

TOWARD SUSTAINABLE DEVELOPMENT OF ECONOMIC SUB-SECTORS: CASE OF INDIAN SERICULTURE

A. K. Mathur¹, Santanu Roy², Jay Mitra³

¹Planman Consulting India Private Limited

New Delhi 110 074, India

²Institute of Management Technology

Dubai International Academic City

P.O. Box 345006, Dubai, UAE

³Centre for Entrepreneurship Research

Essex Business School, University of Essex, Essex Business School, University of Essex, United Kingdom,

E-mails: ¹avinashmathur@yahoo.com; ²sroy@imt.edu; ³jmitra@essex.ac.uk

Abstract. Agricultural extension services being provided predominantly by public agencies in the developing world have contributed to quantum jumps in food production in countries like India. However, these services have failed to eliminate persistent structural poverty among a significant proportion of the farmer households. Part I of the paper summarizes generic problems that have so far persisted in the provision of agricultural extension services in various developing countries (including India) as given in the published literature. It then brings out various elements of the reform processes that are being recommended and implemented in developing country programmes by various donor agencies, like the World bank, FAO, GTZ, etc.

Part II of the paper carries out in brief SWOT analyses of the Indian silk industry. It also highlights the organization and functions of the various infrastructure of the central and state government agencies providing extension services for the sericulture industry. It then critically examines as to how this infrastructure and services are geared to mitigate the weaknesses and threats and exploit the strengths and the opportunities of the sector. Based on this the framework of extension services reforms outlined in Part I of the paper is applied to formulate recommendations on the reorganization of this infrastructure for its better cost-efficiency and effectiveness.

Keywords: Rural technology systems, agricultural extension, sericulture, India, Central Silk Board, strategic lacunae

Reference to this paper should be made as follows: Mathur, A.K; Roy, S.; Mitra, J. Toward sustainable development of economic sub-sectors: case of Indian sericulture, *Journal of Security and Sustainability Issues* 3(2): 15–30. [http://dx.doi.org/10.9770/jssi.2013.3.2\(2\)](http://dx.doi.org/10.9770/jssi.2013.3.2(2))

JEL Classifications: O3, O13, O15

PART I: APPROPRIATE TECHNOLOGY DELIVERY SYSTEMS – A REVIEW

Introduction

India's population in 2011 was over 1.21 billion representing 17.31 per cent of world's population, increasing from 1.02 billion in 2001, a growth rate of

17.64 per cent (Census of India, 2012). Going by the current population figures and the growth rate in population, the population of India is expected to cross that of China by the year 2030 (Indiaonlinepages.com, 2012). While India's population growth rate has been more or less steady over the last four decades and even declined over the last decade, the working age (15 yrs. to 59 yrs.) population has in-

creased from 227 million to 350 million to 380 million (that is, from 52% to 55% to 62%) between the years 1971, 1991, and 2000, respectively. (World Bank, 2002). It is estimated that currently about 50 per cent of India's population is below the age of 25 (Indiaonlinepages.com, 2012). According to a past estimate, India's overall ratio of rural poor to urban poor had increased from about 1.08 in the 1990 to 1.4 in the year 2000 (Datt and Ravallion, 2002).

Strategic investments are required for alleviation of poverty among the rural agricultural households. The direct anti-poverty programmes of the government may have temporarily helped the poor in getting food, etc., but have failed to raise their capacities or productive assets for earning higher incomes on sustained basis (Mukherjee, 1995).

In India the volume of investment has been increasing during the successive Five-Year Plan periods. But the use of increased capital has been considered to be either below potential and/or inefficient resulting in a commensurately low level of output – an indication of the slow rate of technological progress in the Indian agricultural and industrial economies (Thimmaiah, 1990). It has indeed been shown that additional government spending on technological up-gradation in agriculture (research and extension) has the largest impact on agricultural productivity growth, and it also leads to large benefits for the rural poor (Fan et al, 1999).

Moreover, the agriculture sector in developing countries like India are faced with several additional challenges: maintaining the food security, declining cultivated area due to population pressure, declining agricultural productivity due to soil and natural resource degradation, and increasing competition in the globalised markets. One fundamental element in meeting the challenges of the structural poverty and resource pressure is therefore raising the productivity of the land through diffusion of new technologies. This transition from a resource-based to a technology-based system of agriculture places great importance on the technology generation and extension system, being the vital source and channel of transferring the new technologies to farmers (Umali and Schwartz, 1994).

The paper probes into the rural extension service scenario in India and presents a case study of sericulture sector in India to identify the strategic lacuna in rural technology delivery systems.

Managing Transfer of Technologies for use in Rural India – A Strategic Perspective

Technology transfer could be considered to be the process by which technological innovation efforts initiated in different bodies and institutions fructify, get commercialized and contribute to the national economy. This process is not an isolated one and cannot be managed as such. However, the management of the transfer of technologies including those that are developed for use in rural and semi-urban areas is an integral component of the management of the technological innovation process. This underlines the idea that forms of technological cooperation are no longer one way but involve a longer-term mutual benefit beyond a short-term commercial success. Andersen and Lundvall (1989) have pointed out that 'learning by interacting' through technological networks has become as important as the traditional 'learning by doing' as the source for new innovations.

In an earlier study, Roy (2001) had highlighted the importance of adopting the strategy of networking in the management of innovation of technologies suitable for adaptation and use in rural India. He has presented two case studies of technology development efforts for desalination of brackish and saline water for drinking and other purposes undertaken in a particular laboratory functioning under the Council of Scientific and Industrial Research (CSIR), namely, the Central Salt and Marine Chemicals Research Institute (CSMCRI), Bhavnagar. The case studies highlight that the issue of management of transfer of such technologies goes much beyond the immediate and should take into account a whole gamut of environmental factors including government legislations as well as a whole range of economic as well as socio-cultural parameters. Planning in such a framework should elevate from the piecemeal to the integrated, which necessitates the framing up of a policy perspective for the planning process for such technologies

Problems in Delivery of Agricultural Extension Services

In India, as in most developing countries, agricultural extension programmes of the central and provincial governments remain the dominant mechanisms for technological transfer and diffusion in agriculture. These programmes have no doubt led to quantum jumps in agricultural productivity in major cereal crops in irrigated agriculture regions. However, there

have been a number of persistent problems with the agricultural extension system in India that have hampered its effectiveness in widespread agricultural development and alleviation of rural poverty. These problems, as brought out in literature have been summarised below:

Bureaucratic structure

For example, it has been found (Macklin, 1992; Rivera, 1996; and Thimmaiah, 1990) that: (a) Extension bureaucracies have developed with top-heavy and top-down approach; (b) The functionaries have revealed a bias in favour of richer farmers, as against the socio-economically weak and deprived; (c) The households located in remote inaccessible villages are conveniently neglected by the field functionaries; (d) The infrastructure, taken as a whole, is inefficient, lacks adequate resources and is spread too thinly; (e) Uniformity of instructions, preventing any flexibility in adaptation and innovation at the local level, and therefore irrelevant in many cases; etc.

