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Focus : Women and Development

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Contents

Asian Rural Women & Water Resource Management

Hana Kobayashi & Revathi Balakrishnan

Today a common shared understanding is emerging on the importance of involving women in all levels of water management. Yet realising this goal remains elusive. In Asia, rural women's contribution to the agriculture sector and rural production are pivotal to food security and water is an indispensable productive resource for farm and domestic production. This paper presents a framework on gender roles in water resource management and associated concerns on access and rights. It also highlights the situation of power relations in water resource management. Suggestions are presented to narrow the gaps between stated intentions and actual practice to advance Asian rural women's participation in water resource management for ensuring food security.

Hana Kobayashi is Associate Professional Officer & Revathi Balakrishnan is Senior Officer, Gender and Development, FAO Regional Office for Asia and the Pacific.

Water is a resource that is essential for achieving food security, at the farm level for production and at the home level for processing food and sanitation and health. Yet, grave concerns are emerging in relation to availability and access to freshwater. The World Summit for Sustainable Development (WSSD, 2002) held in Johannesburg reported that, currently 1 billion people lack access to safe water and 2 billion lack access to proper sanitation facilities; 6000 children are dying everyday from water-borne diseases. It is predicted that by 2025, half of the world population will face water shortage. The great majority of the people who are affected by this situation live in rural areas in developing countries, including Asia. Even among them, rural women and girls are the ones who have to bear the drudgery of securing water for their families.

Despite women being the primary stakeholders in water management and providers of labour for agriculture, their concerns are rarely reflected in water resource management decisions. It is well documented that women's representation in formal water resource management bodies has been minimal. Experiences from various projects and programmes implemented, and dialogues in conferences and meetings have highlighted the importance of involving women at all levels of water management, and the importance of their involvement has been commonly recognised by the international development community. However, when it comes to actual implementation, there still exist huge gaps in creating space for women in water resource management bodies.

This paper argues issues on women's access to water as a productive resource. Specifically, it discusses how water is an essential productive resource for farm households and women's role in mediating the access to water in farm and home production. First, it examines the critical points raised by the international development community about integrating rural women into water resource management and highlight relevant

commitments related to women and water resource management. It then presents an overview of gender differentiated water resource management and illustrates the complexity of rural women's water use. It argues that women not only play important roles in domestic water management use but are involved in a wide range of productive activities that use water to secure food and health for the family. Discussion focuses on major initiatives of projects and programmes to integrate women into water resource management and explore its limitations. Finally, it concludes with suggestions for improving rural women's right and access to water resource.

Emerging Issues on Water and Rural Women

Degradation of water resources in the region

Population growth is one of the main reasons for pressuring the precious water resources. Between 1940 and 1990, world population has doubled and simultaneously, per capita use of water has also doubled. This indicates that globally, water use has increased by more than four times in the past half century (Clarke, 1993). In Asia per capita water usage is highest with 60% of the world's population using only 36% of the world's water resources (UN, 2003). Industrialization and urbanization are also other factors for the water crisis, demanding more water for economic development, energy production and increase in food demand. At the same time, economic development has degraded water quality in rivers, lakes and groundwater resources due to contamination by pollutants (Population Action International, NA). More over, manmade greenhouse gas generated by burning fossil fuels and deforestation has resulted in global warming and abnormal weather. As a consequence, freshwater ecosystems that provided water supply, water purification, flood control, recycling and transport of nutrients, fish production and protection of biodiversity has become scarce (UN Department of Economic and Social Affairs, 2002).

Most severe impact can be seen in the agriculture sector where 75% of the world's freshwater is used (Gender and Water Alliance, 2003). As shown in Table 1 the agriculture sector's contribution to the Gross Domestic Product (GDP) is significant in many countries in the region. Agriculture sector's contribution is as low as 8.4% and 8.6% in Malaysia and Thailand which qualify as industrializing countries. This is much higher in Myanmar 57.1% which is placed under the category of Southeast Asian country in transition. Countries such as Bhutan, Cambodia, Lao PDR, Mongolia, Myanmar, Nepal and Uzbekistan continue to derive more than third of the GDP from agriculture. In countries such as Bangladesh, India, Pakistan, Tajikistan, and Vietnam about a quarter or more of the GDP is derived from agriculture. The situation will get severe as FAO reports that global food production needs to increase by 60% to close nutrition gaps and cope with the population growth over the next three decades (FAO, 2002).

Table 1: Agriculture Sector Contribution to GDP in Asian Countries (percentage)

Countries	2001
Afghanistan	--
Bangladesh	23.3
Bhutan	36.8
Cambodia	39.2
China PRC	15.2
India	24.7
Indonesia	16.4
Japan	--
Kazakhstan	8.7
Korea Republic of	--
Lao	51.3
Malaysia	8.4
Maldives	8.8
Mongolia	26.0
Myanmar	57.1
Nepal	38.6
Pakistan	25.0
Philippines	15.1
Sri Lanka	19.4
Tajikistan	24.4
Thailand	8.6
Uzbekistan	34.5
Vietnam	24.3

Low Income Food Deficit Countries
http://apps.fao.org/notes/876-e.htm
Source: Asian Development Bank, Key Indicators, 2002. Page 57.

Similarly, percentage of agriculture within annual freshwater withdrawals in the region is very high as shown below in Figure 1. Compared to industry and domestic withdrawals, in most of the countries, agriculture water use is over 90%. In some cases like in Afghanistan and Nepal, agriculture withdrawals reach up to 99%, indicating that it would be very important to achieve greater efficiency in water use to meet future challenges.

With reference to gender, the relative ranking of the countries in the region on Human Development In-

Table 2: Relative Status of Human Development and Gender Development with sanitation and water supply coverage in Asian Countries

Countries	Human Development Index: Rank		Gender Related Development Index: Rank	% of sanitation coverage		% of water supply coverage	
	Category	Ranking		Total	Rural	Total	Rural
Afghanistan	--	--	--	12	8	13	11
Bangladesh	LOW	145	121	53	44	97	99
Bhutan	LOW	140	NA	69	70	62	60
Cambodia	MEDIUM	130	109	18	10	30	25
China PRC	MEDIUM	96	77	38	24	75	66
India	MEDIUM	124	105	31	14	88	86
Indonesia	MEDIUM	110	91	66	52	76	65
Japan	HIGH	9	11	--	--	--	--
Kazakhstan	MEDIUM	79	NA	99	98	91	82
Korea Republic of	HIGH	27	29	63	4	92	71
Lao	PDR	LOW	143	118	46	34	90
Malaysia	MEDIUM	59	54	--	98	--	94
Maldives	MEDIUM	84	68	56	41	100	100
Mongolia	MEDIUM	113	95	30	2	60	30
Myanmar	MEDIUM	127	106	46	39	68	60
Nepal	LOW	142	119	27	20	81	80
Pakistan	LOW	138	120	61	42	88	84
Philippines	MEDIUM	77	63	83	71	87	80
Sri Lanka	MEDIUM	89	70	83	83	83	80
Tajikistan	MEDIUM	112	94	--	--	--	--
Thailand	MEDIUM	70	60	96	96	80	77
Uzbekistan	MEDIUM	95	76	100	100	85	78
Vietnam	MEDIUM	109	89	73	70	56	50

Low Income Food Deficit Countries

The coverage figures produced by technology indicators do not provide information about the quality of the water provided or about its use. Furthermore, factors such as intermittence or disinfection could not be taken into account in the coverage figures. (Gender and Water Alliance, 2003).

Source: UNDP, Human Development Indicators: Human Development Report 2001. Pages 149-152 and 222-225.
The Gender and Water Development Report 2003, Annex 2. Pages 98 to 100.

dicators (HDI) and Gender-related Development Indicators (GDI) and Food Security status illustrates diversity and disparity in gender equality gain as shown in Table 2. It is evident that those countries, which are low and medium achievers in HDI and GDI, are also predominantly represented under the Low-Income Food Deficit Countries (LIFDC) as seen in Bangladesh, Cambodia, Lao PDR, Nepal and Pakistan. In contrast, Japan and Republic of Korea rank high in HDI and GDI.

It is interesting to see the association between GDI and coverage of total sanitation and water supply. It can be said that most of the countries with low GDI have low sanitation and water supply coverage. HDI includes health related indicators and it is safe to assume that there is a link between poor sanitation and lower life expectancy. In rural areas, many countries with low GDI have less than 50% sanitation coverage with 8 countries falling below 20%. A similar link can be made between water supply coverage in rural areas with nine countries providing less than 70% adequate water supply. Since data is not segregated by gender, direct links cannot be made but it provides a broad view of the sanitation and water supply situation faced in rural areas, especially with reference to women (Gender and Water Alliance, 2003).

International Development Initiatives on Water Resources

The UN conferences and conventions have been emphasising the importance of water resource for sus-

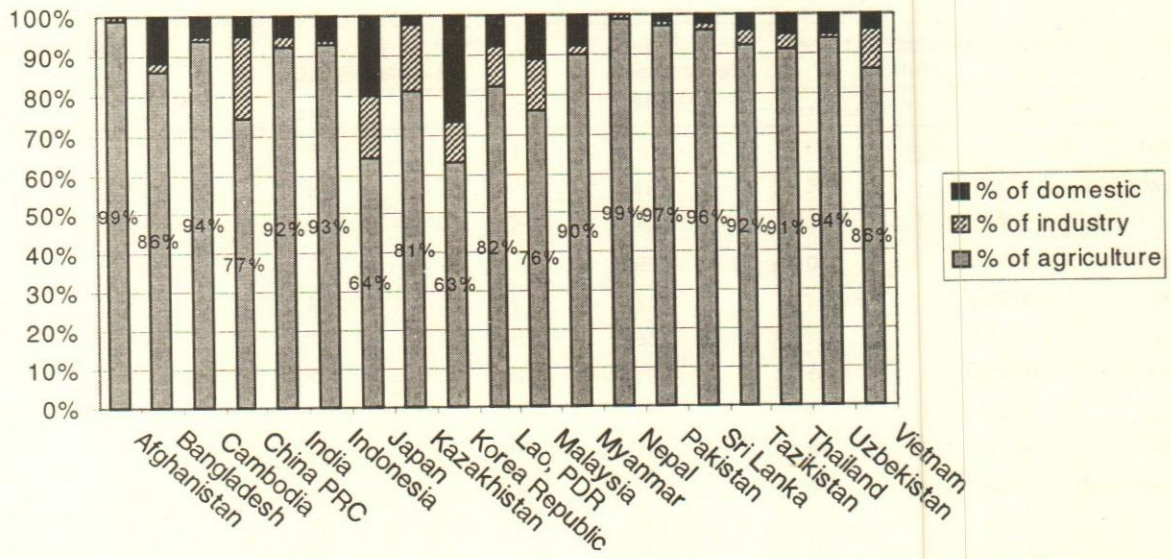

Fig. 1. Freshwater Use by Sector

Source: The Gender and Water Development Report 2003, Annex 2. Pages 95 to 97.

tainable development and integration of women. The first conference on water was in Mar del Plata in 1977 where the conference resolved that 1981-1990 be designated as the "International Drinking Water Supply and Sanitation Decade". Through ten years of effort, more people were able to receive basic support.

Integration of women in the water sector was first addressed in 1992 through the "International Conference on Water and Environment" in Dublin. Among the four Dublin Principles, Principle 3 addressed commitments on gender and water as:

Women play a central part in the provision, management and safeguarding of water. This pivotal role of women as providers and users of water and guardians of the living environment has seldom been reflected in institutional arrangement for the development and management of water resources.

Following the "UN Conference on Environment and Development" (Earth Summit) in Rio de Janeiro, the action plan "Agenda 21" was released by stating "Local communities must participate in all phases of water management. Ensuring the full involvement of women in view of their crucial role in the practical day-to-day supply, management and use of water". These two seminal conferences placed water as the core of sustainable development and women's involvement on the international agenda.

Since 1997, a World Water Forum is being organised every three years to discuss ways to resolve international water problems and there is a gender focus attempted in the deliberations. The United National Millennium summit held in 2000 approved the Millennium Development Goals (MDGs), that by 2015, the proportion of people that could not access potable water should be halved. The World Summit on Sustainable Development (WSSD) held in Johannesburg in 2002 recommended in its "plan of Implementation" that by 2005 all governments should establish national integrated water resource management plans and by 2015 to halve the proportion of people without access to safe drinking water and basic sanitation.

The UN has declared year 2003 as the International Year of Freshwater (IYF). The Third World Water Forum was held in Kyoto in March 2003 to activate the internationally agreed targets and goals. In the ministerial declaration, one of the points called for was "(to) ensuring good governance with a stronger focus on household and neighbourhood community-based approaches by addressing equity in sharing benefits, with due regard to pro-poor and gender perspectives in water policies".

FAO as the leading organization for food security has been addressing the critical situation of water resources. One of their efforts is the Special Programme for Food Security (SPFS) which FAO adopted based upon Agenda 21. This programme aims to help those living in developing countries, in particular the LIFDCs to improve their food security through rapid increases in food production and productivity, by reducing year-to-

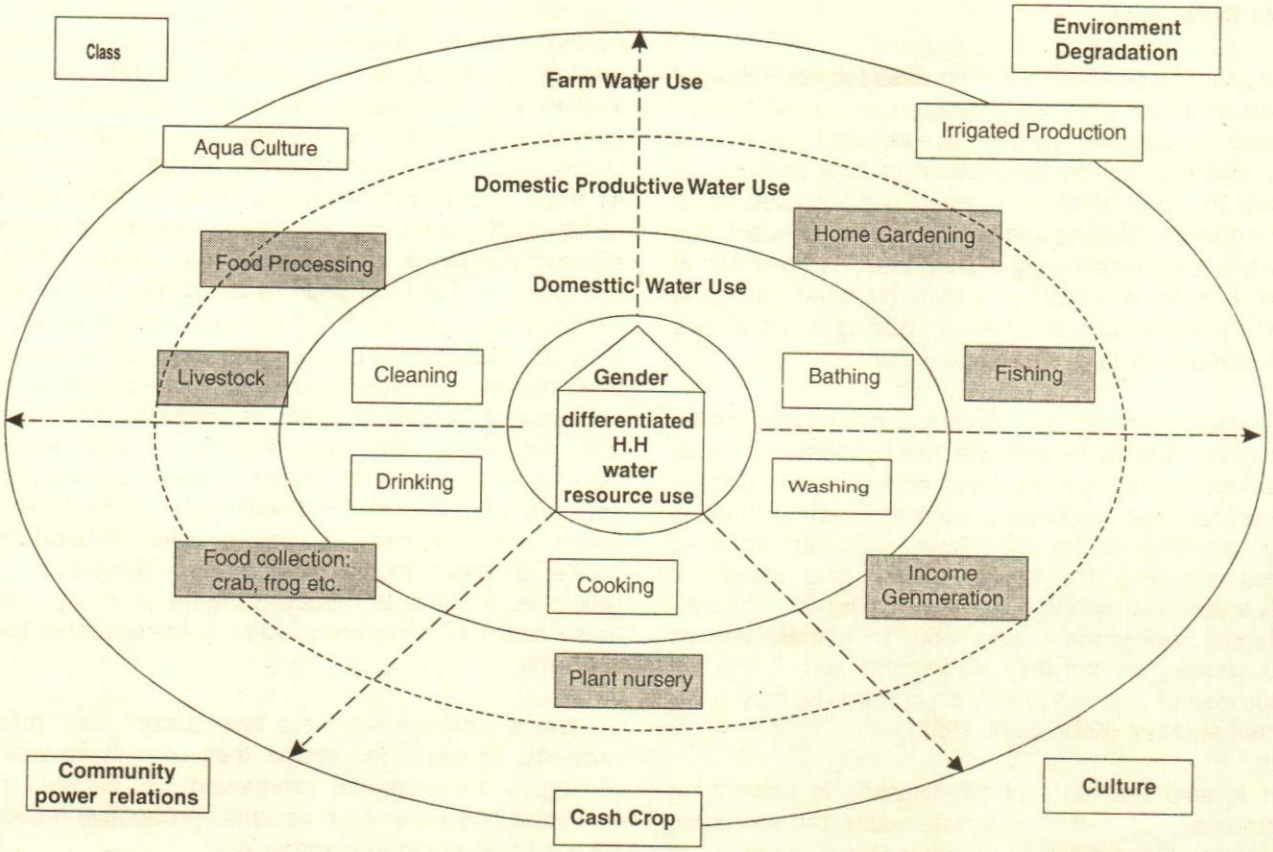

Fig. 2. Gender Differentiated Water Resource

year variability in food production on an economically and environmentally sustainable basis and by improving people's access to food (FAO, 2003). During International Year of Freshwater, FAO will be working towards water resources inventories and evaluation, development of a global water information system, a programme for water policy formulation and river basin planning, improved water use technologies and management tools, a programme on water development and irrigation expansion and water quality control and conservation and environmental effects project. FAO has also selected gender and water resource management as key topics for discussion for the International Women's Day event for 2003.

Global Development Agencies have also committed strongly to the UN for integration of women into water resource management. For example, development finance institutions such as Asia Development Bank (ADB) have developed its "Gender Checklist: Water Supply and Sanitation" to assist the Bank's staff and consultants in implementing the Bank's policy and strategic objective on gender and development. The World Bank has also prepared a "Toolkit on gender in water and sanitation". Research institutes such as the International Water Management Institute (IWMI) of Consultative Group on International Agricultural Research (CGIAR) is also looking into gender and irrigation issues. Bilateral donors such as Department for International Development (DfID), Australian Agency for International Development (AusAID), Canadian International Development Agency (CIDA) etc. have established their own plans and policies on gender and water management. From various efforts made by development agencies, it can be said that through years of conventions and conferences, the importance of integration of gender considerations into water resource management has become the non-negotiable agenda within poverty eradication and sustainable development programmes.

Integration of gender considerations into water resource management has become the non-negotiable agenda within poverty eradication and sustainable development programmes.

Gender Differentiated Water Resource Management Use in Rural Areas

In order to establish a strong case for integration of women in water resource management, it will be appropriate to discuss gender differentiated patterns in water resource use in the context of rural settings. In contrast to urban households where water is used mostly for cooking, drinking and sanitation, rural households use water for a wide range of purposes. As illustrated in Figure 2, water use can be broadly classified into three types: 1) domestic water use, 2) domestic productive water use and 3) farm water use.

Domestic water use: Women's daily lives are intimately connected to and affected by domestic water use because they are the ones who perform all tasks required for their household, such as fetching drinking water, cooking (nutrition/hygiene practice), washing clothes, cleaning the room, provisioning water for family's personal needs including bathing the children. In Nepal, rural women were able to identify various water sources around their settlements and depending on purpose of use, availability and proximity, they go to different sources (Kobayashi, 1997).

It is said that 80% of all diseases in developing countries are caused from unsafe water and sanitation (UN, 2002). Once a family member falls ill, women are often the caregivers. Spread of HIV/AIDS in the region has also affected rural households especially women and the poor by increasing their work to meet the family income with additional medical fees.

In most of the countries men, with some exceptions, rarely involve themselves with securing domestic water. It is usually women and when help is required, children (mostly girls) will take over the task which may keep them away from school.

Domestic productive water use: Women also play important roles in securing food production and income for family economy. Homestead gardening is an important source for family economy. Survey completed in Indonesia shows that women engage in 75% of farm work and 20% of household income. 40% of domestic food supplies are provided through kitchen gardens managed by women (FAO, NA).

40% of domestic food supplies are provided through kitchen gardens managed by women.

Typically, water is required for rural household generating income through various activities such as dyeing cloth for handicrafts, basket weaving, pottery making etc. A field survey in rural Thailand shows that women are processing more than 20 products for marketing (FAO, 2001[1]). In Cambodia, through PRA activities, women have identified that aquatic animals such as frogs, crabs and snails that they collect from the paddy fields serve as important sources of protein, especially in stress periods when they cannot afford to buy other animal food sources of protein. In the same study, women ranked livestock (pig, cow, chicken) as their important family assets. They sell them when they need money for children's education, medical expenses and special occasions such as weddings (Kobayashi and Nou, 2002). Normally, watering livestock is considered as women and children's work, whereas purchasing, breeding and marketing are considered as men's work. Women also nurse plants around their house for food, fodder, fuel, income generation and medicine, which also require watering everyday. In all these activities of women, water is an essential basic resource.

Since rural women have less control over private property, as described above, they often have various strategies to increase production to secure their livelihood and water is an essential productive resource for rural household management.

Farm water use: Men's involvement with water is related to agriculture. In farms, irrigation systems have stabilised and raised harvests, reduced the risks of crop failure and brought higher income. Women provide labour as co-farmers for production and maintenance of irrigation systems, and they directly or indirectly benefit from the use of irrigation water. Even though men and women work together, differences in timing of water deliveries exist based upon gender divisions of work. For example, in Nepal, male farmers demanded water for land preparation for rice cultivation, to make the land soft when they plough. Both men and women demanded water during transplanting of the rice seedlings but women had specific needs also during the season when they engage in weeding (Zwarteveen, 1997). Differences in crop preferences between women and men may also cause differences in water needs. A study done by ICRISAT showed that, women favoured varieties of groundnut which are easier to extract from the shells, have high grain yields and good taste, whereas men preferred those that had better fodder yield and large seeds thus attracting the market (Padmaja and Bantilan, 2002). Women often favour labour-saving attributes and prefer diversified cropping patterns so that they would be able to consume a variety of food crops which means women's water use

in agriculture production is more diverse than that of men (FAO, 1998).

Aquaculture makes an important contribution to the rural economy. In India, women engage in carp, catfish and freshwater prawn breeding and raising. Ornamental fish breeding and culture are also getting popular with low investment and high return but it requires an enormous amount of water (Saleesha and Stanley, 2000).

Besides agriculture and aquaculture, irrigation water and used aquaculture water are convenient water sources for a variety of domestic production and domestic use such as irrigating homestead crops, watering livestock, washing clothes and bathing, which cannot be neglected in rural households (Zwarteveen and Meinzen-Dick, 2001).

Women's access to water use is not only distinguished by gender differentiated water use but it is also mediated by various socio-economic phenomena, social relations of power, culture and natural conditions.

