. These merchants run fruit and vegetable mandis (market places) in cities like New Delhi and Mumbai, from where they supply mangoes to various domestic, regional and international markets. The other groups of private actors are pulp and juice processors and the pickle industry, such as Priya Pickles. Family-run nurseries also come under this category as they constantly experiment with new ways of producing and marketing mango saplings. Indeed, most mango entrepreneurs surveyed operate informally without any significant sideward linkages to formal R&D systems.

Mango stakeholders rely on information about legislation and certification requirements of importing countries only through tacit learning networks of friends and families. Moreover, the mango growers and exporters were unaware of the SPS Inquiry Point for plant protection that has been established at the Department of Agriculture and Cooperation to handle queries or comments on SPS notifications and regulations issued by other member countries of the WTO. Nevertheless, the APEDA web site provides general information about export regulation and approved certifying agencies/laboratories in India. It would appear that this effort to promote codified learning networks through electronic media needs to be integrated with the tacit learning networks of the supply-chain actors.

(iv) Informal sector

The resource-poor mango growers in Krishna district have struggled for food and livelihood security through income from sale of mangoes. For many farmers mango production is a traditional source of employment throughout the supply chain – production, post-harvest and marketing. Some farmers are self-employed while others work for relatively bigger farmers. Some of the examples of the importance of mango sector in rural livelihoods are as follows:

- A 42-year-old woman farmer called Sunita (all names hereafter are not real) owns ten acres of land and grows mangoes on three acres. She rents a stall in the local market and sells her produce on her own. She also buys mangoes from her neighbours. In 2007 the mango crop was good and she made a good profit.

- A 45-year-old-man called Krishna of Agrapalli village owns one and a half acres of land where he grows mangoes and vegetables. He regularly rents a stall in the local market and sells his produce. To adapt to the seasonality of the mango business, Krishna integrates it with vegetables. Profits from the business are the sole support for his family.
- A 16-year-old boy called Bala from a landless family buys mangoes from his neighbours and sells them in the local market. He has done this business for the last two consecutive years. When the mango season is over, he runs other businesses.
- A smallholder farmer aged 60, called Nareshnan, works as a commission agent for merchants in northern India. He buys mangoes from his neighbours, often contract mango orchards before flowering, and supply good quality mangoes to the merchants. Once farmers contract out their orchards, the management responsibility goes to the contractor. Nareshnan sells inferior quality mangoes in local market. He has plans to use processing facilities in Gollapudi market yard to export mangos on his own. He, however, was not sure about the sources of information to involve in export market.

4.3 Patterns of stakeholder interaction

The question then becomes: what has been missing? Given that successful export performance depends upon relevant technology development, which in turn depends on effective information flows among actors what kinds of intervention are likely to improve matters? From an innovation systems perspective the answer must lie in improving relevant patterns of stakeholder interaction. This, in turn, led the authors to specifically investigate what these patterns of interactions are and how they need improving.

(i) Patters of interaction between the public sector and non-profit private sector

This is one of the weakest linkages in the system. If the capacity of the non-profit sector were to be developed, it would serve as a strong intermediary to promote sideward linkages between the public sector, exporters, commission agents and mango growers.

(ii) Patterns of interaction between the public and for-profit sector

Vijaya Laxmi rents the facilities at Gollapudi market yard to process mangoes before sending them to regional export markets. Since the 2006 mango season Vijaya Laxmi has used the facilities to supply mangoes to Indian supermarket chains and South East Asian markets but has failed to export the fruit to high-value overseas markets. This observation leads to two, seemingly opposite, interpretations. On the one hand, the entrepreneur fails to successfully access international markets, in spite of the fact that APEDA provides subsidies for exports, and the state government commits to exempt all duties and taxes on inputs for production and processing of mangoes for export from the AEZ. On the other hand, the entrepreneur was successful in utilising the facilities, specifically subsidised for export promotion, to supply mangoes to domestic markets – clearly deviating from the public policy provisions. Such deviant behaviour would serve as a strong case against policy processes that favour export promotion, as smallholder mango growers are unable to prove that they grow mangoes for export markets.