Reviewing agricultural extension systems in developing countries, Rivera et al (2000) found that “government extension systems are ineffective and inefficient and have been too monolithic, heavy handed, and controlling. There is concern that governments have created extension bureaucracies that are overstaffed, have little funding for operating expenses, use unsustainable approaches, and are overly supply-driven”.

Underdeveloped Services Sector

Agricultural production is closely tied to upstream factors (namely, supply of inputs, credit, technical knowledge and training, etc.) and downstream factors (storage, marketing information, access to markets, transport, processing, etc.) and depends on adequate access to resources, goods and services. Thus, agricultural production and product processing and the services that accompany them function interdependently in economic terms. A list of key agricultural services would include (Dresrüsse et al, 1998; GTZ, 2000):

- (i) Agricultural (technical) extension and information services,
- (ii) Education and training,
- (iii) Rural financing (saving, credit) and insurance,
- (iv) Provision of market information, marketing links, and market promotion,

- (v) Input delivery services for plant/animal production (seed/genetic material, fertilisers, pesticides, irrigation water, machines/implements, etc)
- (vi) Regulatory services (testing and certification of seeds and products, quality control),
- (vii) Provision of social and technical infrastructure (transport, test centers, common processing facilities, markets, etc).

However, the extension services in India covers only the technical information and training [(i) and (ii) above]. Training and Visit (T&V) model of extension system followed in India does not cover farm input and credit supply. The provision of other services has remained largely underdeveloped, being partly and uncoordinatedly covered by the trader, and a multiplicity of line departments of the government agencies (Macklin, 1992; Feder et al, 1999). Thus there exist systemic gaps in the comprehensive provisioning of various agricultural services, hampering growth in agricultural productivity.

Fiscal deficits and Cost-inefficiency

Many developing countries, including India, have for years found it difficult to make adequate resources available for agricultural extension and other related services. For some countries, recent structural adjustments have exacerbated the situation. In India, some 20% of village extension posts are vacant at any given time, mostly in the more remote areas. About 80% of the extension budget is spent on salaries, with minimal funds for extension operations (Farrington, 1994). Thus the extension infrastructure functions sub-optimally with low returns on the investments made for extension provisioning.

Extension Reforms

Given the pivotal role they have in enhancing the productive potential of agricultural economy and for alleviation of rural poverty, agricultural extension and rural information and advisory services are likely to intensify in the foreseeable future. However, the above difficulties demand a reform of the present structure and approaches to agricultural extension. Issues regarding extension reform have been analysed in great detail by a number of experts. The related key issues, as brought out by a number of experts based on implemented reforms in a number of developed and developing countries are summarised below (Umali and Schwartz, 1994; Umali-Deininger,

1996; Rivera, 1996; Smith, 1997; FAO, 1997; Carney 1998; Feder et al, 1999):

Improving Extension Management

The World Bank sponsored Training and Visit (T&V) system of agricultural extension was implemented in 76 countries, including India (late 1970s). The system stressed that certain key features had to be preserved – professionalism, a single line of command, concentration of efforts, time bound work, field and farmer orientation, regular and continuous training, and close links with research. However, the T&V system too has not escaped some drawbacks, for example: unaffordable staff and operational budgets, neglect of poorer/remote farmers, dependence on other rural development programmes, neglect of beneficiary participation in planning and monitoring, and accountability to farmers. However, other reforms, discussed below, related to single commodity focus, concentration of efforts in more potential areas, decentralisation, and partnership with private, non-governmental and farmer organisations in delivery of services can effectively mitigate the said disadvantages with the T&V system.

Decentralisation

Decentralisation includes administrative and political-fiscal devolution of programmes, funding decisions, and staff accountability to local agencies. The effectiveness of decentralisation depends on the extent to which the central and provincial governments actually devolve fiscal and decision-making powers to the local democratically elected government. It also depends on the revenue raising abilities of the local government.

Effective decentralisation would help building local capacity for beneficiary participation in planning and monitoring, replacing the top-down approach and employing locally suited programmes. It also allows better coordination with other development programmes administered by local bodies.

Single Commodity Focus

Many public agencies (like the Central Silk Board, Rubber Board, Coffee Board, etc, in India) focus on one commercial or export crop, or one aspect of farming, such as dairying or livestock. The distinctive feature of the commodity specific extension lies in vertically integrating services for most of the components of the production and marketing systems,

including research, input supply, running common facility and testing infrastructure, product marketing, credit, crop-insurance and minimum price assurance. The single commodity focus can potentially achieve cost-effectiveness, through levies on product sales, or by factoring cost-recovery into product or input prices.

As an alternative model, agro-processing, or input supplying firms provide extension services to their farmer-clients to reduce input supply risks, reduce post harvest losses, and improve quality, quantity, and timeliness of output. Umali and Schwartz (1994) have documented a number of examples of farmers' associations and cooperative commodity ventures which provide extension services to its members.

Paid Extension Services

Some government agencies charge a fee for services to recover part of the costs. The government bears the remaining expenses for the services. This contributes to fiscal sustainability, accountability, and more professionalism and client-orientation. However, paid service extension is likely to exacerbate the generic problem of non-coverage of lower-income groups; this may also clash with political commitments for free services. Stratifying the client market by income level, and requiring progressively greater cost-sharing by higher income groups reduces both generic fiscal and liability problems, and releasing public resources for an 'extension safety net' targeted at low- to middle-income producers in priority areas. The for-fee extension services have been implemented in Mexico, New Zealand, UK, etc.

Plural Service Provision – Redefining the Role of Public Agencies

Involving a variety of stakeholders through contracts and collaborative partnerships for providing a range of extension services helps resolve problems of accountability or incentive to deliver quality service. One of the ways to get around this is subcontracting that 'gets around the institutional inefficiencies associated with public delivery' (Umali, 1997). Involving nonprofit NGOs may further improve responsiveness, cost-effectiveness, and equity in coverage.

Several principles underpin innovations in this category. First is delinking public funding from public delivery. Second, a key governance principle is to open and democratize extension control so that all

stakeholders may express their perspectives and interests, and play appropriate roles in extension design, implementation, and evaluation.

Third, with pluralism the government recognizes that to meet diverse needs and conditions in the farming sector, it should invest more broadly in the whole agricultural knowledge and information system, rather than in public sector extension services alone.

Yet another problem arises in federal governments where both a central government ministry, agency or R&D body as well as the provincial public bodies have roles in development of the same sector. In such cases (in India a number of sectors, including agriculture, sericulture, etc. are in the Concurrent List of the Indian Constitution), there appear problems of overlapping functions, lack of coordination, and invariably loss of synergy of efforts and wastage of funds. In such cases, only technology generation and transfer to state bodies and training of trainers (drawn from the provincial extension agencies, NGOs, etc.) should be retained by the central agencies. Implied in each of the above principles are significant role changes for government ministries/departments of agriculture or commodity specific agencies as they move away from service delivery toward providing an enabling policy environment, coordinating and facilitating the work of other players (emphasis original).