"Feminization of agriculture" is one of the aspects that need to be highlighted and is a contributing factor in increasing women's involvement in water resources in agriculture/farm sector. Increase in male migration as well as increasing incidence of political instability and civil war such as in Afghanistan, Nepal, East Timor, Cambodia and Sri Lanka has forced male family members to leave rural areas. This situation has created more responsibilities on women as rural producers. Female-heads of farms do not have same preferences of water use since they have to combine agriculture tasks with domestic duties. Often they preferred irrigating at times when they were not busy with other tasks (Zwarteveen, 1997) or have selected the varieties that differ from male-headed households.

Class is another social aspect that inhibits certain social groups from access to water. In India and Nepal, socially-disadvantaged groups have difficulties in their access to water because even though it is illegal to discriminate by caste, in practise they still do not share water with upper caste people due to tradition bound purity/pollution norms. Although socially-disadvantaged people also have rights to access common property, usually they have to wait until other caste people finish using it or in some cases they have to use another water source which is of poor quality. Therefore, greater time has to be allocated by women of this social group in obtaining water (Crow and Sultana, 2002). Similarly, religious and culture practices also influence access to water. In Islamic countries, women have to be careful to maintain decorum. In rural areas in Bangladesh, people bathe in ponds near their settlement but women have to bathe at different times than men, often at night or early in the morning, these practices impacting on women's daily time use pattern. In rural areas, in many cases, people who have rights to irrigatable land only obtain rights to water for agriculture production. In this context it is possible to observe intra-community power relations between wealthy households and poor households and opinion of a wealthier household may have favoured conditions of access compared to a poor household (Zwarteveen and Meinzen-Dick, 2001). Due to various constraints as discussed above, women and poor households have to relay more on common property to fulfil their obligation to secure water. However, environment degradation has worsened the water scarcity, which leads to decline in water quality and additional drudgery work. It is women and the poor rural households who are most adversely affected by the quantity as well as quality of water.

People who have rights to irrigatable land only obtain rights to water for agriculture production.

Initiatives to Integrate Rural Women into water resource management and obstacles

To integrate women in water resource management (WRM) and to improve women's livelihood, various initiatives have been taken by projects and programmes as shown in Fig. 3. below.

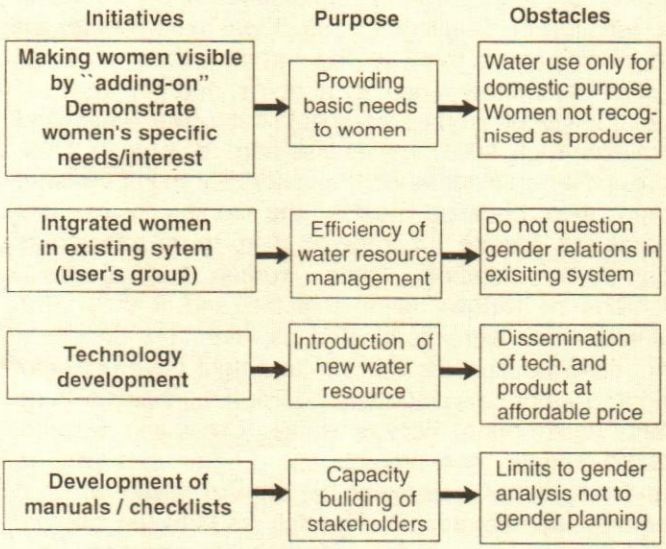

Fig. 3. Initiatives and Obstacles of Water Resource Management

Making Women Visible by "adding-on" Women's Water Issue

One way of integrating women in water resource management projects and programmes are through demonstrating the specific needs of women with respect to water. By making women visible through their role as mothers and domestic caretakers, basic access to domestic water use will be assured. This approach has certainly served advocacy purposes. However, by dealing with women's water use in isolation by "adding-on" women's issue, it has also strengthened belief that women's water needs are in domestic water use (Zwarteveen, 1997). This has led to cutting out women's productive water use needs from the community water agenda, thus making it harder to acquire water for other purposes such as water for farm and in domestic production.

Integrating Women in Existing Water Management Committees

To address women's water use in a more comprehensive manner, the current trend is to transfer water resource management responsibility from the state to communities/local user groups by securing specific membership for women and socially disadvantaged groups in the water user committee, so that their concerns will be incorporated in the decision making process and ultimately water will be used efficiently by both men and women. Although women were formally elected as members of the committee, the effects of this initiative were minimal for several reasons. Firstly there was an assumption that by including women as members, women's voices will be heard. This was not easily achieved because women representatives were not able to function in meaningful ways. It was hard for women to participate actively in the formal setting of water users' committees where local norms and practices still do not favour women to speak out (Zwarteveen and Meinzen-Dick, 2001). It was also hard for women to express their opinions when the majority of members were men. Also, because most of the women in the rural areas are illiterate, it hampered them to be selected as committee members. Often, women from wealthier families or widows were selected and if they were literate, they were nominated as secretary. Secondly, normally, households with no land right have no direct right to water so women and poorer households with no land right cannot access water. (Crow and Sultana, 2002). Thirdly, most projects and programmes failed to understand the existing social context within which a community operates. Power-relations between landlord and tenant, class, gender, negotiation mechanisms have persistently excluded women from traditional water resource management mechanisms. It is obvious that without questioning the existing decision making mechanism, women will not be accepted as equal partners in the committee. Lastly, it also did not question the degree of gender responsiveness in current water resource management, legal and administrative arrangements. In South Asia, women's access to water does not directly imply that women have rights to water and it needs analysis of how laws, policies, principles, conditions and rules govern water allocation and distribution that favour women to access and control water resources for their living (Zwarteveen and Meinzen-Dick, 2001).

Power-relations between landlord and tenant, class, gender, negotiation mechanisms have persistently excluded women from traditional water resource management mechanisms.

Technology Development

The highly technical aspects of water projects and programmes were another reason that prohibited women to participate in activities (Rathgeber, 2003). New water resource management technologies have brought water management technologies closer to women. For example, rainwater harvesting systems by catching rain water on the roofs have provided an additional water source for irrigating crops and even for domestic use for rural women in Maldives (FAO and MSSRF, 1999). In Bangladesh the introduction of cheap and small engines have allowed the small and poorer farm households to gain access to irrigation water and increase their agriculture production (Barker, Koppen and Shah, NA). Introduction of low-cost human-powered treadle pump in FAO project in Nepal has motivated women's groups to establish kitchen gardens, which have significantly contributed to improvement of nutrition status of the community (Lama, 2002). Similarly, many environmentally sound technologies such as wastewater and storm water management (WHO, 2001), water storage tanks, small wells, hand pumps, spring protection and fog collection etc. have been making an important contribution to reduce women's drudgery work (UNEP, 2002). However, limited attention has been paid to promoting new water resource management technologies. There is a need for political will to implement the system and to link with the business sector so that appropriate technology and product will be available at an affordable price for a broader population (World Water Forum, 2003[1]).

Development of Manuals/Checklists to Integrate Gender in Water-related Projects and Programmes

The concept of "Gender analysis" has taken a firm hold on projects and programmes but in the water sector, irrigation planners are still concerned with production and health planners are concerned with water for health and sanitation. In order to raise awareness of a wider audience including engineers, consultants and the rural community and support them to integrate gender issues into the planning process of water projects and programmes, manuals and checklists have been developed. FAO developed Socio-economic and Gender Analysis (SEAGA) Irrigation Sector Guide in 2001 and similar checklists have been developed by ADB and DFID. To some extent, these manuals and checklists have contributed to raise awareness and build capacity of planners to understand the importance of gender in the water sector but it is still questionable how far gender has been really integrated in actual planning and implementation.

Suggestions for Improvement

A regional review of the situation of rural women and water resource management illustrated that women have a diverse relationship with water. It has also shown numerous interventions to integrate gender in water-related projects and programmes. However, a gap still exists between stated intentions and actual practice. In this context, various suggestions for policies, projects and programme interventions will be presented as perspectives for improving access to water of rural women in the Asian region.

Identifying Gender Differentiated Water Use

It can be said that women's water use has been recognised in a narrow context and consequently women are still placed as beneficiaries or target groups in current water resource management projects and programmes. This hampers efforts to promote advancement of rural women as major agriculture producers, since water is an essential productive resource. Rural people need water for farm and domestic production for their household food security and family economy. Irrigation programmes often do not place importance in water use other than for farm irrigation but for rural women, they consider irrigation water as important for domestic use. By saving time, they are able to engage in more productive activities.

It is necessary to better understand gender differentiated water use activities at a number of levels, that of the gendered individual, the household, the community and groups within it, development agencies, and the natural resource system (Cleaver, 1998). By doing so, it will lead to better assessments of water use and understanding of distribution performance, and thus contribute to the identification of more realistic options for water resource management programmes (Zwarteveen and Meinzen-Dick, 2001).

Projects and Programmes should make women understand the importance of their role in water resource management: Often, since women do not have self confidence originating from factors such as being illiterate and not having enough experience in attending meetings, they hesitate and are afraid that they would not be able to understand what was being discussed and may not be able to contribute meaningfully (Meinzen-Dick and Zwarteveen, 1998). Activities to ease women to participate in water resource management projects and programmes should be considered. By providing clearly stated information of the project, taking measures so that women can overcome shyness, making an inventory of women's interest in participation and leading them to concrete plans and identifying potential women leaders who can empower other women (Rathgeber, 2003).

Community should realise the importance of the role of women in water resource management: It is important that the community as a whole, including rural women, recognize the role of women in water resource management and its linkage to farm and domestic production, which will lead to the well being of the household through improved family economy.

Gender responsive policies: Conflicts regarding water often take place along side the canals since distribution of water is partly determined by the location of one's field and people without water right have to break the rules to get necessary water for their living (Meinzen-Dick and Zwarteveen, 1998). Government policies, laws and customary laws in the region are mostly not gender responsive and its negative impacts to rural women and poor people's lives are not known. Although it is not easy to revise government policies and laws immediately, assessment should be implemented to highlight gender responsiveness of current policies and laws and advocate for change.

Gender responsive membership rules: The most easily recognized gender-based barriers for women in a water-related project is that the project often identifies the user by land ownership (in most cases household head-men) but not by actual land users, both men and women, marginal farmers and landless people, who lease-in land from wealthier farmers for their living (Koppen, 1998). Another aspect is the

balance of costs and benefits women receive by participating as members. Local norms regarding political decision making and existing stereotypical ideas about women's roles may also become additional barriers. Gender responsive membership rules should be established by de-linking water rights from right to land, which would allow rural women to "own" water without owning land (Zwarteveen and Meinzen-Dick, 2001). Another attempt can be ensuring at least one-third or preferably half of the committee members women. They should have equal membership responsibilities with equal rights including signatories to project bank accounts (Rathgeber, 2003).

Gender responsive membership rules should be established by de-linking water rights from right to land.

Ensuring access to gender responsive water resource management technologies and training for rural women: Gender responsive technologies that are locally appropriate, affordable and environmentally sensitive should be promoted in order to reduce household drudgery and improve access to safe water. Appropriate training should be provided so that rural women will be capable of using the technology with their own capacity.

Credit Provision: In order to facilitate promotion of gender responsive water resource management technologies, micro-credit/finance arrangements should be provided with the condition that women themselves can obtain loan of her name and manage the introduced technologies.

Gender-disaggregated data and gender differentiated information on water management should be developed: Data and information on water should include gender-disaggregated data and gender differentiated information. By taking advantage of the advances in information technology based data management systems, the information should be made available in a user friendly format so that policy makers, researchers, programme managers, advocacy groups can utilize them for gender responsive planning.

Develop case studies of gender responsive water management practices: It will be important to identify documents which are examples of gender responsive water resource management practices.

Capacity building of staff and assessing mechanism: Capacities of staff including policy-makers, engineers, consultants and project planners etc. need to be built further through trainings, development of manuals and checklists in order to improve the performance of water resource management projects and programmes with a gender focus. Each agency needs to establish a mechanism in assessing programmes in all stages of implementation to create more effective, equitable and sustainable programmes.

Gender Responsive Budget Initiatives: Introduction of Gender Responsive Budget Initiatives in the water sector is suggested to enable governments, donors, multi-lateral agencies and civil society organizations to be accountable to their commitment to gender equity (World Water Forum, 2002).

Inter-collaboration mechanism among various agencies on gender responsive water resource management: Inter-agency collaboration mechanism among government agencies, women's groups, NGOs etc. should be established to effectively utilise limited resources and provide effective interventions for rural women.

Conclusion

During the Third World Water Forum, it was strongly stated that "Improving the sustainable development and management of water for agriculture is essential to meet the world's growing demand for food, enhance food security and alleviate poverty". In Asia, rural women's contribution to agriculture sector and rural production are pivotal and water is an indispensable productive resource for women to mediate the access to water in farm and domestic production. This paper has attempted to unfold rural women's water resource use and bring to light its complex relation with water. It has also elaborated emerging issues on water and rural women, trends that have been affecting water resources in the region and international initiatives to resolve water problems and its impact on rural women. Global agencies have recognized the importance of women's involvement in water resource management but there still exist various obstacles. To narrow the gaps between stated intentions and actual practice, suggestions have been given for polices, projects and programmes for improving women's access to water. As it is said– "Women feed the world", it is widely accepted that women are central to the world's food production and food security but without water, women will not be able to feed the family and contribute to food security. It is time for various stakeholders to re-consider strategies to advance women's role in water resource management for food security and sustainable use of water resources in partnership with rural women.

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Women's Work, its Changing Pattern & Policy Interventions

Mridul Eapen

This paper examines the levels and pattern of female work participation in India, tracing the changes over time as investment increasingly gets directed to forms and processes involving cheaper and flexible labour. In the first section we present the quantitative data on working women, an analysis of which throws up issues which warrant policy interventions. More specific efforts at women's economic empowerment are discussed thereafter and observations on the interlinkages between work and empowerment of women are made.

Mridul Eapen is with the Centre for Development Studies, Trivandrum.

While almost all women 'work', given the conventional concept of work relating to 'paid' or market linked activity, women's economic contribution to the household and economy tends to be largely understated. It has been widely accepted therefore that provision of jobs for women, in particular paid work, is an important way of integrating women into the development process as also making them more visible. Underlying this is the belief that women's subordination and 'invisibility' stems from their lack of independent economic power which can be acquired through work. A classic consensus which was current until the seventies was that the process of development based on industrialisation had marginalised women as production moved from the household to the factory. However, the rapid incorporation of women into the new export-manufacturing sectors from the mid-seventies and across a wider field since the early nineties necessitated a rejection of this proposition. The problem appeared to be not one of women being left out of the development process but of the relations through which they are 'integrated' into the process which needed to be investigated (Elson and Pearson 1981). This issue goes deeper than the belief that women need work to gain autonomy; one has to understand the pattern of work shaped by the extant sexual division of labour and how it changes in the process of development in a gender differentiated way so that women continue to be the inferior bearers of labour. Work per se may fail to "empower" women.

Certain features of the Indian labour market for women have drawn considerable attention:

- Declining work participation rates of women workers particularly in rural areas, continuing in the nineties Reforms period;
- Heavy concentration of women workers in agriculture;

- Growing casualisation/informalisation of the female work force;
- Higher (than male) rates of female educated unemployment;
- Persistent inequalities in earnings;
- Perpetuation of a gendered work structure, women occupying the lower rungs of the labour market hierarchy.

Work Participation Rates of Women

The two major sources of data on workers and their industrial distribution in India, are the decennial Population Censuses and the various Rounds of the National Sample Survey Organisation (NSSO), neither of which is free from problems for an analysis of long term trends. With respect to the former, the problems of inter-censal comparability due to changes in the definition or concept of "worker", make a significant impact on the enumeration of female workers for whom work and non-work can be indistinguishable, especially in rural areas. It is generally accepted that the NSSO methodology and concepts ensure a better enumeration of the work force, especially the female workers; we have used primarily the NSSO data for which a fairly comparable series is available from the seventies.

According to the latest Round of the NSSO for the year 1999-00, there were nearly 393 million workers in the country of which women workers numbered 122 million (constituting less than one-third of the total workers); 103 million in rural areas and 19 million in the urban areas. The NSSO gives three estimates of employment/unemployment depending on the reference period used. We have taken the 'usual' status rates with a year as the reference period (all those who worked for more than half a year are referred to as 'principal' workers and those who did some work but for less than half a year are 'subsidiary' workers). These two categories constitute usual principal status (UPS) and subsidiary workers (UPSS). The other estimates are 'weekly' and 'daily' emp/unemp rates. The total number of women workers remained almost the same since the last Round in 1993-94; as population has increased during the period there was a decline in the worker participation rates for women in rural and urban areas. Worker population rates are about 30 per cent for rural women and 14 per cent for urban women (Table 1). Since unemployment rates have not shown sharp increases (Table 1a), there is a fall in the labour force participation rates of women. Hence the marginalisation thesis appears to hold in the case of women in India.

Table 1: WFPR (UPSS) During the Period, 1977-78 to 1999-2000, in Different NSSO Rounds

Year	Rural			Urban		
	Male	Female	Persons	Male	Female	Persons
1977-78	55.2	33.1	44.4	50.8	15.6	34.1
1983	54.7	32.0	44.5	51.2	51.1	34.0
1987-88	53.9	32.3	43.4	50.6	15.2	33.7
1993-94	55.3	32.8	44.4	52.0	15.4	34.7
1999-2000	53.1	29.9	41.7	51.8	13.9	33.7

Source: 1977-78, 1983, 1987-88: Sarvekshana, Sept. 1990
1993-94: Sarvekshana, July-Sept. 1996
1999-2000: NSSO, Employment and Unemployment Situation in India 55th Round, Report, Part I, May 2002

Table 1(a): Unemployment Rates

All-India	1987-88				1993-94				1999-2000			
	RM	RF	UM	UF	RM	RF	UM	UF	RM	RF	UM	UF
Usual Status	1.8	2.4	5.2	6.2	1.4	0.8	4.0	6.2	1.7	1.0	4.5	5.7
Current Daily	4.6	6.7	8.8	12.0	5.6	5.6	6.7	10.5	7.2	7.0	7.3	9.4

Source: Same as Table 1
RM-Rural Males; RF - Rural Females; UM - Urban Males; UF - Urban Females

To some extent participation rates have declined as women have been going in for more years of schooling; also the sharp decline in certain female dominated sectors of employment such as agriculture and traditional household industries, could have contributed to the fall in growth of numbers. While it is true that poverty in India has been declining, levels of living have not improved to such an extent as to warrant a voluntary withdrawal of women from the work force. We argue that these displaced women workers may in fact be (a) withdrawing from the labour force for lack of 'paid' work, shifting to activities within the household, for instance, subsistence production, which contribute to family well-being but is not included in official work force data. Needless to state such work is hardly economically empowering; (b) the reservoir of cheap labour for labour intensive export manufacturing industries some of which is visible while the rest could be home based, casual, part-time or work in small sweat shops which escape the attention of enumerating agencies.

At the same time, employment opportunities have grown for women with better access to education, skills, markets and resources as in information technology and services like banking, but not at a fast enough rate to compensate for the decline. Also, data show that growth rates of employment for women by 'weekly' and

Table 2: Distribution of Workers (UPSS) by Broad Industry Division

Industry Division	1987-88				1993-94				1999-2000			
	Rural Male	Rural Female	Urban Male	Urban Female	Rural Male	Rural Female	Urban Male	Urban Female	Rural Male	Rural Female	Urban Male	Urban Female
Agriculture	74.5	84.7	9.1	29.4	74.1	86.2	9.0	24.7	71.4	85.4	6.6	17.7
Mining	0.7	0.4	1.3	0.8	0.7	0.4	1.3	0.6	0.6	0.3	0.9	0.4
Manufacturing	7.4	6.9	25.7	27.0	7.0	7.0	23.5	24.1	7.3	7.6	22.4	24.0
Electricity Gas Water	0.3	–	1.2	0.2	0.3	0.1	1.2	0.3	0.2	–	0.8	0.2
Construction	3.7	2.7	5.8	3.7	3.2	0.9	6.9	4.1	4.5	1.1	8.7	4.8
Trade Hotel	5.1	2.1	21.5	9.8	5.5	2.1	21.9	10.0	6.8	2.0	29.4	16.9
Transport	2.0	0.1	9.7	0.9	2.2	0.1	9.7	1.3	3.2	0.1	10.4	1.8
Services	6.2	3.0	25.2	27.8	7.0	3.4	26.4	35.0	6.1	3.7	21.0	34.2
Finance					0.4	0.1	3.8	1.9	0.5	0.1	4.5	2.5
Pub. Admn, Edn. & Soc. Services					6.6	3.3	22.6	33.1	5.6	3.6	16.5	31.7

Source: Same as Table 1.

Note: UPSS-Usual principal and subsidiary status

'daily' status is higher while there is a decline in 'usual' status employment rates, possibly reflecting a growth in demand for short duration employment in informal activities where women are preferred.

Hence, the more recent period of economic liberalisation appears to have caused an increasing inequality in employment opportunities for women. For most women workers the quality of employment is poor, of short duration and without opportunities either for skill development or moving up the ladder. It becomes important therefore to examine the changing pattern of women's employment.

Period of economic liberalisation appears to have caused an increasing inequality in employment opportunities for women.

Pattern of Employment

The share of agriculture in total work force, still remains very high, in particular for women. Since its share in national output declined considerably, the consequent adjustment came about by a near stagnancy in the productivity of labour in agriculture. Almost 75 per cent of working women are engaged in agriculture, a low productivity activity (Table 2).

While non-agricultural employment for women has grown primarily in urban areas, within the non-agricultural sector, manufacturing (in rural areas) and trade, hotels and construction in urban areas have increased their shares considerably. A sector which is a major employer of women is community, personal and social services (constituting a large proportion of the visible urban working women) which includes also banking and finance. While each of these sectors has formal and informal segments, how much the women have gained would be reflected in the type of employment generated. We examine this in terms of (a) sector and status of employment; and (b) occupational and earnings structure.