(iii) Patterns of interaction between the non-profit private and for-profit private sector

This type of learning network appears to have failed in Krishna district, more so due to the lack of interactive learning rather than high-profile ideological differences. The proprietor of Vijaya Laxmi is the president of Vijaya, an association of mango growers. Some Vijaya members claim that the profits made by Vijaya Laxmi should be shared among Vijaya members, while others claim that Vijaya was never involved in the marketing of mangoes. This was one of the reasons for the collapse of the original federation of 16 primary cooperatives with 500 members and its replacement by an (equally dysfunctional) association of 217 members.

(iv) Patterns of interaction between the public sector and informal sector

The Zonal Research Extension Advisory Committee (ZREAC) sets research priorities at the local level. This committee comprises researchers from the state agricultural university, extensionists from the state Departments of Agriculture and Horticulture and farmers. The committee meets twice a year, once in the rabi (winter crop) and again in the kharif (summer crop) season. The District Advisory for Agricultural Transfer of Technology (DAATT), also headed by the state agricultural university, works as a coordinating body among researchers, extensionists and farmers. The state university publishes *Babashaya Panchangam* (a compendium of research findings) in the local language (Telugu) on the occasion of the Telugu New Year. This compendium and other publications, as well as training, exchange visits and consulting services, are some of the important linkage mechanisms that exist between the public sector and rural communities. The emphasis on codified learning is again a "business-as-usual" practice of client-patron relationships between the two sectors. Interactive learning through linkages between the public and informal sectors is still emerging, although it is not specifically apparent in mango. The state government recently emphasised social mobilisation programmes, including the Rythy Palalou Sasthrya Betal (scientists in the farmers' fields), Palaloum Bade (farmers' field schools), Chetan Yatra (farmers' awareness campaign) that provide interpersonal interaction between scientists and farmers.

(v) Patterns of interaction between the non-profit private sector and informal sector

Since Vijaya was the only non-profit private sector organisation working on mangoes in the area, it was expected to have close linkages with rural communities. However, its learning networks are rather limited and exclude smallholder mango growers. In effect, smallholder mango growers are not served in a meaningful way.

(vi) Patterns of interaction between the for-profit private and informal sectors

Vijaya Laxmi and commission agents, who also belong to rural communities, could have strong linkages with individual farmers. However, mango growers are not satisfied with the prices they receive from Vijaya Laxmi and commission agents. Linkages are meant more for produce flows along the supply chain than information flows to improve the overall capacity of mango growers. Most farmers opt for pre-harvest contracts with commission agents. These usually verbal contracts are made well before flowering, and farmers stop taking care of their mango orchards as soon as they have contracted it out. Management responsibility is transferred to commission agents once an agreement has been reached. The practice of handing over management responsibility to commission agents differs from the practice of contract farming, whereby private companies usually provide credit, inputs, technology and other extension services to grow a particular crop and secure a harvest.

While the formal sector stakeholders were engaged in mango-related R&D interventions, the poorer section of the rural communities found it hard to extend their tacit learning networks to access information from codified learning networks of

scientific community. Specifically, the failure to develop this linkage created exclusive learning networks, not only between formal and informal sectors but also between influential and less influential actors in rural communities. Thus the types of learning networks that Vijaya and Vijaya Laxmi are involved in prevent them from accessing increasingly stringent export markets. If the habits and practices around the issues of building innovation capacities, and specifically knowledge mobilisation, are not challenged and changed with strengthening sideward linkages between R&D organisations and informally operating supply-chain actors, Indian mangoes will not only fail to take off in the UK, USA and Japanese markets but are also likely to be completely pushed out of the customary regional markets in South East Asia and the Middle East and even the domestic supermarkets serving the growing Indian middle class consumers. Figure 3 provides a visual illustration of this scenario where challenges to strengthening high-value innovation systems lies on strengthening sideward linkages towards formalising the mango supply chain collapsing the vertical and horizontal axes into a single axis.

5. Discussion and policy recommendations

Clearly the story of mango and export production in Krishna district, Andhra Pradesh, is a dismal one. Despite favourable agro-ecological conditions, extensive investment on the part of the state in R&D and transferring technologies to farmers, technical overseas assistance and the existence of a cooperative organisation designed, *inter alia*, to stimulate technology development and supply-chain management the past decade has seen little significant change. This paper has taken the view that an important part of the problem lies in the lack of the necessary learning and innovation competence that underlies integrated technology development and innovation management (Pant, 2012). There is now ample evidence from the literature that knowledge networking and building adaptive capacities of relevant stakeholders is far more important in a knowledge economy where knowledge is dispersed, fragmented and retained by a myriad of heterogeneous agents, such as public and private stakeholders from policy, research, extension and enterprise domains (Antonelli, 2006; Klerkx *et al.*, 2009). The problem therefore often reduces to promoting collective learning at organisational, network and system levels, especially in how to coordinate context-specific skills, actors, practices, routines, institutions and policies, and integrate multiple streams of technologies, institutions, organisations and agro-ecological processes (Hall, 2005, 2007; Prahalad and Hamel, 1990).