Recognizing that complete privatization of agricultural extension services is often not feasible, developing countries around the world have tried diverse innovative methods to address problems of fiscal sustainability and poor client orientation by integrating the private sector into extension systems. In such cases the government retains a role not only in (part) financing, but also in regulating extension providers. The methods include: *subcontracting* of extension services, *coupons* attached to agricultural bank loans committing a certain percentage of the loan for extension services, *collaborative arrangements* with the NGO and nonprofit sector including cooperative arrangements with universities, commodity boards, and commodity cooperatives or associations (Umali and Schwartz, 1994; FAO, 1997).

Beneficiary participation and empowerment

Evolving control by and participation of beneficiaries has positive effects for most of the generic problems of extension: (a) problem of scale and coverage is solved by grooming farmer leaders with appropriate

local backgrounds, including women, who are able to perform many extension agent roles in a cost-effective manner; (b) complementary services are tuned more closely to farmer needs; (c) farmer dependence on external inputs is reduced; (d) fiscal sustainability and cost-effectiveness is improved through mobilizing local resources and using relevant methods that focus on expressed farmer needs; (e) interaction with technology generation is improved through feedback into the research system.

Some decentralized, cost-recovery, subcontracting, and cofinancing arrangements followed in a number of countries compulsorily require farmers' groups as beneficiary organizations. Elsewhere, farmers' associations organized on commodity lines actually provide extension services to their members (Umali-Deining, 1996). Chamala and Shingi, (1997) have found that commodity-based farmers' organizations have been highly successful in the dairy industry in India. These groups pay great attention to monitoring and self-evaluation, have a significant impact in raising the level of trust, understanding, and links among the various actors and agencies involved in a rural situation.

Privatization

The private sector has the incentive to provide information and services to 'better-off' commercial farmers and members of private associations for whom extension service delivery is profitable. Input suppliers also have strong incentives to provide advice on a range of crop and livestock activities. However, fully privatized extension is not economically feasible in regions with a large base of small-scale, subsistence farmers. In such circumstances, public sector finance remains essential, mixed with various cost-recovery, co-financing, and other institutional partnership arrangements that are appropriate to the pace of structural and commercial changes in agriculture.

All privatization efforts report improvements in accountability, improved efficiency, cost-effectiveness, and reduced public sector costs and dependence on fiscal allocations. Incentives exist for private providers of extension to maintain close links with knowledge generation agencies in order to have a marketable product. However, stratification and separate, publicly-funded targeted programs are needed to counter this risk of neglect of poorer and remote farmers.

In this context, a list of different ways in which an extension service organization may be financed has been given by van den Ban (2000) that offers a useful check-list for the public bodies to consider different financing option for agri-services. According to him an extension organization may be financed by:

1. A government service paid for by taxpayers;
2. A government service paid for by a levy on certain agricultural products;
3. A commercial company selling inputs to farmers and/or buying their products, which in its relationship with its customers also uses extension;
4. A farmers' association which pays for extension from its membership fees;
5. A farmers' association which is subsidized by the government;
6. A non-governmental organization (NGO) which is financed by donations from inside or outside the country and/or by commercial companies for public relations purposes;
7. An NGO which is financed by subsidies from or contracts with the government (either the national or a donor government);
8. A consulting firm which charges a fee from the farmers, who are its customers;
9. A publishing firm which sells agricultural journals or other publications to farmers;
10. Different combinations of the above. For example, it is possible for a government to pay the salaries of extension agents, whilst most of the operational expenses are covered by a farmers' association, or for a commercially-oriented cooperative or input-supply company to send a farm journal to its members/customers.

Harnessing information technologies

Notwithstanding the importance of the more traditional extension methods, such as radio and television, group meetings, field days, demonstrations, and exchange visits, etc., great potential exists for innovative applications of the latest information and communication technologies (ICTs) to enhance extension delivery.

To harness its full potential requires considerable commitment, investments in information and telecommunication infrastructure, and some radical changes in perspective. One change is to lessen the reductionist, sectoral orientation in favor of a pluralist, cross-sectoral, systems perspective of a commu-

nity – for example, aiming to meet a comprehensive set of information needs of a community, which may relate to health, taxation, long distance telephony, education of children, agriculture, agro-processing, storage, marketing and commerce, various government development schemes, etc. Community communication centers (variously called internet kiosks, telecottages, or, telecenters), exemplify the new partnerships emerging for local information access, communication, and education in rural areas. The ownership and financing arrangements of these telecenters are as diverse in nature as the types of communities they serve, and the type of services they offer.

Experiences and recommendations brought from various parts of the world to a FAO sponsored workshop (FAO, 2000) indicated (among others) the following important considerations necessary for success and sustainability of telecenters:

- (a) Broad based and equitable access to ICTs requires as a pre-condition processes of decentralisation, democratization, good governance considerations honouring citizens' right to information, etc.
- (b) A high level "championing" of ICTs education and capacity building of the various stakeholders is required.
- (c) Financial sustainability of the telecenters requires investments for both, the supply of diverse information needed by the community as well as for stimulating demand for information through user education and ICT-capacity building.
- (d) The employment of particular ICT technology as well as the information content should be decided with community participation, taking into account their language, culture, information requirements, etc.
- (e) Beyond physical access, information needs to be timely, retrievable, and easily utilized by a broad range of users, accessible in their own language and consistent with their values.

In India, a number of donor driven (UNDP, ITU, etc) and government sponsored programmes for diffusion of telecenters have been initiated covering many provinces (Shanmugavelan, 2000). Thus a great opportunity exists for the various agricultural services providing agencies to harness the ICT's potential for meeting their objectives more effectively.

The Indian extension scenario

After following the T&V system of agriculture extension during the period of late 1970s to mid 1990s, and recognizing some of the inherent drawbacks in its efficacies, Indian government launched a reform drive, and the key elements of the reformed extension model currently being implemented in India (World Bank, 1998, as revealed by Ashok Kumar Seth) are being excerpted below:

Decentralization of decision-making. Much of the decision-making will be done at the district level, which, in the Indian administrative situation, is an important element.

- Developing district level strategic extension plans based on participatory techniques in which farmers are involved in assessing their needs, and then building the extension messages around those.
- Getting farmers organized into groups, ultimately into associations. Then looking for a sharing of responsibilities, so that certain functions which have been undertaken by village extension workers, for example, can be taken over by a farmer representative.
- Finding ways and means of withdrawing government's involvement in input supply activity- so that these activities can be taken over by the private sector, which is beginning to be the case already anyway.
- Bringing the private sector as a partner into the overall scheme and recognizing they play an important role in technology transfer.
- Allowing much more direct interaction between farmer organizations and the private sector without necessarily having it mediated through a public institution.
- Focusing on upgrading the skills of public employees so that they can increasingly play the role of specialist rather than being involved so heavily in much more frontline extension delivery, which can be shared with the farmers and their organizations.