Women comprised only 17 per cent of organised sector employment in the late 90s (Table 3) and an industry wise break-up of employment in the unorganised/organised sectors shows that in sectors like manufacturing, construction, finance and trade where women's employment has grown, it has been primarily in the unorganised sector whose share has increased in the nineties (Table 4). This is not to deny the fact that women have been slowly increasing their share in organised sector employment which is a positive aspect. However, (a) gender discrimination continues to exist in the occupations they are engaged in as also earnings; and (b) growth in numbers is much higher in the private sector, where earnings and conditions of work are inferior. This can be seen from the earlier Table which shows that it is the private organised sector which employs a higher proportion of women and it is primarily in the private sector that employment for women has been increasing in recent years, in particular in manufacturing. It is well known that higher wages, job security and other non-wage benefits characterise public sector employment whereas a number of micro

Table 3: Total and Women Employment in Organized Sector, India (thousands)

Year	Public Sector			Private Sector			Total		
	Women	Total	% of Women	Women	Total	% of Women	Women	Total	% of Women
1992	2467.0	19209.6	12.84	1522.7	7846.1	19.41	3889.8	27055.7	14.38
1993	2476.7	19326.1	12.82	1549.7	7850.5	19.74	4026.3	27176.6	14,82
1994	2564.6	19444.9	13.19	1589.3	7929.9	20.04	4153.9	27374.8	15.17
1995	2600.4	19466.3	13.36	1627.5	8058.5	20.20	4227.9	27524.7	15.36
1996	2634.5	19429.3	13.56	1791.9	8511.6	21.05	4426.4	27940.9	15.84
1997	2727.6	19559.1	13.95	1909.4	8685.5	21.98	4637.0	28244.5	16.42
1998	2762.7	19417.8	14.23	2010.9	8747.9	22.99	4773.6	28165.8	16.95

Table 4: Percentage Share of Employment in Unorganised Sector to Total Employment

Industrial Sectors	Male			Female			Person		
	1988	1994	1999	1988	1994	1999	1988	1994	1999
Agriculture	99.2	99.4	99.4	97.10	99.48	99.48	98.37	99.41	99.41
Mining & Quarrying	45.6	52.3	49.1	76.82	84.70	82.24	51.13	58.60	54.81
Manufacturing	77.9	80.1	81.8	78.44	93.72	91.62	77.98	84.01	84.55
Electricity, Gas & Water	21.3	30.3	4.2	0.00	77.07	0.00	21.29	35.41	4.03
Construction	86.6	89.1	92.8	93.81	96.13	96.64	88.24	90.04	93.25
Trade	98.0	98.3	98.8	86.77	99.01	99.15	96.82	98.39	98.81
Transport Storage etc.	65.1	71.6	79.0	0.00	52.57	59.66	64.39	71.00	78.45
Financial & Community Services	59.9	67.0	63.4	22.10	73.39	71.45	55.22	68.56	65.55
All Sectors	89.4	90.9	91.4	92.60	96.60	96.05	90.38	92.73	92.86

Source: Gayathri (2002)

level studies show the non-compliance of labour legislation in many private sector undertakings.

This is perhaps the reason why the growth in the proportion of 'regular' women workers in 1999-00, (Table 5) presumably in the private sector, has to be treated with caution; it cannot be equated with the earlier full time, permanent workers enjoying job security and pension, maternity and other benefits. Studies show that there is considerable informalisation of employment in the formal sector which appears to be a part of the flexibilisation process of production and labour in the era of liberalisation; hence the formal/informal dichotomy is misleading; work even within the formal sector could be informal.

The occupational break-up of the female work force reflects a gendered work structure (Table 6). In the category of professional, technical and related work, women dominate in nursing and teaching (in fact if the latter is disaggregated further, the concentration is high among school teachers); in the service sector which

Table 5: Distribution of Workers by Employment Status

Year	Male			Female		
	Self Emp-loyed	Regular/ Salaried	Casual	Self Emp-loyed	Regular/ Salaried	Casual
Rural						
1983	59.5	10.6	29.9	54.1	3.7	42.2
1987/88	57.5	10.4	32.1	54.9	4.9	40.2
1993/94	56.9	8.5	34.6	51.3	3.4	45.3
1999/2000	54.4	9.0	36.6	50.0	3.9	46.1
Urban						
1982	40.2	44.5	15.3	37.3	31.8	30.9
1987/88	41.0	44.4	14.6	39.3	34.2	26.5
1993/94	41.1	42.7	16.2	36.4	35.5	28.1
1999/2000	41.2	41.9	16.9	38.4	38.4	38.5

Source: Various NSSO reports on Employment and Unemployment

Table 6: Per Thousand Distribution of Usually Working by Occupation Group

	1993-94				1999-2000			
	Rural		Urban		Rural		Urban	
	Male	Female	Male	Female	Male	Female	Male	Female
Nursing, other med. & health technicians	1	1	3	20	1	2	4	26
Teachers	13	9	23	105	13	13	22	111
Prof., tech & related workers	27	16	77	149	23	16	75	157
Admn., exec., managerial workers	10	8	64	32	16	9	90	54
Clerical, other supervisors, villa. officials, steno, typist, book keepers, cashiers, etc	15	3	91	69	16	4	84	71
Clerical & related workers	18	4	102	73	20	4	95	76
Merchants, shop keepers, wholesale, retail trade	37	15	114	57	35	13	108	53
Sales Workers	51	21	187	86	50	19	184	90
Housekeepers, matrons, cooks, waiters, bartenders, maids, sweepers, cleaners	4	11	28	131	3	13	24	142
Launderers, dry cleaners, hair dressers	8	8	13	16	10	10	12	19
Service workers	20	21	77	161	24	27	79	180
Cultivators (owners & tenants)	408	367	39	54	377	343	31	42
Agrl. Labourers	275	404	29	102	278	417	20	81
Plantation & related workers	12	14	3	7	10	14	2	6
Farmers, fishermen, hunters, loggers	735	847	88	195	704	834	69	148
Miners, quarrymen, well drillers	4	2	5	3	3	2	4	1
Metal processors	1	0	6	1	1	0	5	2
Spinners, weavers, knitters	11	16	37	57	10	13	24	41
Food, beverage processors	5	5	13	13	6	7	14	10
Tailors, dress makers	9	8	28	45	9	8	28	48
Shoe makers, leather goods, carpenters	25	6	97	14	25	6	96	17
Brick layers, other than construction workers	18	6	36	30	28	8	47	33
Engines, related equipment Operators	14	0	56	2	21	0	64	3
Labourers	25	10	51	47	32	12	50	48
Prod. & related workers	141	84	405	303	163	92	408	294

Source: Same as Table 1

employs a large proportion of women, it is in the category of personal services that women dominate (housekeepers, maids, launderers, beauticians etc). The larger proportion of women workers are production process workers, largely in agriculture and related activities, which are located at the bottom of the labour hierarchy.

Even in 'women friendly' sectors like banking and information technology, the latter allegedly having the potential to open up new avenues for women as a gender neutral employer, such an outcome is not automatic. Women still account for only about 13 per cent of the total workers in banking. What is interesting is that while in public sector banks recruitment appears to be still along traditional lines, women being largely employed at the lower level, in the private foreign banks they are employed in the upper echelons; the numbers, however, are still very small (Table 7). A recent study on the IT sector shows that while a large number of women are employed in this industry, most of them are at the lower end of the technology segment (Rothbeck et al 2002 cited in Gayathri 2002).

To a considerable extent gender disparity in employment and earnings arises due to societal attitudes towards women's education deriving from their perceived role of a home maker, which constrains their

access to higher education and training. However, it is also true that even among the high and equally educated women in the science and technology fields, there is gender discrimination in earnings for similar jobs. As a study for the states of Kerala and Tamil Nadu shows, the gender gap in earnings of highly qualified persons, measured by the ratio of female to male earning is 0.78 in Kerala in the science and technology field. About 18 per cent of the differential can be explained in terms of the occupational segregation, 50-60 per cent by productivity characteristics, which suggests that almost a quarter is in terms of discrimination (Duraisamy & Duraisamy 1997). While changing family norms appear to favour working women, their choices in terms of nature and sector of work are restricted as also their aspirations for a career. While employment for women has increased in previously male dominated arenas with the growing flexibility in the work force, newer job opportunities are being created in a gender differentiated way.

Table 7: Percentage of Women Employees to Total Employees by Type of Bank, March 1995 and March 1996

Type of Bank	1995			1996		
	Total	Women	%	Total	Women	%
Public Sector	862723	100397	12.8	851627	112089	13.16
Private Sector Indian	46801	7067	15.1	48043	7297	15.19
Private Sector, Foreign	449	1583	35.19	5200	1604	30.85
All Banks	914023	119046	13.02	904870	120990	13.37

Source: Gayathri (2002)

Table 8: Number of Females per 100 Males in University Education in Major Disciplines

Year	Arts	Science	Commerce	Engineering & Technical	Medicine
1980-81	59.7	38.9	18.5	6.8	40.4
1985-86	66.7	47.9	28.1	9.2	53.5
1990-91P	65.5	58.3	31.6	12.2	51.1
1995-96P	70.3	56.8	40.8	16.6	52.7
1995-96P	70.3	56.8	40.8	16.6	52.7
1998-99P	80.1	55.3	46.1	24.3	62.1

Source: Department of Education, Ministry of Human Resource Development, New Delhi

P Provisional

Policy Interventions

Hence, from the above certain issues of concern for women are (a) declining visibility in the work force, heatedly debated in the context of the Structural Adjustment Policy in the nineties; (b) persistence of sexual segregation in the labour market in terms of occupation and earnings; (c) lack of skills among large sections of women to take advantage of growing job opportunities; and (d) very little recognition of women's needs arising from their dual/triple role as home makers and community managers. Such labour market conditions do promote a tendency towards greater poverty among women, and as the NSSO data reveal, female headed households (about 10 per cent of all households) recorded a higher incidence of poverty and poorer households had a larger proportion of adult females.

Following from the issues identified, the major interventions have been in terms of creating employment and providing training to women; besides strengthening the policy and institutional framework within which the labour market operates through appropriate legislation and governance structures. This was a decisive break from the earlier policy interventions characterised by welfare oriented, family centred programmes which perceived women primarily as wives and mothers. In India, too, we find a policy shift in the 70s with the findings of the Committee on the Status of Women in India (1974), which revealed that a large majority of women in the economy had been marginalised in the process of growth. In fact, policy planners appeared to increasingly view women as not being in need of an independent income and their consequent neglect and devaluation by the state and society reflected a gender bias in policy. The Report had a nation wide impact with a debate on it in the Parliament which concluded with a very broad mandate to the government "to remove all disabilities that Indian women continue to suffer from".

International events in the shape of World Conferences on women which began in the mid-70s introduced formally the concept of a "national machinery", into the global discourse on women and development. That is, the UN recognised the state as having the primary responsibility for carrying out the recommendations of these conferences calling for commitment at the highest political level in implementing, coordinating, monitoring and assessing the progress towards women's equality.

Gender equality has been advocated in all policy documents and commissions of the Government of India. The concept of an all powerful and centralised mechanism to achieve this was unrealistic given the reality of large bureaucracies and their style of functioning. Women, in the administrative parlance, do not constitute a sector. Theirs is a multi-sectoral, multi-dimensional cross-cutting presence. The Beijing Platform for Action asks "to include all institutional

mechanisms and processes that facilitate, as appropriate, decentralised planning, implementation and monitoring with a view to involving NGOs and community organisations from the grass roots level upwards". This was attempted in the country paper prepared by the Government of India for the Fourth World conference on Women in Beijing. A diagrammatic representation was given of the "national machinery" and its institutional support as a circle with the Department of Women and Child Development at the centre of the circle and other linked agencies/ministries arranged in concentric circles around it.

Gender equality has been advocated in all policy documents and commissions of the Government of India.

A number of special programmes were formulated under the Five-Year Plans (the Sixth Plan for the first time introducing a separate Chapter on Women) for generating employment which can be classified into those promoting self-employment through provision of productive assets and those devoted to providing lean season employment or other forms of wage employment. Programmes have also aimed at economic and social capacity building in terms of imparting skills, literacy, including gender awareness, training, health and basic services like housing, sanitation. While the Government is, of course, a major actor in these interventions, NGOs too have played a significant role.

There are a large number of wage employment and self-employment programmes, some of which have a reservation of one-third for women. We focus primarily on interventions by the state (one relating to self-employment and one to wage employment).

The Integrated Rural Development Programme (IRDP) launched in 1989 is the largest credit-linked self-employment programme for those below the poverty line. There is a subsidy and a loan component provided by the commercial banks for purchase of assets; 30 per cent of the beneficiaries should be women. Assessments reveal that the main problems of self-employment schemes such as IRDP is the inadequacy of credit provided for successful self-employment and the projects are badly designed and executed.

Among the wage employment schemes, we take up the case of the Maharashtra Employment Guarantee Scheme (EGS). Although a state scheme launched in the early 70s it has achieved nation wide acclaim. It was never thought of as a woman's programme but has come to be known as a 'woman project'. The proportion of women participating in the scheme increased to more than half by the early 90s. And if, as the data show, almost half a million persons got work under this programme, of a total of 24 million workers, constituting 2.2 per cent of the work force, then unemployment would have been higher by this percentage in the absence of the EGS. It is interesting to note that this scheme envisages equal payment to men and women for equal work; in practice however, wage discrimination persists (Mahendra Dev 1999).

The question is how much these schemes have added to the numbers of working women in the country and empowered them economically. Some data on the number of women beneficiaries and their share in employment generated is given in Table 9. One lesson which appeared to emerge from the evaluative studies done was the need to bring women together in one place as, for instance, under wage employment schemes like the EGS, which opened up the potential for their collective activity. It was in such a context that newer organisational forms such as self-help groups with access to micro-credit programmes drew considerable attention in the 80s and 90s.

Schemes & Initiatives for Empowerment

Women's studies/movement in a number of countries had identified credit as a major constraint on women's ability to earn. The Self Employed Women's Association (SEWA), formed in the early 70s as a private initiative in Gujarat, set up credit programmes as part of a multi-pronged strategy for the organisation of informal sector women workers who had to pay exorbitant rates of interest to informal money lenders. A unique feature of this "trade union" is its contributory social security scheme which covers health, life and asset insurance. It has grown into a very successful, nation wide organisation, attributed primarily to successful politicisation of gender issues at the local level and even at the national level.

Among state initiatives, one of the first schemes, specifically aiming at women's economic empowerment, was the Development of Women and Children in Rural Areas (DWACRA), which is a sub-scheme of IRDP. It was started in 1982-83 on a pilot basis in 50 districts of India but later spread to all districts in the country. Unlike other programmes targeting at the individual or household level, this focussed on groups of 10-15 women each. The groups were introduced to some viable income generating skills and encouraged to function as entrepreneurs for which an initial seed money

Table 9: Share of Women in Employment Generated under Poverty Alleviation Programmes in Rural Areas

Year	Total Number of Families assisted under self employment programmes (IRDP + TRYSEM)* (million families)	Percent Share of Women	Total Number of man days generated under wage employment programmes (NREP + RLEGP + JRY + EAS)** (million man days)	Percent share of women
1985-86	3.2	11.52	564.0	9.67
1986-88	3.9	16.61	701.5	15.47
1987-88	4.4	20.77	674.9	18.05
1988-89	4.0	24.53	691.5	20.75
1989-90	3.6	27.00	864.4	22.04
1990-91	3.1	32.29	873.8	24.64
1991-92	2.8	35.20	809.2	24.01
1992-93	2.3	35.22	782.1	24.69
1993-94	2.8	35.47	1075.3	22.82
1994-95	2.5	35.42	1225.7	22.25
1995-96	2.3	34.16	1239.4	29.67
1996-97	1.7	31.39	730.1	30.52
1997-98	1.8	35.75	639.4	33.40
1998-99	0.6	34.65	221.0	27.94
1999-2000	0.37@	44.09	137.01#	27.13

Source: Mahendra Dev (1999)

IRDP* : Integrated Rural Development Programme
TRYSEN : Training of Rural Youth for Self Employment
NREP** : National Rural Employment Programme (during 1985-89)
RLEGP : Rural Landless Employment Guarantee Programme (during 1985-89)
JRY : Jawahar Rozgar Yojana (since 1989-90)
EAS : Employment Assurance Scheme (since 1993-94)
@ : Sawrozgar Yojana (Swaryarics)
# : Jawahar Grams Samdhi Yojana and EAS

was provided. The idea was that a group would provide greater solidarity and potential for economic activity by encouraging the creation of thrift societies, enabling women to mobilise funds without recourse to middlemen and providing greater access to bank credit, purchase of raw materials and product marketing which would have been difficult for women individually. Over time, recognising women's responsibilities in the household, DWACRA was linked to other programmes for mother and child, and in the areas of health and education to generate mutual exchange of benefits. The programme has been successful in some states such as Andhra Pradesh where the number of groups increased from about 400 in 1992-93 to 25,000 in the late nineties, benefiting close to half a million women. NGOs have been encouraged by Government agencies to take up schemes under DWACRA. However, despite its integrated approach, recognising women's several roles, and its avowed objective of women's empowerment, the scheme has had limited success, due to difficulties of group formation and non-viability of group activities, marketing being one of its weakest points.

In more recent years, the DWACRA emerged in a new garb – that of women's self-help groups propped up by micro-finance programmes in which the NGOs were very active as also several donors. The Indian government formulated several schemes to support such programmes initiated by the NGOs, linking them with the National Bank for Agricultural and Rural Development (NABARD), Rashtriya Mahila Kosh (RMK, another new scheme introduced in 1993 for providing micro-credit to women in the informal sector) and Small Industries Development Bank of India (SIDBI). However, it was with the large political mobilization of women which took place with the Constitutional Amendments in 1993-94, making it mandatory to reserve 33 per cent of elected seats in local level governance structures (the panchayats) for women, that micro-credit to women organised into self-help groups, became the key programme for the economic empowerment of women not only in India but all over the developing world. There are differences in view regarding its transformatory role in terms of changing gender relations; however, that it has enhanced self-worth, self-confidence and perceived

economic contribution of women to the household benefiting the entire family, cannot be denied.

Large political mobilization of women took place with the Constitutional Amendments in 1993-94.

The years 1994-95 and 1995-96 saw panchayat elections across states in India and women's entry in a critical mass for the first time. This political mobilisation in such large numbers made group formation more organic and viable, initially as neighbourhood groups and later as smaller self-help groups to set up micro-enterprises. Group formation whether under DWACRA or panchayats since the early nineties has recorded an overwhelming growth, in the case of the former from about 8043 numbers benefiting 140,000 women to 92,000 groups impacting on almost 2.2 million women. Under the current Plan (Ninth Plan) even under IRDP there is a shift from the individual beneficiary approach to a group and/or cluster approach.

There is no doubt that despite many problems in group formation, DWACRA or self-help group model appears to be a useful approach towards creating employment for women and by facilitating a collectivity of women, attempts to empower them. It encourages the habit of thrift, making the women self-reliant and through assistance from the government in the form of a Revolving Fund, seeks to integrate them into the economy by providing opportunities of self-employment. However, it is also clear that the approach has to go beyond credit and incorporate other components such as child care, reduction in drudgery of women's work, adult education, provision of health services and overall organisation of women, to be really effective and sustainable.

Conclusion

In conclusion, let us throw open the question of lessons to be drawn on the interlinkages between work (increasingly through access to micro-finance) and empowerment. It is clear that the causation is not automatic. It also needs to be emphasised that "empowerment" should not be conceptualised in a narrow unidimensional way which feeds into dichotomous models of change: women are judged to be either empowered or not empowered on the basis of how closely they conform to a particular indicator (Kabeer 2001). Instead, we should see empowerment as an expansion in the range of potential choices available to women and the actual outcomes reflect the particular set of choices the women value. Even where women do not directly control incomes from work, perceptions of their contribution to the household has increased as also increased confidence through interaction with programme staff and groups. A third lesson to be learnt is the imperative to emphasise the nature and quality of employment being generated; the attempt to create self-employment for women through entrepreneurial ventures based on access to credit can result in a conflict between demands of entrepreneurship and obligations of borrowing. Finally, the potential for success is higher where programmes also incorporate an explicit focus on gender awareness and organisation which has helped many groups to challenge unequal property rights, domestic violence and dowry demands.

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Neighbours of the Global Village: Small Farmers from Gujarat

Surashree Shome

After the Indian government started to open its markets in 1991, SEWA has been continuously involved in evaluating the impact of globalization and liberalization on its members. Studies, meetings and workshops were made to delegate the policy issues in favour of its members at national and international levels. This paper summarizes some of the findings of the discussions made with the small and marginal farmers in five districts of Gujarat. Production cost has increased due to use of hybrid seeds, pesticides and chemical fertilizers from 1991 to 2002. Total profit made in rice crops has decreased by six per cent from 1991 to 2002. Use of pesticides and chemical fertilizer has increased soil pollution, due to improper washing of soil due to lack of water. Decrease in income and productivity has resulted in decrease of sustenance as farmers are buying grains from the market and some of them are also opting for occupations other than agriculture to sustain themselves. Use of chemical fertilizer and pesticides have an impact on health, as farmers are complaining about severe headache, fever, skin irritation and other skin related diseases.

Surashree Shome is working as a Project Coordinator of a study on "Impact of Globalisation on informal Sector: Case of SEWA Members", SEWA Academy, Ahmedabad,

Globalization and liberalization policies are enforced not "by design" but "by default" in India. In the late eighties, India went into a serious imbalance of foreign exchange reserve and we had to pledge our gold reserves abroad to borrow money. Moreover, India took loans and assistance from the World Bank and International Monetary Fund (IMF). As in all such cases, these two institutions imposed their terms and conditions for reforms to curb the deficit. Therefore, India had to carry out the necessary reforms by opening its market to participate actively in the process of globalization. The country has progressed by bringing about these changes in its economic policy, in spite of the conditional economic liberalization. The per capita net national product has increased by 39 per cent from 1991 to 1999.