Unfortunately our investigation of corresponding patterns of interaction show clearly that this has not happened in the case of mango production in this part of India. Neither the activities of the local cooperative body in supply chains, nor the considerable activities of the public R&D sector in technology development and transfer have shown the slightest signs of interaction with economic production. The commodity supply chain remains a purely private sector activity dominated by the commercial interests of mandi (large commercial house) operators that seem quite content to rely on traditional markets. Thus, disconnect between supply chains of commodities and technologies compromised the overall performance of the mango sector.

If Indian mango stakeholders agree with this reality, what should they do to reform public policy towards achieving national comparative advantage in mangoes? Here we suggest six key policy relevant lessons that policy makers and development practitioners should embrace in one way or other. First, neither the tacit learning networks associated with the mango supply chain nor codified learning networks of

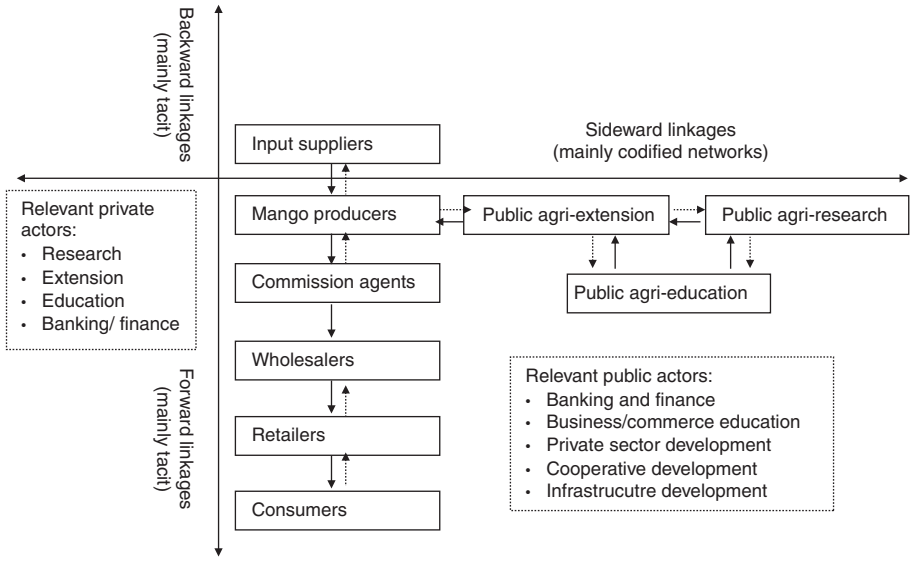

Figure 3.
Learning and innovation networks along and outside the mango supply chain

Notes: Within the networks of backward, forward and sideward linkages, solid arrows illustrate strong linkages and buthoroken arrows illustrate weak linkages. Shaded boxes on the left and right wing of the diagram respectively present private and public stakeholders that are relevant but currently weakly integrated in the learning networks

the public sector R&D organisations have been sufficient to stimulate continuous processes of innovation needed to cope with ever-changing export market demands. The current pre-occupation is mango quality for export markets, but this is just one of a series of evolving challenges. It is hard to anticipate what may come, say after another ten years. It is important, therefore, to develop dynamic learning networks of the relevant stakeholders with their technological, organisational and institutional capacities to deal with unpredictably evolving challenges and opportunities. While the export market can be more stringent, there is an opportunity to target emerging Indian supermarkets serving the growing middle class customers. New policy interventions should be provide enabling environment to connect tacit and codified learning activities that are appropriate to mango stakeholders and at the same time fit with local conditions, such as the traditional norms and values of Indian society.