'Some obstacles remain in the government public institutions – they are well entrenched, they are in a position of power, and they see themselves losing out in this process a little bit. Not only is it the fear of loss, but the fear of change as well, and therefore this whole process of education about their new role is crucial.

'The role of a new Coordinating Committees constituted is to provide policy guidance, to coordinate, to promote concepts that are being put into the projects, and to educate. The membership of that com-

mittee will include both public as well as private parties and NGOs... Working alongside them will be a Technology Dissemination Unit, which will not only coordinate implementation of project activities, but also take an important role in promoting project concerns and educating all the stakeholders.

'Among the innovative ideas of how to bring about this change is to create, at the district level, a body that will take responsibility for the overall planning and management of extension programs. The governing board of a district's program will include a cross section of persons from public institutions, research, extension, NGOs, and farmer organizations. This body would be registered as a non-profit making society so that the rules of bureaucracy would not apply as strictly.

'In order to overcome the issue of budget getting lost at the state level, the funds will be allocated directly to that society without going through the state budget. But the fact remains that the society will still be dependent upon public funds. Ultimately the goal is, that if the society is doing a good job of developing the work program and responding to the needs of farmers, it may well be in a position to generate some revenues through the services it is providing. But perhaps more important, is that it will be freer to develop partnerships with the private sector. And some cost sharing elements may begin to emerge through that process.

'It is a new experiment, therefore it needs to show that it works and is able to effectively deliver on farmers' needs. Once the credibility of the approach and the system are established, then it will become easier to begin to generate revenue through services provided as well as through developing partnerships with other agencies. But public funding will obviously continue to play a very important role even in the long-term. For a very long time to come in the Indian context, a majority of the budget will need to come from government institutions'.

PART II: THE CASE OF SERICULTURE SECTOR IN INDIA

Sericulture: An 'Appropriate' Technology for poverty alleviation

Sericulture has the potential to play a dominant role in uplifting the economic conditions of the rural poor. As an agro-based industry, sericulture fits very well in India's rural structure, where agriculture continues to be the main occupation and where farmers are constrained by increasing fragmentation of the landholding. This is because of the following unique features associated with sericulture technology [Patel, 1992, Panda, 1993]:

- (a) Labour intensive, capable of developing into a subsidiary family-level enterprise for big as well small landholders (the latter being important for subsistence farmers);
- (b) Low investment and quick returns (30-35 day cycle in silkworm rearing);
- (c) A huge domestic and international market for raw silk.
- (d) The technology is not new to most regions in India, with silk weaving traditions dating back to ancient times and spread over many states; Most Indian states have an established infrastructure and extension support services for promotion of the sector.
- (e) Mulberry plant, central to cocoon production technology can grow in almost all types of lands and even in rainfed conditions;

Recognizing the significance of sericulture, the central and state governments in India has taken a series of developmental measures to diffuse the technology far and wide in India through successive Plan periods and also through specific donor-funded projects.

What is Sericulture?

The term 'sericulture' includes the following economic activities: (i) raising food plants (in the form of mulberry plantation¹) on farms for feeding the silk-worms; (ii) production of disease-free silkworm

¹ India has the distinction of being the only country in the world which produces all four types of silk, namely, mulberry, tasar, muga and eri types. However, the mulberry silk, the commonly known silk, dominates the silk industry in India as well as internationally. The relative contribution in national raw silk production from mulberry, eri, tasar, and muga types of silk, respectively, are 92%, 5%, 2%, and less than 1% (out of total 15236 MT in 1998). For the purpose of this paper, the terms silk and sericulture refer only to mulberry type silk.

layings (dfs), eggs, or seeds – a specialized commercial activity undertaken by central and state government agencies and (only in four states) by private licensed seed producers; (iii) indoor rearing of silkworms till the stage they produce silk cocoons (about 30 day egg-to-cocoon cycle), and (iv) sale of silk cocoons produced. Silk industry, however, consists of (a) sericulture, (b) post-cocoon technology – reeling, spinning and twisting of silk yarn from the cocoons; and (c) weaving, printing and dyeing of silk cloth.

Table 1 presents the details of the commercially exploited sericigenous insects of the world and their food plants:

Table 1: Commercially Exploited Sericigenous Insects of the World

Common Name	Scientific Name	Origin
Mulberry Silkworm	<i>Bombyx mori</i>	China
Oak Tasar Silkworm	<i>Antheraea yamamai</i>	Japan
Oak Tasar Silkworm	<i>Antheraea pernyi</i>	China
Oak Tasar Silkworm	<i>Antheraea compta</i>	India
Oak Tasar Silkworm	<i>Antheraea frithi</i>	India
Oak Tasar Silkworm	<i>Antheraea proylei</i>	India
Tropical Tasar Silkworm	<i>Antheraea mylitta</i>	India
Muga Silkworm	<i>Antheraea assama</i>	India
Eri Silkworm	<i>Philosamia ricini</i>	India

Source: Central Silk Board, India
(<http://www.csb.gov.in/silk-sericulture/silk/>)

In the sections below, a brief analysis of the strengths, weaknesses, opportunities and threats (SWOT) that characterize the Indian silk industry has been carried out. The chief characteristics of the organization and functions of the various infrastructural facilities of the central and state government agencies providing extension services for the sericulture industry are then briefly highlighted. It then critically examines as to how this infrastructure and services are geared to mitigate the weaknesses and threats and exploit the strengths and the opportunities of the sector. Based on this the framework of extension services reforms outlined in Part I of the paper is applied to formulate recommendations on the reorganization of this infrastructure for its better cost-efficiency and effectiveness.

The importance of sericulture for India can also be ascertained from the following Table (Table 2) that

lists out the top 10 cocoons (reelable) producers in the world (2005 figures) – India figures at Number 2 in this Table.

Table 2: Top Ten Cocoons (Reelable) Producers - 2005

Country	Production (Int \$1000)*	Production (1000 KG)**
People’s Republic of China	978,013	290,003
India	259,679	77,000
Uzbekistan	57,332	17,000
Brazil	37,097	11,000
Iran	20,235	6,088
Thailand	16,862	5,000
Vietnam	10,117	3,000
Democratic People’s Republic of Korea	5,059	1,500
Romania	3,372	1000
Japan	2,023	600

* Official FAO Figures, production in INT \$1000 has been calculated based on 1999-2000 international prices

** Calculated Figures

Source: <http://en.wikipedia.org/wiki/Silk>

A perusal of Table 3 that the raw silk production figures from India with data from the year 1980-81 to 2010-11, it is clear that the production of raw silk in India has been rising steadily.