After liberalizing the trade and investment regime, MNCs from the world over were encouraged to invest in crucial public sectors, like agriculture, health care and communication. Through the WTO TRIPs Agreement, corporations have forced changes in patent laws creating patents on seed and life forms. Corporations like Monsanto and Syngenta are pirating centuries of farmers' innovation and patenting rice, cotton, mustard, corn, soya and practically all other food crops (Shiva, 2003). This has certainly changed the face value of agriculture. Availability of a wide range of hybrid seeds, fertilizer and pesticide in the market has given our farmers an opportunity to make use of them.

Large proportions of women working in the informal sector in India are marginalized, segregated and unrecognized. They are often victims of low-discontinuous earnings, insecure job environment, woefully inadequate base for collective bargaining and non-existent support services. SEWA, being a trade union of self-employed women workers in informal sectors, is committed to providing them a package of social security by strengthening their self-reliance and ensuring full employment. It organises the women engaged with in-

formal sectors in rural and urban areas through cooperatives' movements. It became SEWA's prime responsibility to look after the policies that threaten the economic and social status of its members.

Background

SEWA is the largest primary trade women union, registered in 1972, at present with an all-India membership of around 530,000 women. In Gujarat, two-thirds of it's over 369,780 members are from the rural areas. It is a union of poor, self-employed women workers, who depend on the informal sector or small businesses for their livelihood. They are not salaried persons with welfare benefits like workers in the organized sector. They are economically poor, socially backward, illiterate and vulnerable to any socio-economic changes in society. But, it is worth mentioning here that these self-employed people of our country are contributing 64 per cent of the total GDP of the country.

Goal of SEWA is to organize women workers of unorganized sector to provide full employment and self-reliance through the strategy of struggle and development. Struggle is against constraints and limitations for their self-development imposed by society and economic factors, and to avail the new opportunities in the employment sector and to strengthen their confidence and bargaining power.

As a member-based organization, its activities are driven by the needs and demands of its members. A wide range of activities are being implemented covering savings and credit groups, micro-insurance, watershed development, dairy cooperatives and fodder security, agricultural development, forest plantation, drinking water, craft production, salt production and gum collection, health care, child care, functional literacy, mobile ration vans, training and research. Member education is the philosophy of SEWA and basic leadership is provided to all members. (Renana and Kanbur, 2003). These activities are implemented by the members through a number of different institutions established by SEWA including a total of 86 cooperatives (dairy, fodder, grain banks, plantation, ration shops, etc.), of which the largest is SEWA Bank, village committees for integrated watershed development, water users groups for management and operation of village water supply schemes, handicraft associations, urban community slum organisations, health workers and child care workers cooperatives. This reflects SEWA's aim to decentralize decision-making powers, including financial responsibility to the individual institutions and to make members and their organisations self-reliant (Renana and Kanbur 2003).

SEWA has also initiated an "Agriculture Campaign" to educate and bring awareness among small and marginal farmers about technological advancement, inputs required, related research studies and marketing trends. This helps them to increase their yield and consequently, income. It also gives the members a platform to voice their plight to policy makers, researchers and academicians at state, national and international levels.

Methodology

About 47 per cent of SEWA's membership comprises agricultural labourers, small and marginal farmers from rural areas. This paper deals with the impact of various economic reforms on the small and marginal farmers of Gujarat.

The research team has conducted extensive PRAs and group meetings with the small and marginal farmers of five villages in Mehsana, Banaskantha, Vadodara, Surendranagar districts of Gujarat. A checklist was prepared in consultation with experts. Meetings and discussions with key informants were also held to get a critical insight of the emerging scenario. The data collected was analyzed as per the objectives of the study.

SEWA has been working for 10-20 years for the empowerment of women in the selected villages. The women members are benefiting from the various interventions on health, social security and literacy programmes for adolescent girls. Some of the members in the group have also taken loans from the SEWA Bank to purchase agricultural tools, animals and vegetable kits.

Groups Selected for the Study

The selected sample group consists of 15-20 small and marginal female farmers, who are 30 to 55 years old and possess agricultural land of 1 to 5 acres. More than 34 per cent of the people interviewed are illiterate. These women are usually engaged in primary and secondary agricultural activities like field preparation, seeding, sowing, weeding, hoeing, watering, harvesting, winnowing, threshing and packaging.

Findings of the Study

Increase in Agricultural Cost

Due to capital-intensive farming, more and more hybrid seeds, chemical fertilizers and pesticides are used instead of traditional seeds and organic fertilizers. Through our survey, we have tried to estimate the change in the total cost incurred by farmers while grow-

Table 1: Total Expenditure Incurred to Grow Rice During 2002 and 1991 in an Acre of Land

Inputs	2002		1991		Change in prod. cost from 1991 to 2002
	Quantity	Rs.	Quantity	Rs.	(In %.)
Seeds	5 kilos (if it fails then they have to buy 400 saplings for an acre of land, which costs them Rs. 600)	Rs. 150	5 kilos	Rs. 20 (But most of the farmers were using seeds saved from the last crop)	650%
Ploughing	Hired Tractor for a day	Rs. 350	labour for 4 days or hired tractor for a day	Rs. 48 (Labour cost was Rs. 12 per day and cost given for tractor was Rs. 50 per acre)	629% (considering that in 1991 most of the farmers are using labour)
Labour in season	45 days*	Rs. 2250 (Rs. 50 per day/ labour)	35 days	Rs. 420 (Rs. 12 per day/ labour)	636%
Water	Charges paid to irrigation society for canal water	Rs. 95 for one watering given to rich crop	Charges paid to irrigation society for canal water	Rs. 30/- for one watering given to rice crop	217%
Fertilizer	- 1 bag of DAP - 1 bag of Urea - 1 trolley of cow dung with transportation cost	Rs.400/- Rs.300/- Rs.400/-	Cow dung from house	–	–
Pesticide	5 bottles and tablets	Rs. 2000/-	–	–	–
Threshing	It takes 1 hour for an acre	Rs. 300/- (cost for an hour)	Labour takes 10 days	Rs. 120 (Rs. 12 per labour/day)	150%
Total cost incurred		**Rs. 6245/-**		**Rs. 638**	**879%**

Source: By author, developed with the help of interviews.

* Now, labourers are hired for sprinkling fertilizer and pesticides.

ing the major crop, i.e. rice, in the year 1991 and 2002. It is found that production cost per acre for rice has increased by 87.9 per cent from 1991 to 200 (refer to Table 1).

Earlier farmers were using seeds stored from the last crop. Now, with the advent of hybrid seeds, it can't be reused for the next crop. Some of the farmers have tried to reuse the hybrid seed but got very low productivity. The farmer has to buy new seeds each season; which has also increased the production cost.

Table 2: Gross and Net Income from Rice crop during 1991 and 2002

Year	Production (kg/acre)	Gross Income (in Rs.)	Cost price (in Rs.)	Net Income (in Rs.)
2002	1200	9600 (@ Rs 8/kg)	6245	3355
1991	1200	4200 (@ Rs 3.50/kg)	638	3562
% Change from 1991 to 2002	0	229% increase	879% increase	6% decrease

Source: By author, developed with the help of interviews.

Change in Total Profit

It has been observed that the selling price per kilo of rice has increased from Rs. 3.50 in 1991 to Rs. 8/- in 2002. Here, if we consider the net income in both the years, then it was more in 1991 than 2002. Even though the selling price is higher in 1991, the increased cost of production has increased the total production cost of rice, therefore the net profit which was Rs. 3562 during 1991 has decreased to Rs. 3355, an overall decrease of 6 per cent.

Change in Variety of Crop Grown

It has been observed that variety of crop to be grown is influenced more by demand than the market rate. Basmati, Kamod and Jeersar variety of rice, which were earlier grown for higher selling price, are being gradually replaced by Gujri and Gujarat 17 varieties, which have higher market demand.

Increase in use of fertilizer and pesticides

It has been observed that the use of fertilizers and pesticides has increased enormously in the last ten years.

Pesticides were introduced five to six years back in the study villages. It was found through discussions that earlier farmers were using cow dung as manure but at present a bag of urea and pesticides, along with a tractor of cow dung, are musts for the growth of a crop. As a result, the total cost incurred for crop production has increased by Rs. 1100/acre. Inspite of this, the production is almost the same or has increased marginally.

Increase in soil pollution

It has been observed that the increased use of fertilizers has gradually decreased the land fertility. The chemicals applied continue to remain in the farmland, as there is no natural washing due to irregularity of monsoon in the state and adds to the fertilizers being applied in subsequent seasons. This leads to an increase in concentration of a few chemicals and depletion of others in the soil. This adversely affects the production of crops and in the long run leads to ecological imbalance.

The use of pesticides has a dramatic effect on the cost of production. The continuous application of chemicals like pesticides, insecticides and rodenticides increase the resistance to the pests. Thus, the farmers are compelled to use higher dosages of these chemicals to control the pests and insects. This ultimately results in increased unit cost of production and environmental hazards.

The water from Sabarmati river used for irrigation carries untreated wastes discharged by industries. And pollutants are settling in the farm lands and also entering the food chain when the water is used for irrigation. This has also led to several health disorders in the farmers. Some farmers are restoring to the use of gypsum for increasing land fertility, which increases the cost by Rs. 2000 per acre and also leads to soil contamination.

Decreased Sustenance in Agriculture

A decade ago, all the crops were grown without the application of fertilizers and pesticides but with increasing water scarcity (especially in the last 4 years) crops require more inputs and care to grow. Even kharif crops require watering. Yet with all these inputs, the farmer is unsure of good produce. With deteriorating farm conditions, more and more farmers have started depending on the local market for food grains.

Due to scanty and erratic income from agriculture, many farmers are selling off their own lands and moving to urban and semi-urban areas in search of livelihood options. Most of the lands sold were used for developing industries leading to reduction of lands under cultivation.

Preference for Machinery

All the groups have shown an interest towards technological advancement in the agriculture sector, especially towards the innovations which have minimized human drudgery and time consumption. The time saved in a season is used to grow vegetables/fodder in the same areas depending on the availability of water. This helps them to overcome the extra production cost given for mechanization.

Impact on Occupational Safety

The direct and indirect health hazards have increased with the increase in use of fertilizer and pesticide. The group has complained of increased skin diseases. Other infections and maladies were also observed due to continuous body contact with chemicals and polluted water.

Increased demand of water

Chemical fertilizer and pesticides demand more water than traditional fertilizers. Thus, in the arid area of Gujarat, water demand for agriculture has increased immensely. In the last five years ground water levels have gone down from 50-60 feet to 100-400 feet in the villages selected for study, showing high and increased demand for water in the agriculture sector.

Reaching the market

Most of the farmers are selling their products to middlemen, who come to the village during the harvesting period. This helps the farmer save transportation costs but most of the time they are selling their products at relatively lower prices than in the market. Lack of finance for transportation and unavailability of storage facility also restricts interested farmers from selling their products in a wider market.

Conclusion

Following can be concluded with the help of discussions made with farmer groups:

- Lack of proper market opportunity along with increased cost of production have increased the burden on the small and marginal farmers.
- Lack of proper knowledge and information on chemical fertilizers and pesticides usage has increased the production cost, soil pollution and health hazard.
- Though the people realize the occupational

hazards, they do not have the option to avoid them.

- Decreased profit from primary occupation has forced people to migrate or opt for other available occupations.
- Decreased productivity has forced farmers to procure grains for their own consumption from the open market.

Increased water demand has led to increased dependency on ever depleting ground water or polluted river water.

Suggestions

Based on the above made observations, the following steps could be helpful to overcome some of the problems in the agriculture sector:

- *Research and development:* Scientists from agricultural universities should be encouraged to interact with farmers for understanding their problems and needs, and work accordingly. Emphasis should be given on developing the local variety of seeds.
- *Active management of inputs and marketing:* Maximizing the benefits and minimizing the costs requires active management and knowledge of the inputs used and proper utilization of the available wide market. Strategies for management should be developed by documenting the successful cases of interventions made in the agriculture sector and implementing it in other areas.
- *Awareness Programme:* Awareness programme by government institutions and organisations should be conducted about chemical fertilizers and pesticides and their proper use.
- *Skill Enhancement:* Managing and mitigating the negative consequences of present economic reforms will require direct interventions to enhance the skills of the farmer, accessibility to technology and on time knowledge about market trends. These interventions need to combine government action and action by organisations of the poor.
- *Organisation:* The small and marginal farmers need organisations to counteract the economic restraints felt in growing and marketing the product. Organisation is also the sine qua non for representation of the interests of farmers in local, national and global policy making councils, a point also emphasized by the World Bank (2000). Public policy can help by developing an enabling legal and regulatory environment in which membership based organisations of the poor can represent their interests and provide them with the services they need.
- *Measures to prevent health hazards:* Proper research is needed to decrease the occupational hazards. A safety kit should be available in the market at a reduced price.

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Feature

The Balanced Scorecard

Jisoo Yu

This article describes the dynamics of the Balanced Scorecard which is a technique used to measure performance. It helps to formulate policies for a competitive performance. The article describes the various features of the scorecard and the methods of ensuring its successful implementation.

Jisoo Yu is Professor, Department of Business Administration, Kookmin University, 861-1, Seoul-136-702, Korea. Paper presented at the APO-NPC Symposium on Balanced Scorecard for Strategic Growth, 26-29 Nov., 2002, New Delhi.

Several approaches have been attempted in the context of performance measurement. Among these, the Balanced Scorecard developed by Robert Kaplan and David Norton has drawn much attention. The approach was first introduced in 1992 and spread rapidly. A recent survey shows that 50% of American companies now use the approach to help manage their organisations.

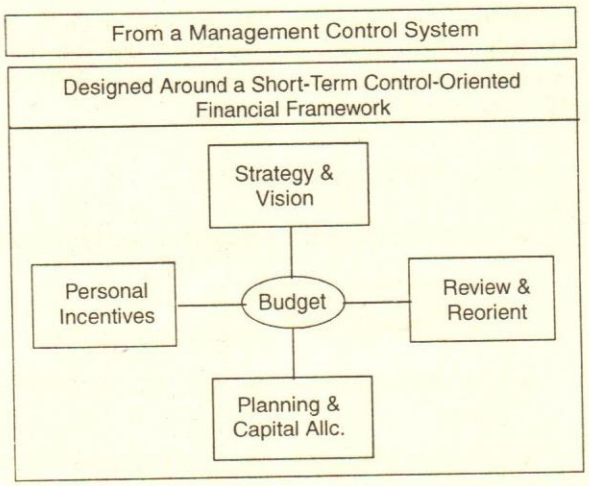
The Balanced Scorecard is a technique to translate strategies into measures that can be understood, communicated, and acted upon. Once developed, it can act as a navigator to guide employees and serve also as a framework for management systems. The approach is depicted below.

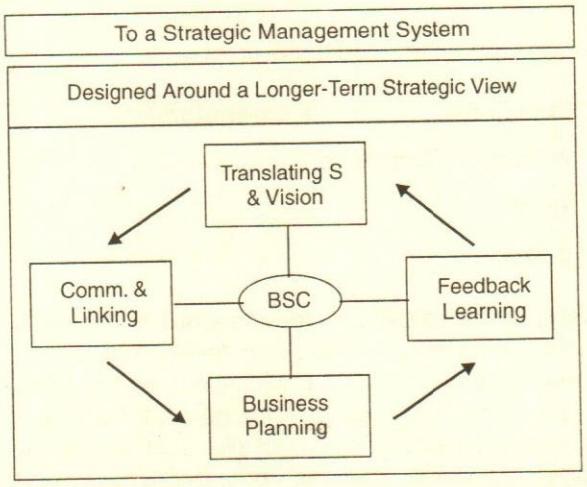
The Balanced Scorecard begins with the premise that financial measures are not enough to manage an organisation. Financial measures only show the past performance. They are not useful in guiding to create future value through investment in customer, supplier, and technology. As Norton put it, the Balanced Scorecard complements measures of past performance (lagging indicators) with measures of future performance (leading indicators).

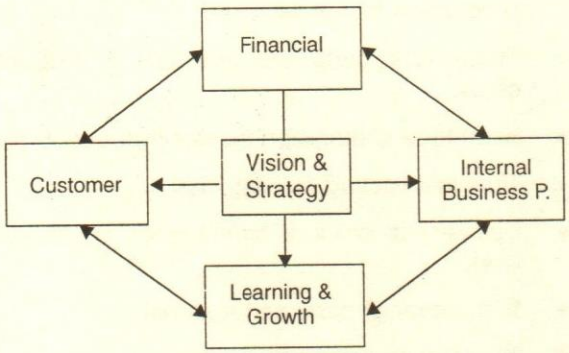
The measures of the scorecard are derived from the vision and strategy of an organisation. The measures are grouped into four perspectives.

First, the financial perspective deals with strategy for growth, profitability, and risk from the viewpoint of the shareholder. Second, the perspective stems from the customer. It relates to strategy of creating value and differentiation from the perspective of the customer. Third, to create customers and shareholders strategic priorities should be given to the internal process. Fourth, the organisation should focus on creating a climate that supports organisational change.

Corporate executives now can use the scorecard to measure how their business units create value for customers. They also can learn how their investments are







made to improve future performance. The scorecard can be an effective tool in revealing the drivers of competitive performance. The scorecard is the mirror of the strategy.

Corporate executives can use the scorecard to measure how their business units create value for customers.

A Guide to Developing Measures

In developing performance systems, the most important and difficult part is what measures are to be used. Developing measures requires investment of time and manpower. To minimize waste through trial-and-error, a systematic approach should be adopted. Here is a methodology of developing measures for reference.

As with developing strategies, visions and so on, developing measures are accomplished through a series of meetings. One person should not direct everything and make all decisions. With proper guidance, the team should spend enough time for discussion and agreement. The following procedure may be taken as reference.

Measurement Meeting 1: Introduction and Planning

- Review progress to this point:
  - Values
  - Strategies
  - The new performance organisations structure
  - Missions
  - Accomplishments
- Review the information on:
  - The failure of measurement
  - Myths about measurement
- Guidelines for developing measures
  - Review the purpose of measurement development.
  - Review the process of measurement development and the agenda for the measurement development meetings.
  - Ask the measurement team to assemble and bring to the next meeting copies of any reports or other documents that contain existing measures of performance.

Measurement Meeting 2: Develop Yardsticks

This is the most important part of the development process. A guideline must be given to the measurement

team on what yardstick be used.

The most common yardsticks used are:

- Standards
- Average Performance
- Target
- Budget

Among these yardsticks, the standard is the most desired one. It is objective and can reflect true performance discrepancies. It also could serve as the basis for standard cost accounting. Management can trace down the source and/or cause of the cost variances. Developing standards requires Industrial engineering (IE) techniques like time and motion study. It is a time-consuming and expensive process. And it is not just a one-time project. Standards like machine hours and man hours are updated regularly to reflect changes of technologies and skills.

There are cases where it is simply impossible to develop standards. For newly designed products, engineers can at best guess how long it takes to produce the new product.

Though the standard can serve as the best yardstick in the context of performance measurement, because of the problems mentioned, it is not widely adopted in industry.

Other alternatives like performance target is used instead. Though setting a target does not require gathering data but a company-wide consensus building process is needed. Measures must be proposed and revised until the majority of employees accept them.

Measurement Meeting 3: Identify or Develop Measures

Three methods of developing measures are introduced below.

Method 1: Selection from Existing Measures

The first method involves reviewing existing measures to see if they are sufficient to serve as indicators. You can adopt the Nominal Group Technique (NGT). NGT is a process for facilitating group discussion.

Method 2: Selection from Sample Measures

It involves reviewing a number of possible measures and selecting those that seem appropriate. Rather than selecting from measures that already exist in your organisation, you select from a list of generic measures. To use this method, you follow the same NGT process. Here are some sample measures.