Second, one element of the current problem is that well-conceived public policy to deal with quality issues is not suited to the institutional setting of the mango trade and this makes such a policy-based approach to quality inoperable. For example, the poor quality of mangoes arriving at destinations was mainly due to a short shelf-life, often determined by defective pre- and post-harvest practices, improper grading and intentional certification of lower quality fruits for export. The mango growers wish to sell all their mangos at once, regardless of quality, but exporters will buy only high-quality mangoes. Interactive learning between producers and consumers to improve the quality of mangoes to meet market requirements is lacking. A key policy principle to deal with this is to foster effective sector coordination through broad-based stakeholder collaboration.

Third, although a sector coordinating body might serve as a facility to encourage integration of tacit and codified learning networks, it cannot be effective until functional linkage policies are developed for scientific research, technology development, technology use, access to information, inputs and credits, financing innovations and marketing produce. Coordinating bodies, such as the ZREAC for research priority setting and the DAATT, which are discussed in Case study, are not enough for complex problems like the one faced by Indian mangoes. A key policy principle to bring structural as well as functional changes to foster sector coordination is to focus directly on the mango sector.

Fourth, investment in infrastructure development and technological innovations alone is obviously insufficient to achieve national competitiveness in the mango export sector. The weak or missing learning networks are undermining the capacity of the sector to innovate in response to changing circumstances, not only in the export market but also in emerging domestic markets. There is a need to integrate R&D organisations with a tacitly-operating mango supply chain, but it is not an easy task. It needs several pilot projects and institutional experiments. For example, a mango export challenge fund with specific rules about partnerships with R&D organisations could be tested to develop linkages between codified learning networks of the public sector organisations and the tacit learning networks of private stakeholders along the mango supply chain. A key policy principle to establish linkages beyond R&D systems is providing a safe niche environment to experiment with new organisational structures and institutional set-ups so that stakeholders are willing to try new things and specifically new learning networks.

Fifth, investing in long-term collaborative research, development and innovation activities is essential, but such a collaboration that operates under classic R&D projects, such as the testing of sea shipment protocol, is obviously not enough. For example, farmers had a hard time internalising the technical recommendations of the scientists, such as temperature and carbon dioxide regulations in the shipping vessels. The later phases of the project tried to incorporate and highlight the institutional issues, but the policy debates were limited to the academic community and, to a small extent, with policymakers. While the formal sector did not adequately pursue the approach, the informal sector stakeholders often remained isolated from this debate. A key policy principle to foster long-term interest in learning networks is to promote policy processes that are responsive to the prevailing production practice and shape emergent policies.

Finally, mango exporters in India involved traditional practices of supply-chain management deploying a cadre of commission agents in rural villages. Not only commission agents but also their merchants compete with each other while procuring mangoes from farmers and shipping to domestic and regional markets. In the increasingly globalised world, the main source of core national competence comes through cohesion and collaboration at the national level, but the size and diversity of India it is often blamed when this is not achieved. A key policy principle to achieve national competence is to focus on ways to promoting collective action, collective intelligence and collective learning.

6. Conclusion

Neither the codified learning networks of the public R&D organisations – technology supply chain – nor the tacit learning networks of the mango supply-chain actors have been sufficient in developing an upward spiral of learning and innovation for

sustainable development of the mango sector. The tacit learning networks of supply-chain actors that focus on produce flows are necessary but not sufficient to address basic quality issues of the importing countries. Although such networks initially appear to catalyse innovations, such as produce and market differentiation, upscaling such innovations require an integrated approach. This, coupled with an excessive focus on codified learning networks exclusively within the public R&D sector, contributes to a downward spiral of learning and innovation as the informal sector stakeholders find it difficult to engage with codified knowledge workers.

High-value agricultural sector, such as mango, particularly as long as it heavily relies on export markets, makes smallholder growers vulnerable to fluctuating international markets and international financial crises. While this paper makes a case for produce and market differentiation, including organic and fair trade mangoes for domestic markets, attention in India is optimistically diverted to develop capacity of smallholder farmers to access international markets. Unless smallholder growers are able to export their high-value produce in premium price, export promotion initiatives are not helpful for sustainable development of high-value agricultural sector. However, for many farmers identifying local and regional markets that are more accessible would be a better solution. For both approaches, developing adaptive capacity of relevant stakeholders to respond to emerging challenges and opportunities is important. Knowledge integration and mobilisation is crucial to build adaptive capacity for an upward spiral of learning and innovation at individual, organisational, network and system level. In other words, competitiveness in high-value agricultural commodities would come from capacities to innovate through a systemic integration of the supply chains of commodity and technology, not from agro-ecological comparative advantage alone.

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