Table 3: Raw Silk Production (MT) in India from 1980-81 to 2010-11

Year	Mulberry	Tasar	Eri	Muga	Total
1980-81	4593	265	135	48	5041
1981-82	4801	257	147	44	5249
1982-83	5214	284	213	37	5748
1983-84	5681	418	270	54	6423
1984-85	6895	444	279	55	7673
1985-86	7029	464	352	52	7897
1986-87	7905	548	392	55	8900
1987-88	8455	463	522	58	9498
1988-89	9683	358	565	45	10651
1989-90	10805	465	589	57	11916
1990-91	11486	380	624	70	12560
1991-92	10658	329	704	72	11763
1992-93	13000	382	726	60	14166
1993-94	12550	299	766	76	13691

1994-95	13450	257	798	74	14579
1995-96	12884	194	745	86	13909
1996-97	12954	235	864	73	14126
1997-98	14048	312	814	62	15236
1998-99	14260	242	970	72	15544
1999-00	13944	211	974	85	15214
2000-01	14432	237	1089	99	15857
2001-02	15842	249	1160	100	17351
2002-03	14617	284	1316	102	16319
2003-04	13970	315	1352	105	15742
2004-05	14620	322	1448	110	16500
2005-06	15445	308	1442	110	17305
2006-07	16525	350	1485	115	18475
2007-08	16245	424	1530	117	18320
2008-09	15610	603	2038	119	18370
2009-10	16322	803	2460	105	19690
2010-11(P)	16957	1166	2760	122	21005

Sources: Annual Reports of Central Silk Board, India for the Financial Years 1980-81 to 2010-11

However, as per 2009 figures (Table 4), India’s contribution to world raw silk production was only 15.5% as compared to China’s 81.89% (Varmudy, 2011). It is also clear from the following Table that Mulberry silk forms the overwhelming bulk of all raw silk production throughout the world. It is for this very reason that in this paper the analysis of silk and sericulture refers only to mulberry silk.

Table 4: World Raw Silk Production (MT) 2009

Country	Mulberry Raw Silk	Per Cent in Total	Total Raw Silk	Per Cent Share of Country
China	84,000	80.77	104,000	81.89
India	16,322	82.89	19,690	15.50
Brazil	811	100	811	0.65
Uzbekistan	750	100	750	0.59
Thailand	665	100	665	0.53
Vietnam	550	100	550	0.44
Korea Republic	135	100	135	0.10
Japan	90	100	90	0.07
Others	304	100	304	0.23
Total	103,637	81.60	126,995	100

Source: http://www.ffymag.com/admin/issuepdf/17-22_silk_dec11.pdf

SWOT Analysis of Indian Silk Industry

Strengths of the Indian silk Industry: (a) A large and expanding domestic production base spread over almost all the states exists in India. India's production of raw silk has grown from 11,486 MT in 1991, about 15,000 MT in 2000-2001, and about 21000 MT in 2010-2011 (Table 3) – currently being number two in the world, next only to China. (b) In spite of stiff competition from mainly China in the high volume, low priced every day wear, readymade markets, India has the ability to offer the high value, low volume items of craft value and having a great variety that have markets in US, West Europe and almost all other continents. (c) About 85% of national raw silk production is consumed by the domestic *sari* market – offering a steady and assured demand to domestic sericulture and acting as a buffer to international fluctuations in silk industry.

Weaknesses of the Indian silk industry: major weaknesses lie in the sub-optimality and skewed productivities in various regions, and a partial dependence on import of the superior bivoltine silk yarn used as warp in the silk weaving industry and export of silk cloth and made ups. In this respect the following is noteworthy: (a) ***Skewedness in contribution by different practicing states:*** Whereas mulberry sericulture is practiced in 21 states in India, Karnataka alone contributed nearly 46.4% in 2009-09 and 45.1% in 2009-10 (Table 5). The five traditional states (Karnataka, AP, TN, WB, and J&K) together contribute 96.4% (in 2008-09) 96.7% (in 2009-10) to the total national raw silk production. The mulberry raw silk production in the country is largely multi-bivoltine cross-breed type in contrast to the superior, bivoltine raw silk, which is traded in international markets.

(b) ***Skewedness in contribution by different practicing districts in each State:*** The picture of skewedness in the proportion of contribution by states is also repeated in different sub-regions within each state. Statistics (not given here) shows that whereas sericulture is practiced in 20 to 40 districts in each state, 70-90 % contribution comes from 3 to 8 districts only.

(c) ***Skewedness in Farm Productivity:*** The cocoon productivity per unit area of mulberry plantation varies very widely among states – from 10 kg/ha in Nagaland to 651 kg/ha in AP (at the gross state level). The three leading states in high productivity are Andhra Pradesh (651 kg/ha), West Bengal (646 kg/ha), and Tamil Nadu (601 kg/ha). What is distressing is that

as many as 12 states have unit area productivity falling below 100 kg/ha. These field achievements may be contrasted with the Chinese achievement of 2000-2200 kg/ha.

(d) ***Weaknesses in the non-farm areas:*** Half of the cocoon reeling sector (which produces silk yarn) capacity in India is still dominated by the traditional *charkha* devices, which are characterized by lower quality and productivity in raw silk. At the national level there appears to be an acute shortage of warp quality raw silk (which is partly met from imports) obtainable from the improved cottage basin machines (constituting only 40% of the national reeling capacity at present) and multi-end reeling machines (10%). India is losing precious foreign exchange by importing raw silk, yarn and fabrics (ref: Table 6 below) to cope up with this weakness.

Table 5: State-Wise Mulberry Raw Silk Production in India (MT)

	2008-09	2010-11
A (Traditional States)		
Karnataka	7238	7360
Andhra Pradesh (AP)	4492	5119
Tamil Nadu (TN)	1411	1233
West Bengal (WB)	1809	1865
Jammu and Kashmir (J&K)	102	110
Sub-Total (A)	15052	15687
B (Non-Traditional States)		
Assam	15	16
Arunachal Pradesh	4	3
Bihar	9	16
Chhattisgarh	5	9.7
Himachal Pradesh	22	20
Jharkhand	1	3
Kerala	20	22
Madhya Pradesh	96	95
Maharashtra	200	218
Manipur	96	101.5
Mizoram	9	16.5
Meghalaya	2	5.2
Nagaland	2	3.4
Orissa	4	8.8
Punjab	4	5.3

Rajasthan	1	1.55
Sikkim	1	3
Tripura	8	12.5
Uttarakhand	17	14
Uttar Pradesh	42	60.45
Sub-Total (B)	558	635
Grand Total (A+B)	15,610	16,322

Source: http://www.ffymag.com/admin/issuepdf/17-22_silk_dec11.pdf

Table 6: India's Import of Raw Silk, Yarn and Fabrics (in Million \$)