Production Planning/Scheduling

- % deviation from actual/planned schedule
- % on-time shipments
- % utilization of manufacturing facilities
- % manufacturing facilities at maximum utilization
- % overtime attributed to production scheduling
- % earned on assets employed
- Ratio cost consumables supplies to cost production materials
- Ration cost parts and materials to production costs
- % on-time submission master production plan
- Time lost waiting on materials
- Das receipt of work orders prior to scheduled work
- % turnover of parts and material
- % accuracy order status checks
- % reduction cost of inventory from previous year
- % on-time issuance of daily status report
- No. times actual shop operation starting time greater than X minutes passed scheduled time
- No./lbs./cost delayed orders
- % usage of internal sources for semi-finished materials on components
- % back orders

Personnel

- Personnel costs/average no. of employees
- Recruiting costs/no. of recruits retained
- Training costs/average no. employees
- Cost of wage increases/average no. employees
- Cost of lost production due to labour problems/ average no. employees
- No. man days lost in production due to labour

problems/no. man days worked

- No. man days lost due to absenteeism/no. man days worked
- No. employees who leave/average no. employees
- No. employees one year service/no. employees
- No. employees more than one year service/total no. employees
- Training costs/training days
- Training days/trainees
- Recruiting costs/recruits interviewed
- Recruits selected/recruits interviewed
- Recruits accepting/offers made
- No. recruits remaining on job twelve months/no. recruits accepting employment
- No. accidents or time lost due to accidents
- Ratio supervisors or managers to work force
- Benefit cost as % of compensation
- % implementation of performance appraisal recommendations
- % accuracy of employee answers on company knowledge test
- % sick leave utilization
- % errors in processing personnel records
- No. requests for transfer
- Cost of testing applicants
- % tardiness
- Ratio of employees available for promotion to total employees
- % adherence to job classification/reclassification schedules
- % new hires completing orientation within X days
- % supervisors and managers completing basic supervision training within X days of promotion or appointment to position
- % new supervisors or managers completing basic supervisor training
- Cost hours of outside training
- % assessments of outside training submitted on time
- % insurance claims processed on time

Marketing/Sales

- Total dollar sales
- Ratio of actual to projected sales
- % new account sales
- % new product sales
- Total no. new orders, accounts, new product orders
- Total no. accounts
- Gross margin
- Marketing and sales expense
- Total sales/quotations
- Total sales/orders
- Total dollar sales/sales expense
- Sales expense as % of dollar sales
- No. sales per salesperson per day
- Total sales/calls
- Total quotations/total sales calls
- New account presentations/new account calls
- New product presentations/new product calls
- Sales expenses/total calls
- Profit as % of total sales
- Sales this year/base year sales
- % previous year sales
- Sales growth in real (inflation adjusted) terms
- Accounts receivable/average daily sales
- Selling man-hours/dollar sales
- No. units sold/man weeks
- No. new customers gained
- Dollar revenues/dollar sale costs
- Dollar revenues/dollar sales quota
- No. prospects per week
- Average quality rating of prospects
- Profit before tax (PBT)
- Capital turns
- Number rebuys

- Return of capital
- Sample expense-% of sales
- Travel and entertainment-% of sales
- Cost/no. invoices past due
- % accuracy sales forecast
- % pricing variations to standard

Purchasing

- Dollar purchases made
- % purchases handled by purchasing department
- Dollar purchases by major type
- % purchases/dollar sales volume
- % "rush" purchases
- % orders exception to lowest bid
- % orders shipped "most economical"
- % orders shipped "most expeditious"
- % orders transportation allowance verified
- % orders price variance from original requisition
- % mail not metered
- % "personal" mail
- % orders "cash discount" or "early payment discount"
- % major vendors-annual price comparison completed
- % purchases-corporate guidelines met
- Elapse time-purchase to deliver
- % purchases under long-term or "master contract"
- Dollar adjustment obtained/dollar value "defective" or "reject"
- Purchasing costs/purchase dollars
- Purchasing costs/no. purchases
- Dollar value rejects/dollar purchases
- % shortages
- Dollar value rejects/dollar purchases
- Dollar value orders outstanding/average daily value purchases
- % dollar inventory/dollar sales
- Average cost per requisition
- Average lead time for purchases
- Average time purchase request for issuance of purchase order
- Ratio of no. requisitions received to forecasted
- Vendors or suppliers % on-time performance
- Vendors or suppliers quality rating
- Vendors or suppliers % standards conformance
- Stock outs per time period indexed to inventory costs
- % purchase order changes

General Manufacturing

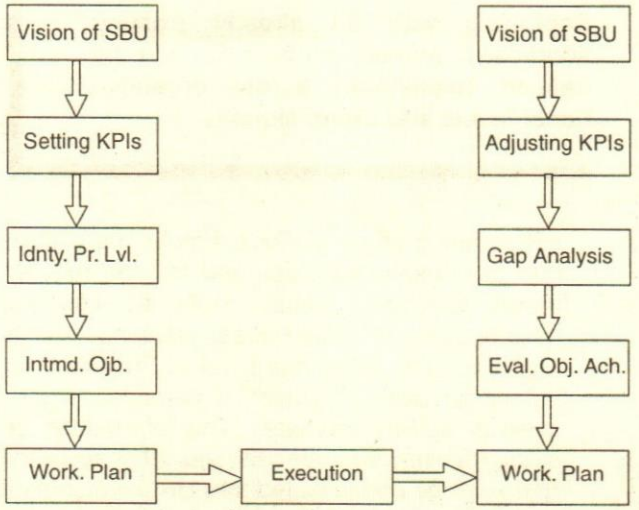
- % downtime by machine type
- % reworkable waste
- % non-reworkable waste
- % operator efficiency to standard by type of operation
- % quality checks different from standard by type of check
- No. investigated accidents
- No. first aids (minor accidents, uninvestigated)
- % machine efficiency to standard by type of machine
- No. machine stops due to operator errors
- Direct labour dollar variance to planned
- Total dollar variance to planned
- % attendance/absenteeism
- % turnover
- % shrinkage over standard
- % lots completed on time
- % lots late due to plant
- % maintenance hours
- % reworks or rehandles
- % scrap by type of scrap
- Actual man hour/standard man hour
- Actual machine hour/standard machine hour
- Market quality/production-line quality
- Time taken from order receipt to delivery

- Actual/budget costs
- R&D costs/company profit contribution (actual or estimated)
- No. or dollar value of new products developed (last year, five years)
- No. or dollar value of process improvements (last year, five years)
- No./% hours overtime
- No./% hours on scheduled assignments
- R&D total costs as % of gross (or net) sales
- % cost reduction objectives met
- % product development delivery (target) dates met
- No. years payout of research investment (actual or projected)
- % product development actual/planned costs
- Ratio no. R&D managers to no. R&D employees
- Ratio No. R&D postgraduate/R&D graduate (or nongraduate) staff
- Ratio R&D support/R&D technical staff
- % turnover (technical personnel)
- Dollar value (actual or estimated) of new products or process improvements to total R&D cost

Measurement Meeting 4: Review of Selected Measures

Once the measures are selected, they should be put into a performance measurement model like BSC. They should be reviewed again in the light of the practicability and the holistic aspects of measures. The BSC model should be a good tool to judge the balanced alignment of measures. The validity and the relevancy of measures should also be conducted.

It is desirable to incorporate the measures into business planning. The target performance translated in measures can give employees clear guidelines. Employees can act accordingly. At the end of the planning year, the management can use a single platform, that is, the target performance measures to evaluate the teams, the departments, the strategic business units, and the individuals. In this way, the integration of the management process and the evaluation process can be achieved.



ERP Solution to Facilitate the Design of Effective Balanced Scorecard

Some ERP vendors incorporated the balanced scorecard into their solutions. They support the development and maintenance process of a Balanced Scorecard through the following functionality:

- Definition of strategic objectives and initiatives by the four perspectives of the Balanced Scorecard.
- Definition of an influence diagram (cause-and-effect linkage) to visualize dependencies among strategic objectives on a Balanced Scorecard.

Standard templates are provided as a starting point for users to begin modeling their strategies.

- Definition of strategic measures for strategic objectives. The selection of measures is facilitated by the availability of industry-specific KPI catalogs. These catalogs can be extended through individually defined KPIs through the use of the KPI Builder. KPIs in a Balanced Scorecard are automatically populated with appropriate data from ERP systems or external sources.
- Definition of multi-scorecard dependencies and linkages. Beginning with an already existing scorecard, related scorecards can be defined consistently across organisational levels and dimensions.
- Target setting for KPIs integrated across various levels and dimensions of the organisation. The definition of targets is directly integrated with enterprise planning, resource allocation and the

Beginning with an already existing scorecard, related scorecards can be defined consistently across organisational levels and dimensions.

HR planning process. For example, the evaluation of competency gaps and training requirements can be directly input as planning assumptions in Web-based planning sheets together with other plan values relevant for enterprise planning such as personal targets, sales or activity estimates. This information on skills, training requirements and other resource gaps can be consolidated into HR development and investment plans. Ultimately, final plan values are transferred back to the ERP, HR development and payroll systems.

- Scenario-based planning and simulation.

Once the Balanced Scorecard is developed and in place, ongoing performance monitoring is supported through:

- Single and multiple Balanced Scorecards displaying objectives and measures with targets and actual results for review and assessment by managers and staff. Each scorecard includes the capability for interactive simulation to support performance review and decision-making sessions and the ongoing definition of new initiatives and programmes needed to achieve strategic targets.
- One vendor solution includes visuals and graphics display tools called a management cockpit. It supports performance assessment and decision-making through interactive measurement drill-downs and simulation capabilities.
- Balanced Scorecards with the relevant KPI targets and actual results for important stakeholder groups. The scorecards can be accessed through a Web browser or used within the management cockpit room to support management, stakeholder, and analyst meetings.

How to gather data to develop measures

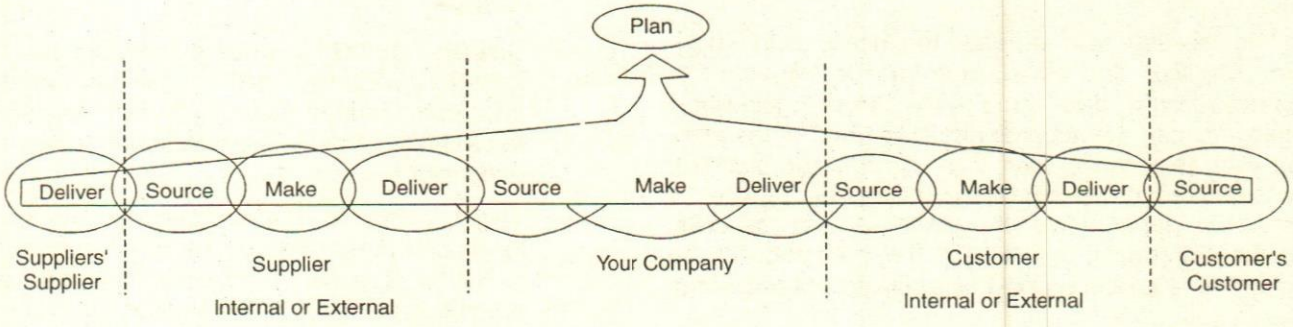
ERP is not an option but an imperative. To develop measures, accurate data must be collected timely. It happens sometimes that scraps are not reported and reworks are done without proper approval. Data do not reflect the actual performance. The advantage of ERP is that data are created and stored as work progresses. The integrated feature of ERP system prevents data manipulation by an individual and/or business unit. For example, the system does not allow process reworks without creating and releasing new production orders.

Why is it difficult to develop valid measure?

Take an example of the measure; % dollar sales for the purchasing department. The level of inventory may be under the control of the purchasing department. The authority of determining the inventory level is given to the sales department or the production department. The level of inventory could be high because of the business conditions. The lot size of procurement has to be large to take advantage of discount. Or the raw material shortage compels the purchasing department to secure the material in advance.

Extension to Supply Chain

Efforts were made to develop performance indexes for supply chain. The Supply Chain Council (SCC) spearheaded the development of a performance measurement model for supply chains. SCC is a non-profit, independent organization, organized in 1996. It has developed and endorsed the Supply Chain Operations Reference (SCOR) Model as the cross-industry standard



for supply chain management. The SCOR Model is founded on four distinct management processes.

The Supply Chain Council (SCC) spearheaded the development of a performance measurement model for supply chains.

Experience has shown that developing a roadmap to achieve performance objectives for the supply chain has been difficult:

- Communicating objectives across the supply chain
- Choosing between supply chain improvement options
- Identifying the Return on Investment projects
- Monitoring and managing the performance of the improved supply chain

Many corporations' efforts failed because they were not able to link supply chain objectives with business objectives; to understand the performance requirements of each link in the supply chain; to communicate within the implementing organisation and between supply chain partners; and to link supply chain improvement programme management with performance objectives.

For those who are having difficulties in installing measurement systems, the SCOR Model can serve as a reference.

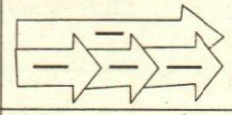
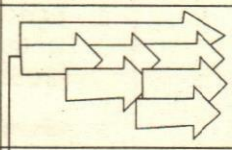
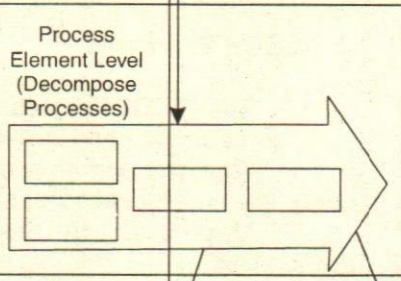
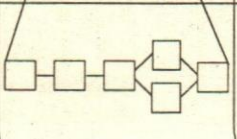
SCOR Model

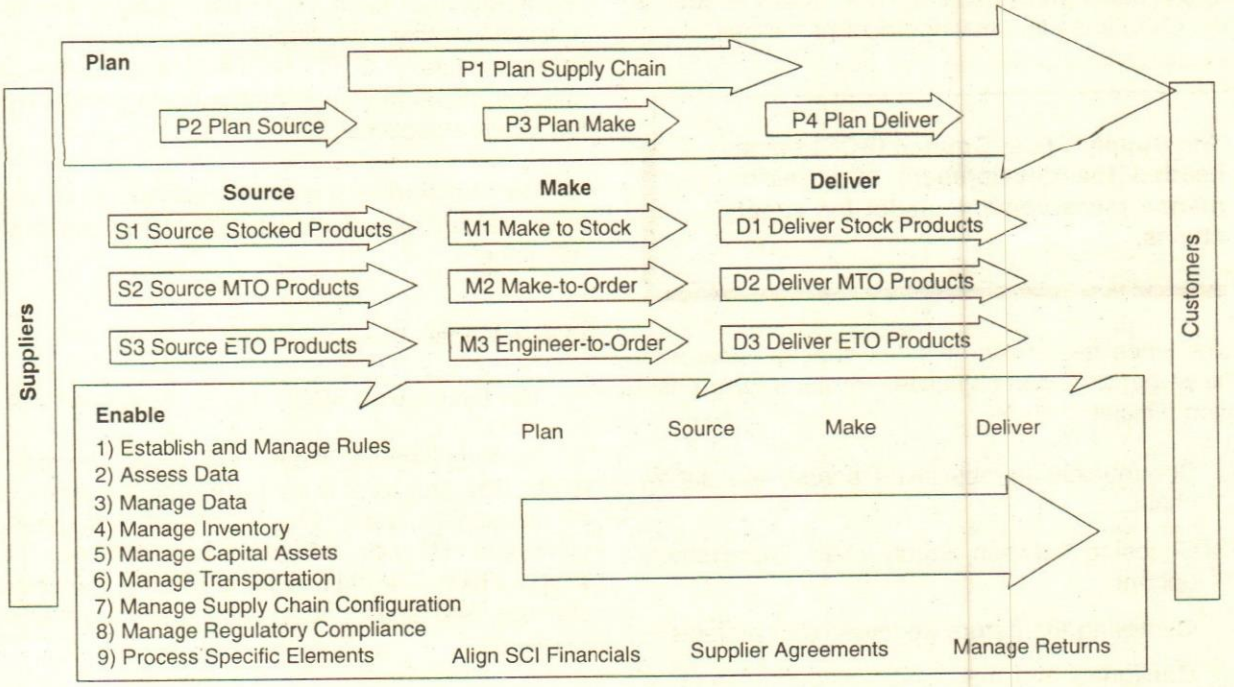
The overview of SCOR model is depicted below.

As the diagram shows, the model consists of 4 levels. The first level is to set the performance targets of the supply chain. The next level is to implement operations strategy, reflecting characteristics of your supply chain. The third level is refining the operations strategy. And finally, adopt practices to enhance performance.

Examples of Measures Used in SCOR Model

Developing measures for a supply chain is as difficult as for a company. Here are some examples of measures for supply chain performance.

	Level #	Description	Schematic	Comments
Supply Chain Operations Reference-model	1	Top Level (Process Types)		Level 1 defines the scope and control for the Supply Chain Operations Reference-model Here basis of competition performance targets are set
	2	Configuration Level (Process Categories)		A company's supply chain can be ``configured- to-order" at Level 2 from approximately 24 crore ``process categories". Companies implement their operations strategy through their unique supply chain configuration.
	3	Process Element Level (Decompose Processes)		Level 3 defines a company's ability to compete successfully in its chosen markets and consists of: Process element definitions Process element information inputs and outputrs Process performance metrica Best practices, where applicable System capabilities required to support best practices Systems tools Companies ``fine tune" their Operations Strategy at Level 3
Not in Scope	4	Implementation Level (Decompose Process Elements)		Companies Implement specific supply chain management practices at this level Level 4 defines practices to achieve competitive advantage and to adpat to changing business conditions



Performance Attributes	Metric
Cycle Time	Schedule cycle time Schedule interval
Cost	WIP inventory days of supply Material losses Scheduled resource cost
Service Quality	Schedule achievement
Assets	Capacity utilization

Other performance measures could include:

Delivery performance

Order fulfillment performance

- Fill rate
- Order fulfillment lead time

Perfect order fulfillment

Supply-chain response time

Production flexibility

Total logistics management cost

Value-added productivity

Warranty cost or returns processing cost

Cash-to-cash cycle time

Inventory days of supply

Asset turns

Performance measures should be an effective tool to trace the source of problems in the supply chain. It is, however, a daunting task to develop performance measures that could trace the source of inefficiencies in the supply chain. As many corporations increasingly form a complex network of collaboration, interdependencies among business units also increase. The increased interdependencies make it hard to achieve the traceability. Like developing systems for a corporation, supply chain partners should cooperate in developing performance measurement systems.

Performance measures should be an effective tool to trace the source of problems in the supply chain.

SCOR Processes

The SCOR processes comprise three phases: source, make, and deliver. Every company that plans to install the performance systems should have complete understanding about its own supply chain. The SCOR process can serve as a good reference in this context.

Using an analysis framework like the SCOR process, a thorough analysis of the supply chain process should be conducted. Measures must be developed, based on full knowledge of the supply chain.

	Supply Chain Scorecard v. 3.0		Performance Versus Competitive Population			
	Overview Metrics	SCOR Level 1 Metrics	Actual	Party	Advantage	Superior
EXTERNAL		Delivery Performance to Commit Date	50%	85%	90%	95%
	Supply Chain Reliability	Fill Rates	63%	94%	96%	98%
		Perfect Order Fulfillment	0%	80%	85%	90%
		Order Fulfillment Lead times	7 days	7 days	5 days	3 days
	Flexibility & Responsiveness	Production Flexibility	45 days	30 days	25 days	20 days
INTERNAL	Cost	Tota Logistics Management Costs	10%	13%	8%	3%
		Warranty Cost	NA	NA	NA	NA
		Value Added Employee Productivity	$122K	$156K	$306K	$460K
	Assets	Inventory Days of Supply	119 days	55 days	38 days	22 days
		Cash-in-Cash Cycle Time	196 days	80 days	46 days	28 days
		Net Asset Turns (Working Capital)	2.2 turns	8 turns	12 turns	19 turns

Scorecard of Supply Chain

Like the case of performance systems for a company, the scorecard can be completed for a supply chain. Here is an example.

Conclusion

Realizing vision and strategies must be supported by effective measurement systems. The business solutions like ERP can be useful tools in installing an integrated performance measurement system. Though ERP can be valuable, it is still just a tool. Designing measurement systems cannot be done automatically by business solutions. It takes human effort. Developing effective performance measurement systems demands innovative ideas, knowledge about the business processes, awareness, and teamwork.

Reference

David Norton (1999), SAP Strategic Enterprise Management- Translating Strategy into Action: The Balanced Scorecard, May, The Balanced Scorecard Collaborative, Inc., and SEM Product Management, SAPAG.

Joseph H. Boyett and Henry P. Conn (1995), Maximum Performance Management, Capstone.

Scott Stephens, Supply Chain Council & Supply Chain Operations Reference Model Overview. □

Chance favours the prepared mind.

– Louis Pasteur

Feature

Concurrent Engineering in New Automobile Design

Subrata Mitra & Bani K. Sinha

Concurrent Engineering (CE) has gained importance in the light of increased competition and globalization. CE provides a competitive advantage to companies by helping them reduce the product development cycle. For example, in automobiles, Japanese companies have been able to cut down product development time with the help of CE, and now, on an average, take 60% of the time to roll out a new car model as compared to U.S. and European manufacturers. The ability to quickly introduce new car models puts Japanese manufacturers ahead of competition. This paper demonstrates, through an illustration, how grouping of activities can be done for CE in designing new automobiles. A clustering algorithm, called Bond Energy Algorithm (BEA), is employed to identify design activities, which can be executed simultaneously. It is found that the results conform to the kind of schedule followed by Japanese automobile manufacturers.

Subrata Mitra and Bani K. Sinha are with the Indian Institute of Management Calcutta, Joka, Diamond Harbour Road, Kolkata.

Application of Concurrent Engineering (CE) in construction and manufacturing industries worldwide has gained importance in the light of increased competition and globalization. CE provides a competitive advantage to construction projects by enabling them to complete earlier than the normal duration, thereby reducing the payback period and increasing the useful life of projects. CE also improves the project effectiveness in terms of cost and quality, and in turn the overall productivity of project organizations. According to Gunasekaran and Love (1998), CE is a multi-disciplinary team approach for construction, which can be achieved by introducing the contractor, major subcontractors and suppliers during the design phase of the project. Ngowi (2000) presented a study of how implementation of CE in the procurement system could alleviate some of the problems that the construction industry in Botswana was facing. Another study done by Dey (2000) on the infrastructure construction projects of the Indian petroleum companies shows how CE could reduce the project completion time to half the normal duration.

In the context of manufacturing industries, CE is also known as Integrated Product Development (IPD), which implies simultaneous design of the product and the processes. A recent study (Koufteros et al. 2001) indicates that firms that experience a high technological and product change in their environment are using more CE practices. CE helps companies shorten the product development cycle and quickly bring products to market. Reported reductions are of the order of 30-70% of the total development time (Jarvis, 1999). Because CE helps companies bring products to market ahead of competition, it also enables them to charge premium prices before the competitors offer similar products, and achieve faster and higher Return on Investment (ROI). The product life cycle becomes longer than before. CE is a multi-disciplinary approach involving Marketing, Finance, Design, Engineering, Manufacturing and Quality Control, and it is concerned with all elements of the product life cycle from conception

through disposal. Since CE involves cross-functional teamwork, preferably a team of 4-12, it requires fewer design changes in subsequent manufacturing stages, thereby saving significant development time, and it also results in higher quality of product and higher productivity (Prasad, 1997).

In product design, the bulk of production costs are typically established at the conceptual design stage. In automobiles, approximately 80% of the overall product manufacturing/assembly cost is committed at the end of the design process. This indicates that automotive design and assembly system modelling at an early stage of the CE process is important (Ashton & Ranky, 1998). The Japanese automobile companies have successfully implemented CE principles. Clark & Fujimoto (1987) reported that while the average time taken from first design to customer delivery by U.S. and European automakers was 60 months, Japanese companies rolled out a new car in 40 months, a saving of one-third in development time. The situation has not charged since then as Pawar and Riedel (1994) observed that Japanese industry needed only about 60% of the time and half the people to develop a car as compared to European industry. Of course, there are exceptions like Rolls-Royce, which introduced a CE programme in 1991 to reduce the development time of a particular car model from seven years to three years to meet Japanese standards (Tang, Jones et al., 1997). Quicker introduction of new car models with the help of CE is one of the competitive advantages that the Japanese automakers enjoy over their U.S. and European counterparts.

Quicker introduction of new car models with the help of CE is one of the competitive advantages that the Japanese automakers enjoy over their U.S. and European counterparts.