Items	April-March 2010-11	April-March 2011-12
Raw Silk	203.60	232.05
Natural Silk Yarn	46.29	28.09
Silk Fabrics and Made-Ups	134.03	79.93
Total	383.92	340.07

Source: Central Silk Board, India (<http://www.csb.gov.in/statistics/silk-exports-and-imports/total-import/>)

Opportunities: A supply-short environment of raw silk, increasing demand world-wide, and a relatively developed domestic industry offer great opportunities for growth and expansion of this agro-based industry, and therefore for poverty alleviation in potential areas. This is evidenced from the following trends: (a) The world's total raw silk production had declined from 95,980 MT in 1993 to 86,812 MT in 1996, and increased over the last decade to 126,995 MT in 2009. There exists an aggregated shortfall in raw silk supply against demand at international level. In the domestic market, the demand exceeds production met by imports from China. (b) The demand for silk goods has been increasing steadily around the world depending on the region of the globe. Apart from the fashionable items of higher value, there has been a great spurt in the production and demand of silk garments of everyday use, sports wear, home textiles, knit-wears, etc., all around the world. (c) The production of raw silk in China has been quite stagnant over the years. (d) *India's export* of silk goods contributes significantly to the country's coffers as per Table 7 shown below. However, the latest trend shows that there has been a slight decline in India's export earnings in the year 2011-12 as compared to

the previous year.

Table 7: Total Export Earnings of Silk Items (in Million \$)

Item-Wise Export	April-March 2010-11	April-March 2011-12
Natural Silk Yarn	8.65	3.76
Fabrics, Made-Ups	457.38	194.28
Readymade Garments	149.98	264.42
Silk Carpet	4.63	4.01
Silk Waste	7.93	10.39
Total	628.57	476.86

Source: Central Silk Board, India (<http://www.csb.gov.in/statistics/silk-exports-and-imports/total-export-earnings/>)

Threats to the sericulture/silk industry are posed from (a) the post-WTO, liberalized trade regimes whereby cheap raw silk may be dumped in India from countries like China, Brazil, Korea, rendering sericulture unattractive for the farmers; (b) the increasing fiscal deficits being faced by the central and state government promotional agencies threatening the fiscal sustainability their support infrastructure and programmes and services.

Public Infrastructure for Research and Extension in Sericulture

Sericulture forms part of the Concurrent List of the Indian Constitution. Public infrastructure for promotion of sericulture in India, therefore, exists at two levels: a central agency, namely, the Central Silk Board (CSB), currently functioning under the central Ministry of Textiles; and the state level Directorates of Sericulture².

THE CENTRAL SILK BOARD INFRASTRUCTURE

The Central Silk Board was established by an Act of Parliament in 1948 to take control of the then fledgling silk industry. However, with increasing Plan allocations, and particularly after a World Bank aided project (1989-96), its infrastructure has undergone a massive expansion. Currently, it has the following

² In states where sericulture production levels are low, the promotional functions have been put under the Ministries/Departments of Textiles, Small Scale Industries, Handlooms, etc. (like in Gujarat, Punjab, Himachal Pradesh, etc.)

units under its direct fold:

I. RESEARCH, REGIONAL RESEARCH & RESEARCH EXTENSION

On-Farm (pre-cocoon) Technologies

- Research Institutes (6): Mulberry Silk–3, Tasar–1, Muga–1, Eri–1.
- Regional Research Stations (21): Mulberry Silk–12, Tasar–8, Muga & Eri–1.
- Research Extension Centres (62): Mulberry Silk–46, Tasar–10, Muga & Eri–6.
- Sericulture Training Schools (13)
- Extension Centres (46)

Off-Farm (post-cocoon) Technologies

- Research Institute (1)
- Demonstration/Training/Service Centres (21) (Mulberry Silk–12, Tasar–9, Muga & Eri–1)

II. MASS PRODUCTION OF SILK-WORM EGGS (SEEDS)

- Basic (parental) Seed Production Farms (57) – Mulberry Silk-worm (26), Tasar Silk-worm (23), Muga & Eri Silk-worm (8)
- Commercial Seed Production Centres (27) – M Mulberry Silk-worm Seeds (24), Tasar (nil), Muga & Eri (3)

III. INDUSTRIAL SERVICES

- Silk Conditioning & Testing Houses (5)
- Eco-Testing Laboratories (4)
- (Export) Certification Centres (2)
- Common Facility Centre (1)

THE STATE GOVERNMENT INFRASTRUCTURE

Karnataka and Andhra Pradesh are the only states having their own R&D Institutes for sericulture. The main infrastructure common under each of the state governments (except a few) includes:

- Commercial Silkworm Seed Production Centres;
- Extension Centres for transfer of new technologies, input (eggs, disinfectants) supplies;
- Reeling Training and Farmer Training Schools
- Market Infrastructure for government monitored sale of cocoon and raw silk.

Organization of Infrastructure and Services *versus* Sector Characteristics

As shown in Table 5, The sericulture development in India has been highly skewed. Whereas five states – Karnataka, Tamil Nadu, West Bengal, Andhra Pradesh, and Jammu and Kashmir (called the traditional states, or TS) – contribute overwhelmingly to the national raw silk production, another 19 states (called the non-traditional states, or NTS) together contribute only a fraction of the total production.

Increasing Plan allocations and the emphasis laid on the sector, and particularly during the implementation of a World Bank (and Swedish Devpt. Corpn.) aided project (1989–1996), the extension infrastructure of the Central Silk Board and the state government directorates expanded rapidly. The infrastructure added included, extension centers, centers for mass production of parental and commercial grade silkworm seeds, technology demonstration and training centers. This also strengthened the CSB research institutes and the regional research stations located in different agro-ecological regions of the country. It is noteworthy that the extension infrastructure under Central Silk Board was added in parallel to that already existing or added infrastructure under the state govts. The spatial distribution of the infrastructure included all the TS and the NTS. The premise was that after an initial and decisive fillip is given for growth and expansion of sericulture, the CSB infrastructure would be taken over by the state governments. However, none of the states have actually taken over the CSB extension infrastructure (barring that the TS have taken over some of the extension centers), as the concerned directorates/departments in the states did not have an assured fund allocation for the maintenance of the same.

The above developments have placed the CSB and the state government directorates in a mix of advantageous and disadvantageous situations from the point of view of the growth of sericulture and the financial sustainability of the extension infrastructure. These have been summarized below:

(a) CSB well placed for technology generation/transfer and advisory role for states: CSB is well equipped for formulation of unified national strategies / policies and Plans, providing consultancy for state-level strategy formulation, providing coordination required for implementation of various state-, national-, and

international - level programmes; It also has an adequate research infrastructure and has developed a good stock of technology packages (and capacity for transferring them to the states) for higher productivity and quality in the pre- and post-cocoon areas for all regions and seasons. These capabilities are auger well to exploit the strengths and opportunities presented by the international and national silk industries.