Most of the papers in literature deal with the benefits and implementation issues of CE in a project environment, be it construction or new product development. They highlight the changes required in the organizational structure and culture, and emphasize on better communication and coordination among functions for effective implementation of CE (See, for example, Wilson & Wilson, 1994; Schmidt, 1997; Paashuis & Boer, 1997; Tucker & Hackney, 2000). Very few papers deal with the issue of actually identifying the tasks, which can be performed concurrently. For example, Dowlatshahi (1999) presented a CE approach to the design issues in manufacturing, packaging and transportation in the early phases of product design and development. A recent paper by Denker, Steward and Browning (2001) introduces an approach known as the Dependency Structure Matrix (DSM), which develops task dependencies based on information dependencies. This approach reduces the number of iterations, and hence the product development cycle time, in a CE environment. If tasks are scheduled in parallel without considering their dependencies, this can lead to additional iterations and increased cycle time. The approach in this paper has been to make use of a clustering algorithm to group the activities, which have common design parameters and should be considered for simultaneous execution. This is demonstrated with the help of an illustration in the context of new automobile design.

Design Parameters in Automobiles

The first step in the process of identifying the activities to be carried out simultaneously is to decompose the project into a number of *sub-systems* (SS) based on functional requirements. Each sub-system can be further subdivided into a number of manageable and homogenous units called *modules* (M). Each module, in turn, can be further subdivided into a number of *design factors* (DF).

New product development in automobiles is a very expansive and complex process, and requires the coordinated functioning of several departments. For demonstration purpose, we consider three most critical sub-systems in automobile design, namely Power Train Engineering, Body Engineering, and Paint Shop Design and Operations, which are also high lead time activities. The sub-systems are further broken down into modules and design issues, which are listed below.

Power Train Engineering (SS1)

This sub-system includes design and manufacture of the engine and gearbox assemblies for the automobile, and therefore constitutes functionally the most important activity in the development of a new car. Owing to highly stringent quality standards involved in this activity, the lead time also tends to be on the higher side.

(a) Engine design (M1): This module represents the first and most important step in the power train design and its outcome affects the overall quality of the final product.

- Power and fuel specifications: Initial power and fuel specifications are the major parameters, which differentiate the product from the competitor's offer.

- Engine design, prototype and testing: Specific designing of an engine follows the power and fuel specifications. The first prototype of the engine is developed and is tested under varying conditions, if possible with the prototype of the body of the vehicle itself.
- Plant and machinery and construction: Subsequent to the engine design, process planning for its manufacture is decided and accordingly, the plant and machinery required for the same is planned and acquired. Details regarding the construction of the engine shop are specified to the central construction department or contractor.
- Plant services: The plant services in the form of air, water and power are specified to the central services department or is sourced specifically for the engine shop.

(b) Gear Box design (M2): The design and manufacture of gear box assembly is also a critical activity, and involves a high degree of complexity.

- Engine specifications: This includes all the aspects of engine design relevant to the design of the gear box.
- Gear Box design, prototype and testing: The design of the gear box is started after receiving guiding instructions from engine design. Once the prototype of the gear box is ready, it is to be tested with the engine. This engine – gear box test is very important for the effective functioning of both, subsequently, and has to be successfully accomplished at this stage.
- Plant and machinery and construction: Subsequent to the gear box design, process planning for its manufacture is decided and accordingly, the plant and machinery required for the same is planned and acquired. Details regarding the construction of the shop are specified to the central construction department or contractor.
- Plant services: The plant services in the form of air, water and power, are specified to the central services department.

(c) Assembly and testing (M3): This module deals with assembly and testing of the prototype of the vehicle. This stage has to meet the standards decided by the designers and cannot be postponed.

- Power train specifications: The overall specifications for the power train of a vehicle are tested for their compliance with the engine and gear box designs as accomplished in the previous modules. The method involved for doing so is planned in this section.
- Plant and machinery: The equipment required to accomplish the above mentioned test is very sophisticated and capital intensive. Its planning and acquiring is dealt with in this section.
- Plant services: The plant services in the form of air, water and power are specified to the central services department.

Body Engineering (SS2)

Strategically, this activity assumes the highest importance in terms of being the first facade of the product visible to both customers and competitors. Also, the design standards set in this activity are extremely tight and sophisticated. It is the one aspect whose effective implementation would ensure repeatability and manufacturability of the product. This activity, again, is very capital intensive and of a very high lead time.

(a) Body design (M4): This module deals with designing and making of the prototype of a motor car. It is a very iterative process and the final outcome is very much dependent on the fancies of the top management and compliance from the rest of the design teams.

- Prototype design: This could be done internally or by outside agencies. Nowadays, owing to the presence of a number of specialized firms in this area, a lot of automobile companies are resorting to getting this job done externally.
- Body specifications: Subsequent to the prototype design, is the setting of body specifications, in terms of the sheet metal and the matching tolerance required.
- Block design and assembly design: This activity involves the panel divisions made in the body and serves as an input to the die design and weld planning activities.

(b) Die design (M5): Die design is a capital intensive and technologically critical module. For critical panels (the outer ones), development is done internally. For not so critical panels like inner panels and reinforcements, development can be outsourced.

- Panel specifications: This activity is an antecedent to the die design activity, though ex-

perienced die designers do start their rough-cut operations before the panel specifications are complete on paper.

- Die design: The outcome of this activity decides the overall quality in terms of aesthetics of the vehicle.
- Installation and commissioning : Subsequent to the die design, die shop commissioning and installation of machinery follows. Details regarding the construction of the die shop are specified to the central construction department or contractor.
- Plant services: The plant services in the form of air, water and power are specified to the central services department or is sourced specifically for the die shop.

(c) Weld design (M6): This module ensures the overall quality of the vehicle. It is also, the "bottleneck" area in terms of the throughput time.

- Weld process planning: This activity starts after the body design and decides the overall throughput time on the assembly line, and is also the chief determinant of the body's quality.
- Plant and machinery and construction: Subsequent to the weld process planning, weld shop construction and installation of machinery follows. Details regarding the construction of the weld shop are specified to the central construction department or contractor.
- Plant services: The plant services in the form of air, water and power are specified to the central services department or is sourced specifically for the weld shop.

Paint Shop Design and Operations (SS3) (M7)

Nowadays, paint technology has come a long way with automobile majors having state of the art paint shops, flexible enough to accommodate a number of models. Owing to differentiation in terms of the outer paint finish forming an essential part of the overall product, application of the best technology in this area assumes high significance.

- Paint specifications: Following panel specifications is the setting of specifications in terms of the paint requirements of the vehicle.
- Paint process planning: The process planning in the paint shop is the most important activity as most of the operations in this shop are process-based and very little human intervention is possible.
- *Plant and machinery and construction:* Subsequent to the paint process planning, paint shop construction and installation of machinery follows. Details regarding the construction of the paint shop are specified to the central construction department or contractor.
- Plant services: The plant services in the form of air, water and power are specified to the central services department or is sourced specifically for the paint shop.

The design factors relevant to the above mentioned modules are as follows.

- Power and fuel specifications
- Engine design
- Gear Box design
- Body specifications
- Block design and assembly design
- Die design
- Weld process planning
- Paint specifications
- Paint process planning
- Assembly and testing plant and machinery
- Assembly and testing plant services
- Engine and Gear Box shop plant and machinery
- Engine and Gear Box shop plant services
- Engine and Gear Box shop construction
- Die shop installation and commissioning
- Die shop plant services
- Weld shop plant and machinery
- Weld shop plant services
- Weld shop construction
- Paint shop plant and machinery
- Paint shop construction
- Paint shop plant services

Application of Concurrent Engineering

Application of CE requires identification of modules, which share common design factors. An incidence matrix is to be constructed with rows representing

modules and columns design factors. An element of the matrix, a_{ij}, is assigned the value 1 (0) if design factor j is (is not) an essential requirement for module i. The assignment of binary numbers poses a challenge to the designer requiring judgment and experience. A clustering algorithm, called Bond Energy Algorithm (BEA), is subsequently employed to obtain the independent clusters of modules and design factors. The reason for choosing Bond Energy Algorithm (BEA) is that its performance is superior to other array-based clustering algorithms such as Rank Ordering Clustering (ROC) and Direct Clustering Analysis (DCA) (Chu and Tsai, 1990). Also, compared to other sophisticated clustering algorithms such as Augmented Linear Clustering (ALC) and Artificial Neural Network (ANN) based algorithms, the performance of BEA was found reasonably satisfactory for medium-sized industry problems (Kaparthi and Suresh, 1994).

Bond Energy Algorithm (BEA)

BEA has wide applications in Group Technology, Manufacturing Cell Formation and Relational Database Management Systems. The purpose of the algorithm is to display the natural variable groups and their interrelations by permuting the rows and columns of an input matrix (McCormick et al, 1972). BEA seeks to maximize the Measure of Effectiveness (ME), a measure of the density of bonds between neighbouring elements of the input matrix. For a matrix with m rows and n columns, the ME is given by

$$ME = \frac{1}{2} \sum_{i=1}^{m} \sum_{j=1}^{n} a_{ij} \left[a_{ij+1} + a_{ij-1} + a_{i+1j} + a_{i-1j} \right]$$

with $a_{oj} = a_{m+1j} = a_{io} = a_{in+1} = 0$

The flowchart of the algorithm is shown in Fig. 1.

Results and Discussions

Table 1 below shows the assignment of design factors to modules and the ME value of the incidence matrix. BEA takes this unclustered matrix as input and produces a clustered output matrix as shown in Table 2. The ME value has also improved to 39.

It is seen from Table 2 that there are distinct groups of modules, called Module Families (MF), and design factors, called Design Factor Families (DFF), indicating activities that can be executed simultaneously. It may be noted that a number of iterations of the algorithm may be required before a meaningful result is obtained. The descriptions of the module families are as follows.

Table 1: Input Incidence Matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	1	1	1									1	1	1								
2	1	1	1									1	1	1								
3	1	1	1							1	1											
4				1	1	1																
5				1	1	1									1	1						
6							1										1	1	1			
7								1	1											1	1	1

ME = 33

Table 2: Output Clustered Matrix

	19	18	17	7	8	22	21	20	9	11	10	3	2	1	14	13	12	6	5	4	16	15
4																		1	1	1		
5																		1	1	1	1	1
2												1	1	1	1	1	1					
1												1	1	1	1	1	1					
3										1	1	1	1	1								
7					1	1	1	1	1													
6	1	1	1	1																		

MF 1 MF 2 MF 3 MF 4

ME = 39

MF 1: Weld shop design and construction

MF 2: Paint shop design and construction

MF 3: Engine and Gear Box design and testing; plant and machinery and shop construction

MF 4: Body design; die design and die shop construction

The result is similar to the kind of schedule followed by Japanese automobile manufacturers. Engine and Gear Box design and Body design activities can be started simultaneously. Construction of the Assembly and testing facility can commence with Engine and Gear Box design such that the prototype can be tested as soon as the preliminary design is complete. After testing, Engine & Gear Box shop construction activities can be initiated. Body design will be subsequently followed by die design and die shop construction. Weld shop design and construction can start after body design with weld process planning. Paint shop activities, on the other hand, can be started from the beginning of the project independent of the rest of the activities. This is owing to the fact that nowadays paint shops are flexible enough to accommodate a lot of models, and also involve activities with long lead times. Figure 2 (not drawn

to scale) shows the Gantt chart of concurrent execution of different module families.

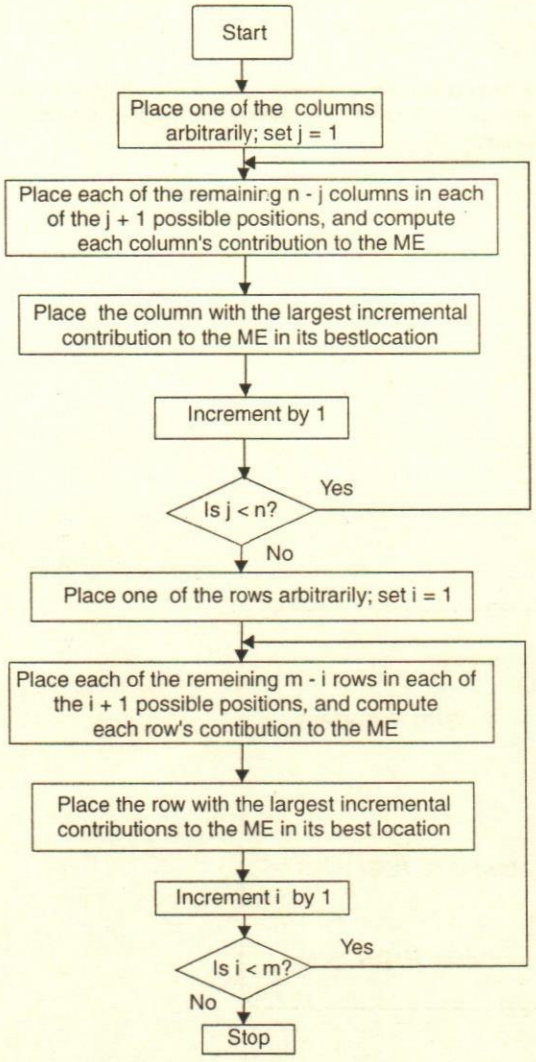


Fig. 1. Flowchart of the Bond Energy Algorithm

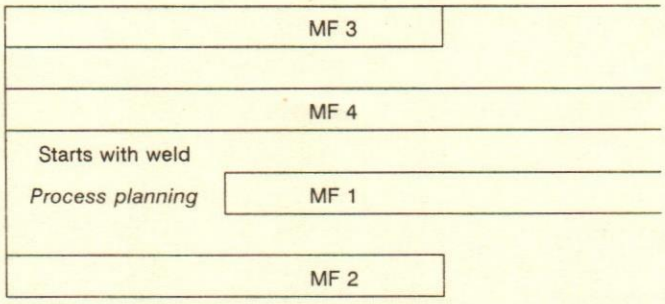


Fig. 2. Gantt chart showing overlapping module families

Conclusion

This paper demonstrates, through an example, the role of CE in the design of new automobiles. A clustering algorithm, called Bond Energy Algorithm (BEA), has been applied to identify the groups of design activities, which can be performed simultaneously. It has been found that the grouping of activities thus obtained has a similarity with the kind of schedule followed by Japanese automobile manufacturers. BEA has been chosen for grouping of activities due to its superior or comparable performance vis-à-vis other clustering algorithms for medium-sized problems. But as the size of the problem increases, BEA takes a longer time to solve, and in that case algorithms based on neural networks would be appropriate in terms of superior solution quality and execution time.

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□

The more opinions you have, the less you see.

– Wim Wenders

The most important thing in communication is to hear what isn't being said.

– Peter F. Drucker

Feature

Quality Optimization of Turned Parts (EN24 Steel) by Taguchi Method

Hari Singh & Pradeep Kumar

The objective of the present paper was to obtain an optimal setting of the turning process parameters viz. cutting speed, feed, and depth of cut, which may provide an optimal surface roughness to En24 steel (0.4% C, 220 BHN), a difficult-to-machine material, by using a titanium carbide coated carbide tool. The effect of selected process parameters on the surface roughness of En24 steel turned parts and the subsequent optimal settings of the parameters were accomplished using Taguchi's parameter design approach. The results indicate that the selected process parameters significantly affect the mean and variance of surface roughness of En24 steel turned parts when machined by titanium carbide coated carbide tool. The per cent contributions of parameters as quantified in the S/N pooled ANOVA envisage that the relative power of feed (61.47%) in controlling variation and mean surface roughness is significantly larger than that of cutting speed (9.97%) and depth of cut (17.64%). The predicted optimal value of the surface roughness is 76.18 ru. The results have been confirmed by conformation experiments.

Hari Singh is Lecturer, Department of Mechanical Engineering, NIT, Kurukshetra, India. Pradeep Kumar is Associate Professor, Department of Mechanical & Industrial Engineering, IIT, Roorkee.

In order to provide satisfaction to the customer and to stand in the competitive market, the producer has to acknowledge that considerable advantage can be obtained by controlling quality at the design stage instead of controlling it at the manufacturing stage or through the inspection of final products. This is the basic idea of off-line quality control. Taguchi's method is one of the most comprehensive and effective systems of off-line quality control.

Taguchi has built upon W.E. Deming's observation (Roy 1990) that 85 per cent of poor quality is attributable to the manufacturing process and only 15 per cent to the worker. Thus, his attempt was to develop robust manufacturing systems, which are insensitive to uncontrollable factors that may arise during the manufacturing stage or during the useful life of the product.

Taguchi recommends a three-stage process to achieve desirable product quality-system design, parameter design, and tolerance design (Roy 1990; Ross 1996). In the present paper Taguchi's parameter design approach is used to analyze the effect of turning process parameters viz. cutting speed, feed, and depth of cut on surface roughness of En24 steel and to obtain an optimal setting of these parameters that may provide the optimum surface roughness to En24 steel parts. The TiC coated carbide tool was used to turn the En24 steel parts.

Turning Process Parameters

In order to identify the process parameters that may affect the quality of turned parts, an Ishikawa cause-effect diagram was constructed and is shown in Fig. 1. The process parameters affecting the quality characteristics of turned parts are listed below (ASM 1995):

- Cutting tool based parameter—tool material, tool geometry.

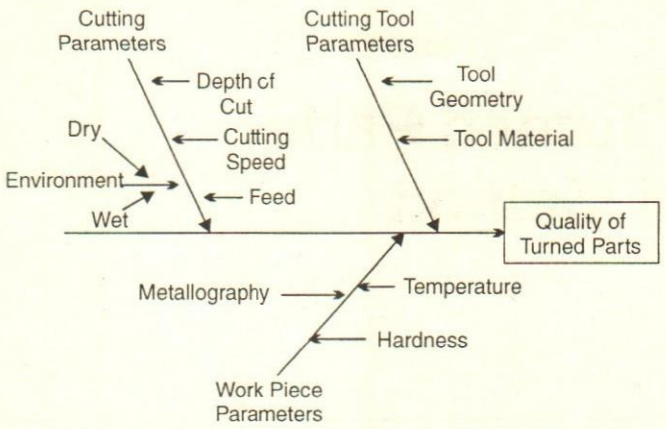

Fig. 1. Ishikawa Cause-Effect Diagram of a Turning Process

- Work piece based parameters – metallography, hardness, etc.
- Cutting parameters – cutting speed, feed, depth of cut and cutting environment.

En24 alloy steel is a difficult to machine material and this alloy finds its application in the production of axle shafts, differential shafts, gun barrels and various parts of machine tools (Mottram and Woolman, 1996). The Widadar TG inserts (SPUN 120308) were used for turning En24 alloy steel.

The following process parameters were selected for the present work:

- Cutting Speed – (A)
- Feed – (B)
- Depth of cut – (C)

The ranges of the selected process parameters were decided by conducting the experiments by using one variable at a time approach (Singh 2000). The process parameters, their designated symbols and ranges are given in Table 1.

Table 1: Process Parameters and Their Ranges

Process Parameters	Symbol	Range
Cutting speed (m/min)	A	190-310
Feed (mm/rev)	B	0.14-0.18
Depth of cut (mm)	C	0.70-1.00

The following parameters were kept fixed during the entire experimentation:

Work material : En24 steel

Cutting tool insert : Widadur TG

Insert geometry : SPUN 120308 (ISO designation)

Tool holder : CSBPR 2525H12 (ISO designation)

Cutting environment : Dry cutting

Selection of an Orthogonal Array (OA)

Before selecting a particular OA, for an experiment, the following two items must first be established (Ross 1996):

- The numbers of parametrs and interactions of interest.
- The number of levels for the parameters of interest.

The numbers of parameters are already decided and are given in Table 1. As most of the mechanical system behaves in a non-linear fashion, it was decided to study second-order interactions among the parameters. The following intractions were selected to visualize their effect on surface roughness of En 24 steel when machined by TiC coated carbide tools, if any:

- Cutting speed and feed.
- Feed and depth of cut, and
- Cutting speed and depth of cut

It was further decided to study each selected parameter at three levels. This is due to the reason that non-linear behaviour, if any, of the parameters of a process can only be revealed if more than two levels are used (Byrne and Taguch 1987). It is also necessary that the interval between the levels in multi level experiment must be equal (Ross 1996). The process parameters and their level values are given in Table 2.

Table 2: Process Parameters and Their Levels

Process Parameters	Parameters Designation	Levels		
		L1	L2	L3
Cutting speed (m/min)	A	190	250	310
Feed (mm/rev)	B	0.14	0.16	0.18
Depth of cut (mm)	C	0.70	0.85	1.00

Since each three level parameter has 2 degrees of

Table 3: L_{27} (3^{13}) Orthogonal Array (Parameters and Interactions Assigned) With Responses (Raw Data & S/N Ratios)

S. No.	RUN	A	A	AXB	AXB	C	AXC	AXC	BXC	–	–	BXC	–	–	Response		
		1	2	3	4	5	6	7	8	9	10	11	12	13	R1	R2	R3
1	6	1	1	1	1	1	1	1	1	1	1	1	1	1	Y11	Y12	Y13
2	3	1	1	1	1	2	2	2	2	2	2	2	2	2			
3	23	1	1	1	1	3	3	3	3	3	3	3	3	3			
4	21	1	2	2	2	1	1	1	2	2	2	3	3	3			
5	7	1	2	2	2	2	2	2	3	3	3	1	1	1			
6	13	1	2	2	2	3	3	3	1	1	1	2	2	2			
7	14	1	3	3	3	1	1	1	3	3	3	2	2	2			
8	9	1	3	3	3	2	2	2	1	1	1	3	3	3			
9	2	1	3	3	3	3	3	3	2	2	2	1	1	1			
10	10	2	1	2	3	1	2	3	1	2	3	1	2	3			
11	22	2	1	2	3	2	3	1	2	3	1	2	3	1			
12	26	2	1	2	3	3	1	2	3	1	2	3	1	2			
13	8	2	2	3	1	1	2	3	2	3	1	3	1	2			
14	4	2	2	3	1	2	3	1	3	1	2	1	2	3			
15	15	2	2	3	1	3	1	2	1	2	3	2	3	1			
16	16	2	3	1	2	1	2	3	3	1	2	2	3	1			
17	25	2	3	1	2	2	3	1	1	2	3	3	1	2			
18	20	2	3	1	2	3	1	2	2	3	1	1	2	3			
19	27	3	1	3	2	1	3	2	1	3	2	1	3	2			
20	11	3	1	3	2	2	1	3	2	1	3	2	1	3			
21	5	3	1	3	2	3	2	1	3	2	1	3	2	1			
22	18	3	2	1	3	1	3	2	2	1	3	3	2	1			
23	1	3	2	1	3	2	1	3	3	2	1	1	3	2			
24	12	3	2	1	3	3	2	1	1	3	2	2	1	3			
25	24	3	3	2	1	1	3	2	3	2	1	2	1	3			
26	19	3	3	2	1	2	1	3	1	3	2	3	2	1			
27	17	3	3	2	1	3	2	1	2	1	3	1	3	2	Y271	Y272	Y273

The 1's, 2's and 3's represents level 1, 2, and 3 of the parameters which appear at the top of the column.

(–) Represents no assignment in the column, R1, R2, R3 represent repetitions.

Yij measured values of quality characteristic (response)

freedom (DOF) (Number of levels-1), the total DOF required for three parameters each at three levels is 6[= 3 × (3–1)]. The degree of freedom (DOF) for a second order interaction is 4(2 × 2). So, with three parameters each at three levels and three-second order interactions, the total DOF required is 18 [= 3 × (3 – 1) + 3 × (2 × 2)]. As per Taguchi's method the total DOF of selected OA must be greater than or equal to the total DOF required for the experiment. So, an L27 OA (a standard 3-level OA) having 26 (= 27 – 1) degree of freedom was selected for the present work. The L_{27} (3^{13}) OA is given in Table 3. This array specifies twenty-seven experiment runs and has thirteen columns. Using linear graphs for L_{27} OA, the interacting columns were identified and parameters were assigned to specific columns accordingly (Peace 1993). The assignment of process parameters and interactions to columns is also given in Table 3.

Experiment, Analysis and Discussion

En24 Steel rods of 90mm diameter and 500mm length were turned on an H-22 center lathe (make HMT) using TiC coated carbide tool. The mean hardness of work material En24 steel (0.4% C) was 220 BHN. Specimens of En24 steel were prepared against the trial conditions given in Table 3. Three specimens for each trial condition were turned using randomization techni-

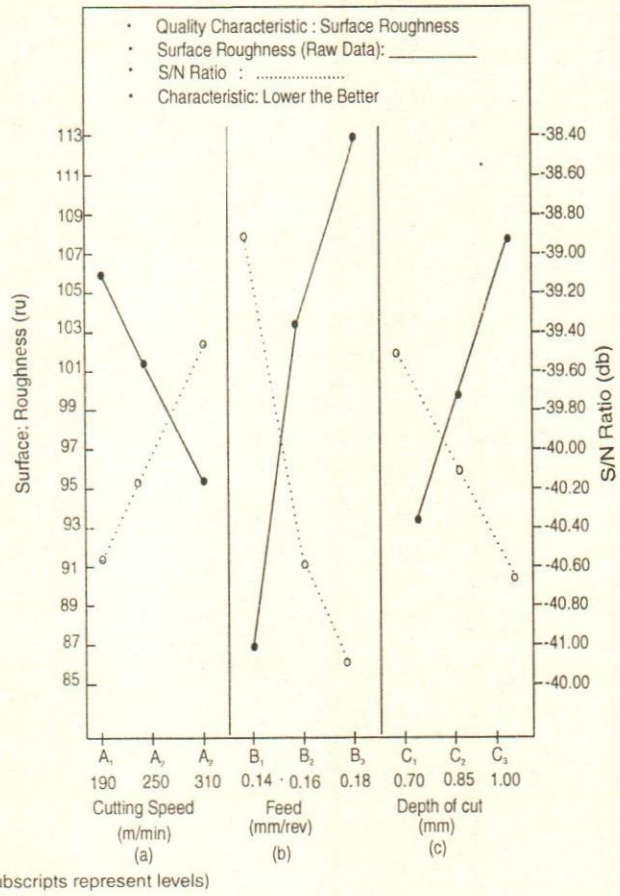

Fig. 2. Effects of Process Parameters on Surface Roughness (Raw Data) and S/N Ratio

que (Ross, 1996). Thus eighty-one specimens were made and the surface roughness was measured for each specimen using Philips roughness tester, type PR 9150. The results of the experiments for 27 trial conditions and 3 repetitions are reported in Table 4.

The surface roughness is a 'lower the better' type of quality characteristic. So, S.N ratio for 'lower the better' type of response was used and is given below (Byrne, and Taguchi 1987):

$$\text{S/N ratio (dB)} = -10 \text{ Log}\left[\frac{1}{n}\left(y_1^2 + y_2^2 + \ldots\ldots + y_n^2\right)\right] \quad \ldots(1)$$

Where y_1, y_2 ....y_n are the response values of quality characteristic (i.e. surface roughness) for a trial condition repeated n times.

The S/N ratios were computed using Equation 1 for each of the twenty-seven trials and the values are reported in Table 4 along with the raw data. The mean response refers to the average value of the performance characteristic for each parameter at different levels. The average values of surface roughness for each parameter at levels 1, 2 and 3 are calculated and are given in Table 5. These values are plotted in Figure 2. The main effects i.e. the effects of process parameters on the response characteristic when the process parameters change from one level to another are also given in Table 5 and can be envisaged from Fig. 2.

The average values of S/N ratios of various parameters at different levels are reported in Table 6 and are also plotted in Fig. 2.

Table 4: Experimental Data of Surface Roughness and Signal to Noise Ratio

Random-ized	Trial No.	Surface Roughness (ru)			S/N Ratio (dB)	S/N Ratio (dB)
		R1	R2	R3		
1	1	80	80	90	–38.43	–1.23
10	2	90	100	90	–39.41	–2.72
19	3	100	110	100	–40.29	–3.88
2	4	100	120	110	–40.85	–2.27
11	5	100	100	100	–40.00	–3.47
20	6	110	100	110	–40.57	–4.87
3	7	110	110	110	–40.83	–2.76
12	8	120	130	120	–41.83	–4.01
21	9	130	130	120	–42.06	–5.29
4	10	80	90	80	–38.43	–3.46
13	11	80	90	90	–38.77	–5.35
22	12	90	100	90	–39.41	–5.40
5	13	110	100	90	–40.03	–3.89
14	14	100	100	110	–40.29	–5.88
23	15	100	110	110	–40.57	–6.50
6	16	100	100	100	–40.00	–4.66
15	17	110	110	120	–41.09	–6.93
24	18	130	120	120	–41.83	–7.10
7	19	80	70	70	–37.32	–4.75
16	20	90	80	80	–38.43	–5.90
25	21	90	100	90	–39.41	–8.05
8	22	100	90	90	–39.41	–5.39
17	23	90	110	100	–40.03	–6.98
26	24	100	110	100	–40.29	–8.38
9	25	90	100	100	–39.72	–5.93
18	26	100	110	110	–40.57	–7.65
27	27	110	110	120	–41.09	–9.39
Total		2690	2780	2720		

$\bar{T}_{SR}$ = Overall mean of SR = 1.01.11ru, R1, R2, R3 represent repetitions

SR = Surface Roughness,

It is clear from Figure 2 that surface roughness is minimum at the 3rd level of parameter A, 1 st level of parameter B and 1st level of parameter C. The S/N ratio analysis also (Figure 2) suggests the same levels of the parameters (A_3, B_1 and C_1) as the best levels for minimum surface roughness of En24 steel turned parts.

Table 5: Main Effects-Raw Data (Surface Roughness)

Process Parameter	Average values of Surface Roughness (ru)			Main Effects (ru)	
Designation	L1	L2	L3	L2-L1	L3-L2
A	106.3	101.1	95.9	-5.2	-5.2
B	88.1	102.6	112.6	14.5	10
C	94.4	101.1	107.8	6.7	6.7
AXB	101.1	100	102.2	-1.1	2.2
BXC	100.4	100.9	102	0.5	1.1
AXC	101.9	100.7	100.7	-1.2	0

L1, L2, L3 represent levels 1, 2 and 3 respectively of parameters.
A–cutting speed, B–feed, C–Depth of cut.

Table 6: Main Effects –S/N Data (Surface Roughness)

Process Parameter	S/N Average values (dB)			Main Effects (dB)	
Designation	L1	L2	L3	L2-L1	L3-L2
A	-40.47	-40.05	-39.59	0.42	0.46
B	-38.88	-40.23	-41.00	-1.35	-0.77
C	-39.45	-40.05	-40.61	-0.60	-0.56
AXB	-40.07	-39.94	-40.10	0.13	-0.16
BXC	-39.92	-40.03	-40.16	-0.11	-0.13
AXC	-40.11	-40.00	-40.00	0.11	0

Table 7: Pooled ANOVA-Raw Data (Surface Roughness)

Source	SS	DOF	V	F ratio	SS'	P
A	1451.85	2	725.925	19.77*	1375.6255	9.05
B	8155.56	2	4077.78	111.05*	8079.3355	53.15
C	2400	2	1200	32.68*	2323.7755	15.29
AXB	(148.15)	(4)	–	Pooled	–	–
BXC	622.22	4	155.555	4.24*	469.77097	3.09
AXC	(59.26)	(4)	–	Pooled	–	–
T	15200	80			15200	100.00
e (pooled)	(2570.37)	(70)	36.7195		2951.4926	19.42

*significant

In order to study the significance of the process parameters in affecting the quality characteristic (surface roughness), analysis of varianace (ANOVA) was performed. The pooled ANOVA of the raw data (surface roughness) is given in Table 7. The ANOVA was also performed on S/N data. The S/N pooled ANOVA is given in Table 8.

Table 8: Pooled ANOVA-S/N Data (Surface Roughness)

Source	SS	DOF	V	F ratio	SS'	P
A	3.557	2	1.7785	11.86*	3.338	9.97
B	20.803	2	10.401	69.39	20.584	61.47
C	6.127	2	5	20.44*	5.908	17.64
AXB	(0.274)	(4)	3.0635	Pooled	–	–
BXC	(1.594)	(4)	–	Pooled	–	–
AXC	(0.254)	(4)	–	Pooled	–	–
T			–			
e (pooled)	33.485	26			33.485	100.00
	(2.998)	(20)	0.1499		3.655	10.92

Cutting seed (A), feed (B) and depth of cut (C) are significant at 95 per cent confidence level in both ANOVASs (Tables 7 Raw data, and Table 8 S/N data), these affect both the average value of the surface roughness as well as the variation in the surface roughness. The interaction between feed and depth of cut (BXC) is significant in raw data ANOVA only and thus influences only the average value of surface roughness (Ross, 1996). The ANOVAs also suggest that the interactions between cutting speed and feed (AXB) and between cutting speed and depth of cut (AXC) are insignificant. The per cent contributions of parameters as quantified under column P of Table 7 and 8 reveal that the influence of feed (B) in controlling both the mean value and variation of surface roughness is significantly larger than that of cutting speed (A) and depth of cut (C). It is also clear from Table 7 that the relative power of interaction between feed and depth of cut (BXC: 3.09%) is significantly much less than the relative power of feed (B: 53.15%) and depth of cut (C: 15.29%). Thus the effect of interaction in affecting the mean value of the surface roughness is quite small and is not considered to estimate the mean value (Ross, 1996). The parameters and their selected levels are given in Table 9.

Table 9: Optimal Levels of Process Parameters

Process Parameters	Parameters Designation	Optimal Levels
Cutting Speed (m/min)	A_3	310
Feed (mm/rev)	B_1	0.14
Depth of cut (mm)	C_1	0.70

Estimation of Optimum Value of Surface Roughness

The optimum of the surface roughness (m_{SR}) is

predicted at the selected levels of significant parameters. The significant parameters with optimum levels are already selected as A_3, B_1 and C_1 (Table 9).

The estimated mean of the response characteristic (surface roughness) can be computed as (Ross, 1996):

$$\mu_{SR} = \bar{A}_3 + \bar{B}_1 + \bar{C}_1 - 2\bar{T}_{SR}$$

Where $\bar{T}_{SR}$ = overall mean of surface roughness

= 101.11 ru* (Table 4)

*ru = roughness unit, 1 micron = 40 ru

$\bar{A}_3, \bar{B}_1, \bar{C}_1$ are the mean values of surface roughness with parameters at optimum levels (Table 5).

$\bar{A}_3 = 92.9$ ru, $\bar{B}_1 = 88.1$ ru, $\bar{C}_1 = 94.4\,\mu$

Hence

$$\mu_{SR} = 95.9 + 88.1 + 94.4 - 2 \times 101.11 = 76.18 \text{ ru}$$

A confidence interval for the predicted mean on a confirmation run can be calculated using the following equation (Ross, 1996):

$$\text{C.I.} = \sqrt{F_\alpha\,(1, f_e)\left[\frac{1}{n_{eff}} + \frac{1}{R}\right]} \qquad (3)$$

Where,

$F_{\alpha:(1,f_e)}$ = F ratio required for α

α = risk

f_e = error DOF

V_e = error variance

n_{eff} = effective number of replications

$$n_{eff} = \frac{N}{1 + [\text{Total DOF associated in the estimate of mean}]}$$

R = number of repetitions for confirmation experiment

N = Total number of experiments

Using the values $V_e = 36.72$ and $f_e = 70$ from Table 7, the confidence interval (C.I.) was calculated.

Total DOF associated with the mean (μ_{SR})

$= 2 \times 3 = 6$, Total trials = 27

$N = 3 \times 27 = 81$

$$n_{eff} = \frac{81}{1 + 6} = 11.57$$

$\alpha = 0.05$

$F_{0.05;(1,70)} = 3.98$ (Tabulated)

So, C.I. = ± 7.83

The predicted mean of surface roughness is:

$\mu_{SR} = 76.18$ ru

The 95 per cent confidence interval of the predicted optimum (surface roughness) is:

$$[\mu_{SR} - \text{C.I.}] < \mu_{SR} < [\mu_{SR} + \text{C.I.}]$$

$$68.35 < \mu_{SR} < 84.01$$

Confirmation Experiment

Three confirmation experiments were conducted at the optimal setting of process parameters. The average surface roughness of En24 steel turned parts using TiC coated carbide tool was found to be 73.33 ru. This result was within the C.I. of the predicted optimum of the characteristic (surface roughness).

Conclusion

The following conclusions have been obtained for the range of process variables given in Table 1. Any extrapolation must be confirmed through further experimentation.

- The per cent contributions of parameters to the variation of surface roughness of En24 steel turned parts using TiC Coated carbide tool in decreasing order are as follows:

Parameter	Per cent Contribution on Surface Roughness
Feed (B)	61.47
Depth of cut (C)	17.64
Cutting speed (A)	9.97

- The optimal levels of turning process parameters for optimal surface finish are:

Parameter	Optimal levels
Cutting speed	3 (310 m/min)
Feed	1 (0.14 mm/rev)
Depth of cut	1 (0.70 mm)

- The per cent contribution of interaction between feed and depth of cut (BXC) in affecting the average value of surface roughness is 3.09 per

cent while the other interactions, cutting speed and feed (AXB), cutting speed and depth of cut (AXC), are insignificant.

- The predicted range of optimal surface roughness is $68.35 < \mu_{SR} < 84.01$.

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I see true innovation to be made up of three 'creativities'—creativity in technology, product planning, and marketing.

– Akio Morita

Feature

Role of Knowledge Intranets in R&D Productivity

Mohan R.K. Nimmagadda

The strategic mapping of research knowledge through corporate intranets and knowledge management informatics initiatives is gaining importance in the bio-pharmaceutical industries. Synchronisation through mapping of systems and processes within the available organisational human resources & intellectual capital networks (ICN) would collectively bring out the best knowledge sharing practices, which are of prime importance for the industry's sustenance. Long-term sustainability for this industry is in terms of the strategic knowledge management practices through cross-functional human resources and their ability to contribute and leap ahead of the market competition through sustainable innovation and economics. With most of the biotechnology & pharmaceutical companies looking forward to mergers and alliances for their survival, organisational structures that protect the critical creativity are essential for keeping their future sustainable. Post Human Genomics stands to revolutionise and fragment further the industry and the very nature of practicing commercial biological science.

Mohan R.K. Nimmagadda is the Centre Director, CBABM and CEO Helix Genomics Pvt. Ltd.

Bio-Pharmaceutical Research and Development

The success of large-scale Bio-Pharmaceutical companies in bringing drugs to the market (D2M) and growing revenues in the past has generated increased shareholder expectations for future performance. For research and development leaders, this would mean rising pressure to deliver more, higher-value compounds will soon be required to file four to six abbreviated new drug applications (ANDAs) every year. It is, however, becoming increasingly difficult to meet these objectives by scaling through conventional practices. Competition and uncertainties represent both opportunities and threats to Bio-Pharmaceutical companies and this discontinuity makes it impossible to predict accurately what the business environment will look like even in the next year.

Research and development is both threatened and is offering companies with new opportunities by the discontinuity created by the rise of capital-intensive technologies like Bioinformatics. Managing knowledge resources for organisational capability building, in order to explore the natural sciences and controlling access to internal consumers, will become the assets of the future. Bio-Pharmaceutical companies must now look at these assets and create strategies for owning and trading them. The drug discovery process would be transformed dramatically in the post genome-sequencing era and would occupy centre stage in the modern biological research. The area of drug development through genomic research would lead to the development of new clinical diagnostic procedures and therapeutic products that would enable drugs to be prescribed selectively to patients for whom they will be effective and safe "customised medicines".

In the past, a significant proportion of time was available with the researcher to analyse and review the raw data. Bio-Pharmaceutical companies have recognised the potential of this resource some time ago and

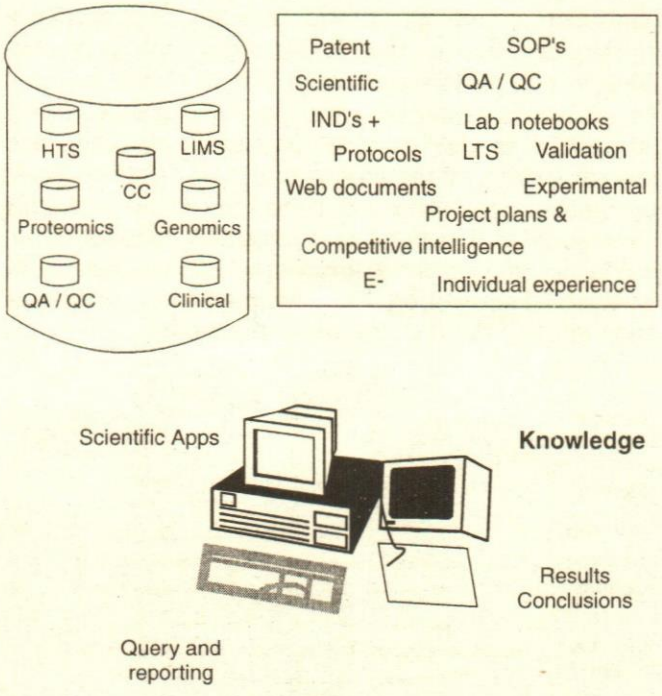

Fig. 1. K-Generation From Structured and Unstructured Data Sources.

the term "data mining" was often used to describe the effort to capitalise on it, perhaps reflecting a sense of working in the dark. The challenge here lies in improving database design, developing software for database access and manipulation, and data entry procedures to compensate for the varied computer procedures the systems used in different labs. Competitive advantage through knowledge management is for the companies, which need a common platform for seamless transfer of data, information and knowledge to achieve knowledge management for an enterprise-wide informatics based decision support system.

Knowledge management systems can be used, for example, to capture and disseminate data and information involved in target identification, assay development, screening and lead optimisation, and preclinical development. Future success depends on how good a job a company does in selecting targets, developing assays, optimising new drug candidates, and getting them to the clinic before its competitors can.

There is a huge amount of unstructured, ad hoc data that requires a corporate intranet based knowledge management system. The two biggest issues of Bio-Pharmaceutical companies are knowledge management based collaborative networks/practices and the other one being discovery/development interface. So, the next step is data integration to drive experiments in a seamless fashion. On the research side of the business, companies are investing in advanced computing technology in order to streamline drug discovery and speed up clinical compliance. As competition increases, speed to market (S2M) becomes more important.

The two issues of Bio-Pharmaceutical companies are knowledge management based collaborative networks/practices and discovery/development interface.

Bio-Pharmaceutical R&D Intranets

India is currently producing drugs and pharmaceuticals through Biotechnology and Pharmaceutical engineering route at a globally competitive cost but still accounts for only 1.3 per cent of the global Bio-Pharmaceuticals bulk drug production markets. Emergence of life sciences based technologies, processes and products is driving the global Biotechnology and Pharmaceuticals industry that has resulted in Speciality Bio-Pharmaceuticals that are produced from chemical processes and reverse engineering by picking up proteins whose functions and already known. Indian Bio-Pharmaceutical firms are required to move further for business consolidation through joint ventures and collaboration efforts in areas like R&D, manufacturing, field-testing, clinical trails and marketing.

With the opening up of the Human Genome Map (HGM), it is expected that the companies, which can use genetic knowledge for new drug development, and those, which can control microorganisms for drug production, will dominate the future of the Biotechnology and Pharmaceutical industry. Even though most of the human resources have been trained in research areas, highly skilled techno-scientific professionals are required for supporting commercial product development and for accurate monitoring of the field and clinical data. It is estimated that the economics of innovation for the therapeutic Biotechnology and Pharmaceutical products in India is much lower in relative comparison and is about US$250 million or even lower per molecule-product. The industry while developing its capabilities should decide whether to invest in developing newer technologies and products or to provide development based services to collaborate in clinical trials for biotech medicines or field studies for agri-biotech products.