(b) Rapid Area expansion but poor linkages: Consequent to the World Bank project, CSB, through its own efforts and extension infrastructure, rapidly expanded mulberry area plantation in the country (by 25,000 ha). However, after an initial expansion, there was a substantial uprooting of mulberry plantations, particularly in all of the NT states. This was mainly due to the facts that:

(i) The capacity of the state governments to carry on the extension work after the withdrawal of the CSB was not developed.

(ii) The up-market post-cocoon industrial sector, like reeling, weaving, which place demand on the products of sericulture and therefore encourage its growth, was highly underdevelopment, if not absent, in the new areas;

(iii) The new reeling machines developed by CSB and sought to be diffused among entrepreneurs (through the technology demonstration and training centers) for providing up-market demand for sericulture, required high investments and year round supply of raw material to be viable.

(iv) The newer sericulture areas in the non-traditional states were mostly rain-fed areas with the farmers mostly practicing subsistence agriculture, and therefore not in a position to invest in the building and equipment prescribed under the technology package. The regional research stations located in these regions also failed to develop appropriate silkworm rearing equipment which would suit the peculiar characteristics of the local entrepreneurs. This has resulted in comparatively low productivities, seriously hampered growth of sericulture and the up-market reeling sector, and contributed to the highly skewed development of sericulture in the country as a whole (Mathur, 1995).

(c) Poor Financial Viability of Commercial Silkworm Seed Production Centers: The commercial silkworm seed production centers (24 in no.) were established to give an initial fillip to the sericulture sector by producing quality disease free eggs of the developed supe-

rior races of silkworm, which form important inputs to sericulture. These centers were mandated to were required to maintain strict financial discipline by recovering its costs (including establishment, operating, and depreciation of plant and building) through the price mechanism. However, each of these centers has so far been running in a net loss due to typically high establishment expenditures and poor financial discipline associated with public infrastructure.

(d) Duplication of activities between CSB and state directorates: From a comparative geographical mapping of support infrastructure spread over different states and running under CSB and the state level directorates, and from the comments received from the state govt. directorates of sericulture on the utility of CSB infrastructure located in their respective states (particularly in traditional states), it was found that there exists heavy duplication of extension activities – including production and sale of commercial silkworm seeds, technology diffusion, training of farmers and reelers, etc.

(e) Undue Centralised Bureaucracy and Control within CSB: The CSB's Institutions, regional stations, and centers (numbering about 400 in total and spread throughout the country) presently operate in an environment of undue control and very limited freedom. For example, for every item of purchase or expenditure beyond Rs.2,000 (till 1999) an Institute or its sub-unit has to seek scrutiny and sanction of CSB HQ. Similarly, all new as well as ongoing research projects being carried out in all the Institutes and stations of CSB are reviewed quarterly by the Headquarters in spite of the respective Research Advisory bodies. The pre-cocoon research and extension, the post-cocoon research and extension, and the silkworm seed production organisations of CSB also function in vertically compartmentalized controls – resulting in lack of integrated development of various components of the sericulture sector of any region. This invariably results in bureaucratic delays, lack of flexibility required to meet the local conditions, and poor coordination with the state directorates and other local authorities and R&D laboratories.

(f) Poor Sustainability and Development of Partnerships: Serious efforts for development of partnerships in the provision of extension services, and privatization of mass production of silkworm seeds, have not been undertaken by either the CSB or the state directorates. In most of the states (except in some of the traditional

states like Karnataka, TN, and AP), even nurseries for the mulberry plants and the young-age silkworms (*chawki farms*) are owned and run by the state govt. directorates. This has resulted in ever-increasing demands on budgets, very high proportion of establishment expenditures (as much as 70-80%), and serious concerns on sustainability of the support infrastructure.

Recommendations on Reform of Extension Infrastructure and Services

The framework and principles that underpin the reform processes of extension services, brought out in Part I of the paper are utilized below to formulate recommendations that are likely to remedy the set of lacunae in skewed development of sericulture in the country, as well as in the organization of the extension infrastructure and services under the CSB and the state government directorates.

(a) Improving Extension Management: There is need for better feedback from the field to the research system in case of dry-land regions inhabited by poor farmers, so that proper efforts are made for development of more suitable technology packages. This would lead to better productivities, wider diffusion of sericulture, and help development of up-market reeling sector. Also suitable reeling machines need to be developed which require lower investments and adoptable by poorer entrepreneurs in these regions.

(b) Decentralisation: The CSB needs to devolve administrative and financial authority to its regional centers and research Institutes. It must allow the regional offices to develop partnerships with state-level governments departments, district and village bodies, NGOs, farmer organisations, entrepreneurs, etc to draw up integrated plans for development of forward and backward linkages. It must also bring about a better role clarity in its functions, namely, (i) It must confine itself to technology generation and transfer to state level functionaries, NGOs, and private entrepreneurs, and divest the infrastructure and extension activities meant for end-beneficiaries. It must also have better coordination and role division with the state sericulture directorates, which are in a better position to understand the local conditions and coordination with the local actors.

(c) Privatization: A substantial proportion (50-60%) of silkworm seed production is being carried out by licensed producers in the traditional states. These

producers also extend credit and quality control facilities to the sericulturists. However, the balance demand is met by commercial silkworm seed production centers under the CSB and the state directorates. These are inherently unviable financially due to bureaucratic controls and high establishment costs. The production activity (if not the entire infrastructure) must be transferred to private entrepreneurs under suitable incentive schemes and contractual arrangements, so as to maintain quality and production levels, etc. Suitable partnerships can also be developed with them for rendering extension services, etc.

(d) Plural Service Provision and Beneficiary participation: So far the mentioned central and state agencies have more or less a monopoly in the provision of extension services. Efforts must be made to develop alternative service providers from the NGO, private and cooperative sectors. Sericulture cooperative societies must be encouraged and trained for commercial operation of nurseries, providing extension to their members (perhaps with part financing by the govt.). Synergistic partnerships must be forged with the regional rural banks (and micro-finance institutions), who are spearheading the current movement in formation of credit related self-help groups, for provision of credit and insurance facilities to sericulture cooperative societies. The private commercial silkworm seed and disinfectant manufacturers and NGOs may be provided incentives and partial financing for providing various extension services.

(e) Harnessing information technologies: The CSB and state governments must take advantage of the recent spread of telecenters movement in India to develop alternative modes of extension delivery. Telecenters covering information services for sericulture and/or reeling/weaving sectors may be given initial support in the form of capital, information content etc. Internet links to dedicated websites of the government and manufacturers associations can help get instant information on market prices of cocoons/raw silk in urban centers, technology packages, supply of inputs, traders, etc. These possibilities, however have to be explored in conjunction with recommendations on privatization, developing plural service provision, etc.

Conclusions

Utilizing the published literature, efforts have been made to synthesize in one place various develop-

ments in extension reforms in various parts of the developing world and as recommended by the International donor agencies like, the World bank, FAO, GTZ, etc. This has resulted in a set of underpinning principles that must guide the reform process for extension services in any agro-sector. Attempt has been made to apply this framework to sericulture sector in India, taking into account an earlier available SWOT analysis for this sector. It is hoped that the set of recommendations formulated for sericulture, along with the reform principles enunciated, would be useful for applications to other agro-based sectors which are facing more or less similar problems.

References

- Andersen, E.S. and Lundvall, B.A. 1989. Small National Systems of Innovation Facing Technological Revolutions: An Analytical Framework, in Freeman, C. and Lundvall, B.A. (eds.), *Small Countries Facing the Technological Revolution*, 9-36, Frances Printer, London.
- Census of India .2012. Available on the Internet: < http://www.censusindia.gov.in/2011-prov-results/data_files/india/Final_PPT_2011_chapter3.pdf>.
- Datt, G. and Ravallion, M. 2002. Is India's Economic Growth Leaving the Poor Behind?, *Policy Research Working Paper Series*, May, World Bank.
- Dodgson, M. and Hinze, S. 2000. Indicators Used to Measure the Innovation Process: Defects and Possible Processes, *Research Evaluation*, 8(2): 101-114.
- Dresrüsse, G. et al. 1998. *Rethinking Agricultural Service Policy*, German Technical Cooperation (GTZ), Eschborn.
- Fan, S. 1999. Linkages Between Government Spending, Growth, and Poverty in Rural India, *IFPRI Research Reports*, International Food Policy Research Institute, Washington, D.C.
- FAO.1997. *Improving Agricultural Extension: A Reference Manual*, Food and Agricultural Organisation of the UN, Rome.
- FAO .2000. The Role of Information and Communication Technologies in Rural Development and Food Security, *COAIM and ICT Workshop*, Sustainable Development Department, FAO, Rome.
- Farrington, J. 1994. Public Sector Agricultural Extension: Is there Life after Structural Adjustment?, *Natural Resource Perspectives No. 2*, November, Overseas Development Institute, UK.
- Feder, G.. 1999. Agricultural Extension: Generic Challenges and Some Ingredients for Solution, *Policy Research Working Paper 21129*, The World Bank.
- GTZ .2000. Agricultural Services – New Challenges for Rural Capacity Development, *Summary of Proceedings on 'Services for Rural Development'*, German Technical Cooperation (GTZ).
- Indiaonlinepages.com. 2012. Available on the Internet: <<http://www.indiaonlinepages.com/population/india-population-2011.html>>
- Liyanage, S. 1995. Breeding Innovation Clusters through Collaborative Research Networks, *Technovation*, 15(9): 553-567.
- Maccoby, M. 1997. Learning to Partner and Partnering to Learn, *Research Technology Management*, May-June: 55-57.
- Macklin, M. 1992. Agricultural Extension in India – Past Present and Future, *World Bank Technical Paper No. 190*, The World Bank, Washington DC.
- Mathur, A.K. 1995. *Determinants of Adoption & Productivity of Rural Technology: Case of Sericulture Technology in Dehradun District (U.P.)*, Ph.D. Thesis, Centre for Rural Technology & Development, Indian Institute of Technology, Delhi.
- Mathur, A.K.; Mehra, K., and Jain, A. 1999. *Identification of Steps for Optimum Utilisation of Infrastructure and Manpower of Central Silk Board*, Report of a Consultancy Project assigned by Ministry of Textiles, GOI, National Institute of Science Technology and Development Studies, New Delhi.
- Mukherjee, N. 1995. Why Our Poverty Alleviation Programmes Fail to Benefit the Poor, *Kurukshetra*, May-June: 41-42.
- Nelson, R.R. 1993. *National Systems of Innovation*, Oxford University Press, New York.
- Niosi, J. 1999. The Internationalization of Industrial R&D – From Technology Transfer to the Learning Organization, *Research Policy*, 28: 107-117.
- Panda, S.K. 1993. Scope of Mulberry Sericulture in New Areas, in 'Sericulture Development in Non-Traditional Areas', BAIF, 86-94, Pune.
- Patel, K.V. 1992. Sericulture: An Instrument of Change, Some Grassroot Level Lessons, *Indian Silk*, July: 24-35.
- Peters, L., Groenewegen, P. and Fiebelkorn, N. 1998. A Comparison of Networks between Industry and Public Sector Research in Material Technology and Biotechnology, *Research Policy*, 27: 255-271.
- Repetto, R. 1994. *The 'Second India' Revisited: Population, Poverty and Environmental Stress over Two Decades*, World Resources Institute, Washington D.C.
- Rivera, W.M. 1996. Agricultural Extension in Transition Worldwide: Structural, Financial, and Managerial Strategies for Improving Agricultural Extension, *Public Administration and Development*, 16:151-161.
- Rivera, W.M., Zijp, W. and Alex, G. 2000. *Contracting for Extension – Review of Emerging Practices: A Good Practice Note*, Agricultural Knowledge & Information Systems (AKIS), The World Bank.
- Rosenberg, N. 1982. *Inside the Black Box: Technology and Economics*, Cambridge University Press, Cambridge.
- Roy, S. 2001. Networking Strategies for Innovative Technologies in Rural India, *Journal of Rural Development*, 20(4): 693-710.
- Shanmugavelan, M. 2000. Information Technology (IT) in Developing Nations, *Intermedia*, 28 (1).
- Smith, L.D. 1997. Decentralisation and Rural Development: The Role of the Public and Private Sector in the Provision of Agricultural Services, *Technical Consultation on Decentralisation*, FAO, Rome.

A. K. Mathur, Santanu Roy, Jay Mitra
Toward sustainable development of economic sub-sectors: case of indian sericulture

Thimmaiah, G. and Hadimani, R.N. 1990. India: Case Study, in Campbell, M.J. (ed.), *New Technology and Rural Development: The Social Impact*, 37-115, Routledge, London.

Umali, D. L. and Schwartz, L. 1994. *Public and Private Agricultural Extension: Beyond Traditional Frontiers*, The International Bank for Reconstruction and Development, The World Bank, Washington DC.

Umali, D.L. 1996. New Approaches to an Old Problem: The Public and Private Sector in Extension, *Extension Workshop: Alternative Mechanisms for Funding and Delivering Extension*, World Bank, Washington DC.

World Bank .1996. Agricultural Research and Extension: Lessons from China, *Précis Number: 108: Operations Evaluation Department*, World Bank, Washington.

World Bank .1998. *Changing Extension Institutions: India*, An Interview with Ashok Kumar Seth, Principal Agricultural Specialist, SASRD, February. AKIS Discussion Paper, The World Bank, Washington DC.

World Bank .2002. *World Development Report 2002*, World Bank, Washington DC.