The Idea-to-Project-to-Product knowledge for a successful organisation is to discover and develop a novel candidate molecule which may take 12-15 years of productive innovation and would involve large number

The decision support systems or the research-based expert systems would enable data interface according to the functional groupings within the organisation.

of people from both inside and outside the organisation like contract researchers, hospitals, etc. For every project that is successful, there may be a hundred that were to be dropped at various stages of lab research and industrial scale up towards commercial development. The decision support systems or the research-based expert systems would enable data interface according to the functional groupings within the organisation that have generated the data. Knowledge management initiatives integrate such data trafficking issues across the organisation which would enhance the volume of the generated data and also its availability, but often can reduce the accessibility time of the project specific information and knowledge from the data-information jungle.

Biotechnology and Pharmaceutical projects cut across the functional groupings within a company wherein the project is managed in a complex and matrix relationship. Lack of networks and or disfunctioning of collaborative software networks (Collabware) and inflexibility towards accommodating the changing environment, and more importantly, lack of incentive based structure for conducive exploitation of such available laboratory research are the major bottlenecks for R&D knowledge intranet growth. Generation of the combinatorial pediatrics and vaccines for various infectious diseases have the world's largest demand markets along with the various recombinant-DNA based proteins.

Strategically, the business of Biotechnology and Pharmaceuticals involves identifying potential research areas, product targets, and long-term investments in R&D, basic drug discovery research, intellectual property development, knowledge management, technology transfer and product scale up for commercialisation. Since R&D is knowledge intensive and critical to the success of any Biotech/Pharmaceutical organisation, focus must be on developing efficient and effective systems and processes towards better management of knowledge resources.

Designing Organisational Knowledge Intranets

At the organisational level, knowledge management intranet is the collaborative process by which the organisation generates wealth from its intellectual or knowledge assets. In a way, concept of learning organisation is harbinger to KM intranets. Organisational knowledge base is quickly becoming the only sustainable competitive advantage critical to the industry. As such, this resource, which is in its unique selling proposition or USP, must be protected, cultivated and shared among the enterprise members. Until recently, companies could succeed based upon the individual knowledge of a handful of strategically positioned individuals. organisational knowledge cannot replace individual knowledge; it complements individual knowledge, making it stronger and broader.

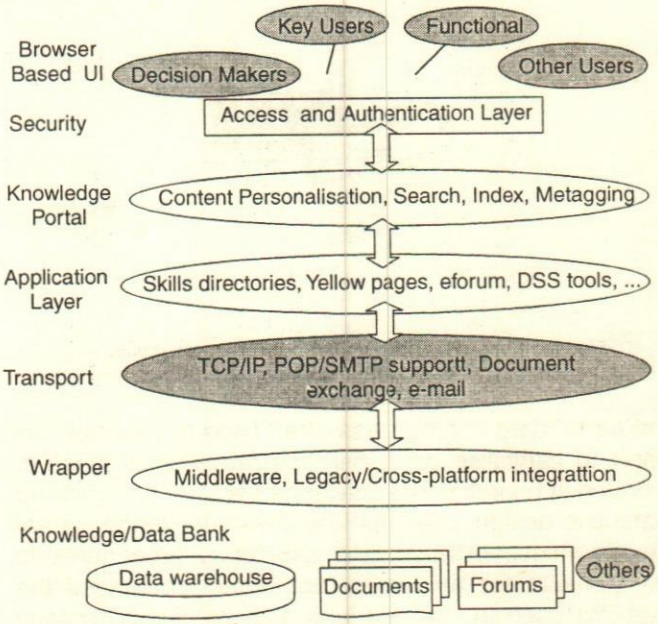

Fig. 2. Building of Knowledge Management architecture over corporate intranet for R&D environments.

Thus, the full utilisation of an organisation's knowledge base coupled with the potential of individual skills, competencies, thoughts, innovations and ideas will enable a company to compete more effectively in future businesses. Knowledge management initiatives taken up by the companies and practitioners world wide, reveal how companies created value from their intangible assets. Changing of strategic direction with an abundance mind set, and then to develop operational approaches that foster knowledge transfer, knowledge co-creation across corporations and cultures, which would account for knowledge activities and their value to organisations and stockholders are be-

Full utilisation of an organisation's knowledge base will enable a company to compete more effectively.

coming the biggest issues in the Bio-Pharmaceutical industries.

There has been, recently, rapid growth in both quantity and variety of data generated in the drug discovery process. In large measure, however, the emphasis has been on the capture and storage of data, rather than its application in expert support for decision-making. Since data explosion is being driven by automation and new technologies, staff will increasingly concentrate on data analysis rather than generation; there need to be methods in place to capture the results of their analyses, to share those results with colleagues and collaborators, and to use them in support of decision-making. The application of such methods will change the overall discovery process and will be the key to improved efficiency and speed, without which the discovery pipeline will be blocked by accumulated and underutilised data. The re-engineering of the clinical development process over the last decade sets a precedent for what we will see in drug discovery re-engineering.

In contrast, the discovery process is centred on the selection of promising candidate compounds, targeted to the most significant markets. The key is in managing 'actionable' information through 'information container' and decision-support technology approach, which are required rather than document management interface.

The container should be able to contain files of all types: not only text documents, but also non-text files such as molecular structures, gene sequence alignments, images, results tables, entry forms, etc. It should also contain links to key internal and external resources, discussion items, key e-mails, external search results, status and summary reports, etc. Knowledge management (KM) technologies provide many of the tools required to support such a discovery process.

To illustrate the need, consider the cancellation of a typical discovery project. If data management techniques are in place, data generated during the course of the project will still be retained in corporate databases. However, what the team members did with that would generally be lost as they discard their own paper and electronic files and concentrate on other projects, and as key members, especially the project leader, subsequently leaves the company. It is not unusual for a project to be restarted, perhaps after a competitor's lead fails in the clinic. However, the project is usually set back substantially because of the important knowledge lost during the hiatus. Similarly, new projects in closely related areas cannot benefit from the 'lessons learned'.

Most companies pursuing Bio-Pharmaceutical research employ matrix management methods. One dimension of the matrix is comprised of the functional groups (Departments) of scientists with similar skills, while the other dimension is made up of the projects that cut across the departments and are at different stages. Generally, the generation and storage of data is the responsibility of departmental members (e.g. members of the chemistry department would all use and add to the same compound registration database, while molecular biologists contribute to a sequence database). In contrast, most knowledge is generated during the projects. Indeed, the same analytic data might be used by two different projects to reach very different conclusions because of their different therapeutic goals.

Most companies pursuing Bio-Pharmaceutical research employ matrix management methods.

In many ways knowledge management in drug discovery is synonymous with project life cycle management (PLCM). And there is considerable need for comprehensive project life cycle management from the conception of a new approach, through drug discovery and development, to market and eventually to product market expiry. KM intranets can also bring useful tools to laboratory management. With the increasing industrialisation of the discovery processes, task and workflow management tools are becoming essential at the work place. Their value is further increased when they handle not only the assignment of tasks to team members, but also integrate with experimental systems.

Notification of the completion of an experimental run, automated analysis of results and result-dependent task assignment are some other examples. Classic laboratory information management systems do a reasonable job of managing experimental data, but are not designed to provide notification in a way that flexibly 'recognises' organisational structure – in other words, who needs to know what and when. Interfaced with a powerful corporate KM system, these shortcomings can be effectively addressed. Relating structured data queries to corporate knowledge repositories involve both structured and unstructured data. Information contained within these reports and the collective knowledge of all aspects of drug discovery projects are used to make decisions.

Full project lifecycle management is the proliferation of information (and information about information) in the context of a project and across project phases, in terms of milestones, conclusions, decision points, and workflows, to and from any information stakeholder.

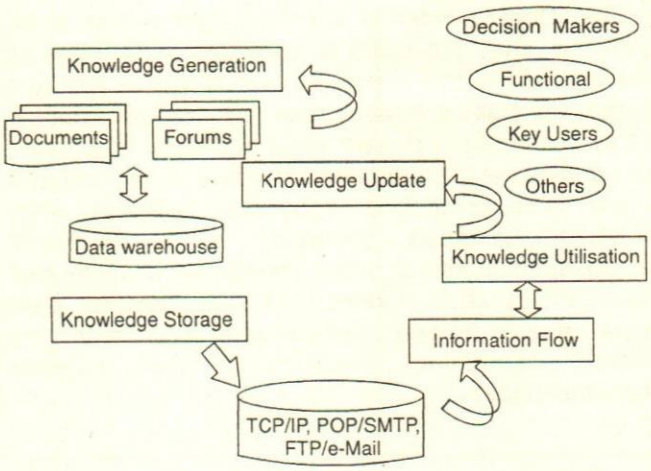

Fig. 3 The Knowledge Intranet Cycle (Corporate K-Net)

Source: Mohan, R.K. Nimmagadda and Prasad, Dr. B.V.L.S. (NICOM January 2003), Strategic Management of Bio-Pharmaceutical Knowledge Intranets for Improved R&D Productivity.

Keeping intellectual capital within your company is of prime important in such high-pressure environments. Information is the lifeblood of all projects and, together with data and documents, forms the corporate memory. Directing projects requires a strong leader with a versatile set of tools. Companies need to integrate the efforts of all their projects and departments. Making the right decisions at the right time for the right reasons will lead to a blockbuster new drug. Decision makers need to have access to relevant information in the proper context.

Knowledge is the key enabler of so many business competencies and is affected by such a wide range of organisational factors that it can be confusing for management to know where to start. Until now there has been no reliable, independent and objective way to measure knowledge efficiency or the key "pressure points" for potential performance improvements. The Knowledge management assessment we propose covers organisation knowledge base assessment, information flow locations, knowledge generation checkpoints, knowledge storage paradigms, knowledge utilisation and user level updates. The Knowledge management intranet covers four prime areas which are KM intranets to benchmark current levels of R&D performance, key business drivers critical to future sustenance, significant assessment findings relating to the key business issues, specific areas for improvement for opportunities to grow.

To conclude

Management attention to Knowledge factors has increased with growing evidence that effective management of knowledge impacts key business issues such as profitability, growth, market position, asset utilisation, product and process innovation and the management of customer relations. While information and communication technologies are the enabler of much of this potential transformation, it is people who make it happen. Individually and collectively, an organisation's employees hold the key and "know how" necessary to make the difference between the leader and the followers. The average business experiences a continual loss of knowledge when opportunities to generate and capture this knowledge are missed, or when key employees are lost to the competition. This represents a constant drain on future competitive advantage and profitability.

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Feature

Information Technology at Regional Level

R.G. Desai

The regional dimensions of growth of the Indian economy are assuming increasing relevance in the context of the progressive diffusion of structural reforms at the sub-national level. In terms of trend growth rate, Karnataka, West Bengal, Maharashtra, Tamil Nadu, and Andhra Pradesh have done well in the 1990s. The regional growth experience of the 1990s suggests that States pursuing reforms seemed to have experienced higher growth rates in recent years with some tendency towards convergence. In order to ascertain the leading role of few states in India an in-depth study has been made to explore the real causes. In future perhaps the growth of the state economy will be assessed not only by per capita SDP (State domestic Production) but also by per capita bandwidth available. The IT sector in India is important not just because of its performance and potential, but because these factors have influenced the policy environment in India.

R.G. Desai is Professor, Bangalore University, Bangalore, a Fellow with the KK Birla Foundation, New Delhi, and a Visiting Fellow at ISEC, Bangalore.

The regional dimensions of growth of the Indian economy are assuming increasing relevance in the context of the progressive diffusion of structural reforms at the sub-national level. Growth is getting increasingly assessed in terms of durable improvement in the regional growth profiles in which the interface between public policies for accelerating development and standards of living is the greatest. Moreover, regional patterns of growth provide a gauge of the quality of public policies and their impact on macroeconomic welfare. The various facets of the growth experience of States in India are critical for developing an understanding of the sources of demand generation as well as changes in productivity and growth. The growth performance in the States is often the outcome of institutional and non-economic factors interacting with the initial conditions which encompass various aspects of human capital development. Varying degrees of reforms in different States have yielded wide variations in growth performance. In this context, the popular characterization of backward States such as Bihar, Madhya Pradesh (M.P), Rajasthan and Uttar Pradesh (U.P) as a homogenous group of poor performers does not hold good in terms of recent economic performance (Ahluwalia, M.S 2002). It has also been argued that reforms have unshackled a number of States like Andhra Pradesh, Gujarat, Karnataka, Maharashtra and Tamil Nadu who could achieve their true economic potential in recent years (Bajpai, 2000). From a completely different paradigm, the faster growth in select States has been interpreted as the operation of some kind of unbalanced growth with differing rates of catching up. There are other issues raised in the context of Indian regional development, viz., fiscal, infrastructure and human resources development.

Objectives

General objective of this paper is to assess the economic performance of states during the New economic reform period since 1991 via development of Information and Communication Technology (ICT). However the specific objectives are as follows:

1. To assess the regional growth experience of states in India during the 1990s
2. To appraise the existing ICT initiatives, specially that of leading states in India
3. To identify the causes for success of leading states in IT revolution and
4. To examine the contribution of such leading states in terms of export of software, hardware and IT Enabled services and E-governance.

Methodology

This paper highlights the new dimension of development taking place in some states via the ICT route. Accordingly the data is gathered from states as well as the centre. Most of the data was collected from secondary sources such as the Directorate of Economics and Statistics of respective state governments and some from the Website, India.stat.com. (statistically speaking) and some from the seminar papers submitted at the IT Professional Forum in Bangalore as far as the analysis of data is concerned, there is a comparison of the performance of leading states through percentages and adapted trend growth rates calculated from the semi-logarithmic function in the RBI Report on Currency and Banking 2002-03.

Regional Growth Profiles

The State-wise profile of per capita State Domestic Product (SDP) drawn up for 15 major States (representing nearly 90 per cent of the Indian population) exhibits significant variation. In 1980- 81, there were only four States viz., Maharashtra, Punjab, Gujarat, and Haryana whose per capita real SDPs (at 1980-81 prices) were higher than the all-India per capita real GDP. The trend remained more or less similar in 1990-91. In the 1990s, this group expanded to include Tamil Nadu. Relative ranking in terms of absolute SDP need to be evaluated against a comparison of growth rates In terms of trend growth rate (Table 1) Karnataka, West Bengal, Maharashtra, Tamil Nadu, and Andhra Pradesh have done well in the 1990s. The regional growth experience of the 1990s suggests that States pursuing reforms seemed to have experienced higher growth rates in recent years with some tendency towards convergence. At the same time, the regional growth experience is indicative of some kind of unbalanced and divergent growth. The analysis of regional distribution and growth of industries by M.H. Bala Subrahmanya (2003) has brought out many noteworthy issues. Among the states, Maharastra was the most industrialized region in 1970-71 and it has maintained its industrial supremacy over the period till 1997-98. Since then, the industrial status of West Bengal has gradually eroded. This is strikingly evident in terms of number of factories, fixed capital investment, employment and gross value added. In terms of employment, Tamil Nadu, Andhra Pradesh, and Karnataka emerged more prominent in the 1990s and accounted for nearly 1/3th of the total industrial employment in 1997-98. In terms of investment, Gujarat emerged as the second most important state in the country in 1997-98. However, in terms of investment and employment the status of Bihar declined considerably. Given this it is possible that India might experience a concentrated industrial growth confined to the "eight leading states" in the immediate future. (M.H. Bala Subrahmany 2003).

Table 1: Trend Growth Rate of Per Capita State Domestic Product (SDP)

States	1980-81 = 100	1993-94 = 100	
	1981-82 to 1990-91	1981-82 to 1993-94	1993-94 to 1999-2000
1	2	3	4
Karnataka	4.0	4.5	4.5
Gujarat	3.3	3.1	2.4
West-Bengal	2.7	2.9	5.6
Kerala	4.3	3.7	3.5
Tamil Nadu	3.9	4.2	5.1
Orissa	3.2	3.7	5.8
Maharashtra	2.2	3.1	5.1
Andhra Pradesh	2.6	2.7	5.7
Punjab	3.4	3.2	3.7
Madhya Pradesh	2.0	2.0	4.6
Uttar Pradesh	4.0	3.6	2.5
Haryana	2.7	2.3	3.2
Bihar	2.4	1.7	2.0
Rajasthan	2.5	0.9	2.7
India	3.4	3.2	4.8

Notes: 1. Due to non-availability of data the average growth rates reported under column 4 for Madhya Pradesh, Gujarat, and Kerala are calculated over the period 1993-94 through 1998-99.

2. The trend growth rates are calculated from semi-logarithmic function.

Source: Directorates of Economics and Statistics of respective State Governments.

Information Technology and State Economies

In the world of Hi tech economy, how have the states performed? How the policy of state governments vary? Is there proactive support of the bureaucrats in

the new ICT revolution. In the world of Software development one speaks of measuring oneself on Capability Maturity Model (CMM-Level). It has 5 levels, the lower most called 'Initials'is at level 1 and the highest called 'optimizing' is at level 5. On behalf of the Dept of Information Technology, Govt. of India, NCAER made a survey in 2003 about the development and penetration of IT in the State economies. In this survey States have been rated on five parameters viz. Network Access, Network Learning, Network Society, Network Economy and E- Governance.

Further states have been slotted into Six categories as:

1. Leaders
2. Aspiring Leaders
3. Expectants
4. Average achievers
5. Under achievers
6. Laggards.

States E-Readiness: The Leaders and the Laggards in the Information Technology in India

1. Leaders: Karnataka, Maharashtra, Andhra Pradesh, and Tamil Nadu
2. Aspiring leaders: Delhi, Chandigarh, Gujarat and Goa.
3. Expectants: West Bengal, Uttar Pradesh and Kerala
4. Average Achievers: Madhya Pradesh, Panjab, Haryana, Rajasthan and Pondicherry
5. Under Achievers: Himachal Pradesh, Uttaranchal, Orissa, Chatisgarh, Myzorum, Tripura , Megalaya and A&N Islands
6. Laggards: Assam, Jharkhand, Lakshadeep, Bihar, J&K, Sikkim, Arunachal Pradesh, Nagaland, Diu & Daman, Manipur, Dadra and Nagar Haveli

Highlights

- Karnataka, Andra Pradesh, Tamil Nadu, and Maharashtra are the leaders in terms of e-readiness.
- In terms of network access, Delhi has been rated as the best state in view of high teledensity, percentage of household - with phones and cable TV, Cell phones, P.C. population, Internet connection, length of optical fibres in operation, and number of villages covered by village public telephones.
- In terms of network learning. Chandigarh, Maharashtra, Delhi, Karnataka, and Tamil Nadu are on top in terms of percentage of college and schools with internet access and computer labs, universities offering Information Technology courses, number of websites of schools and colleges etc.
- In terms of network society Karnataka and Chadigarh are also ahead of others in the number of online companies, local language websites and interfaces, number of government websites and of households having access of internet with computers and phones.
- In terms of network policy states of Maharashtra, Tamil Nadu, Chadigarh, Karnataka, Goa, and Gujarat are the best. This is evaluated on Government's efforts to address issues related to telecom, e-commerce, taxation, IPR (Intellectual Property Rights) and presence of an IT Policy and cyber laws.
- In terms of e-governance the states of Karnataka, Andhra Pradesh, Tamil Nadu and Gujarat are on top with regard to the rural IT applications in agriculture, education, medicine, trade- infrastructure initiatives and success related to e-governance projects like e-procurement, land registration, utility bills etc.
- In terms of network economy Maharashtra alone is on top. This is rated based on numbers of IT parks, floor area of IT parks, sales turnover of IT companies in the states and number of jobs that require Info tech skills.

Reasons For Their Leading Role

The leading States have their own edge over other states in the following areas viz:

Supply of IT skilled Workers

Infrastructure needs

Policy Environment

E-governance

Supply of IT Skilled Workers

Huag's (1991) study in the US showed that five main factors play a part in the locational decisions of new software companies: (a) Labour availability (b) In-

Table 2: State wise Engineering Colleges sanctioned and their intake for Courses/Programmes in Computer Science/Information Technology during 2000-2001

	Diploma Level		Degree Level		MCA Level		Grand Total			
States	Institutes	Intake	Institutes	Intake	Institutes	Intake	Institutes	%	Intake	%
Tamil Nadu	161	8690	413	27263	143	7295	717	23.5	43248	26.4
Karnataka	320	8150	201	14185	69	3075	590	19.4	25410	15.8
Maharashtra	214	11005	317	20723	19	870	550	18.0	32598	19.9
Andhra Pradesh	106	5475	271	17695	167	6595	544	17.8	29765	18.5
Uttar Pradesh	79	2557	144	8568	44	2240	267	8.6	13365	7.8
Gujarat	50	2586	52	3190	10	480	112	3.6	6256	3.6
Delhi	19	895	12	710	7	310	38	1.2	1915	1.2
Goa	3	100	4	240	7	310	14	0.4	650	0.4
Chandigarh	2	70	2	60	–	–	4	0.1	130	0.1
Total	1020	42068	1543	99822	483	21740	3046	100	163630	100

Source: 1. Rajya Sabha unstarred question No. 1548, dated 9.3.2001

2. Web site: www.indiastat.com

frastructure (c) Quality of life (d) Proximity to Customers and (e) Proximity to previous employer and residence.

One of the reasons for a strong presence of ICT industries in the southern leading states in India is due to a base created by establishing technical colleges, institutes and universities which provide qualitative and truly world class engineers. In addition to the revolution of Electronics and Communication the knowledge workers in these states earn less than their counterparts in the developed world. The data on number of colleges/institutes and their intake have been called out from the AICTE data base. The results are truly encouraging and there is a strong correlation between the numbers of engineering graduates coming out from these states and the establishment of ICT firms in such states.

It is evident from Table 2 that during 2000-01, the total number of engineering only diploma & graduates in electronics & communication science and MCA graduates intake from 3046 colleges was 1,63.630. Out of which 80 per cent are from 4 leading states such as Tamil Nadu, Karnataka, Maharashtra, and Andhra Pradesh. In terms of number of institutes and intake in imparting Diploma/ Degree/Master courses in IT related courses, Tamil Nadu is leading with 717 institutes and 43,248 engineering intake capacity followed by Maharashtra with 550 institutes but an intake of 32,598, and Andhra Pradesh with 544 institutes with 29,765 intake capacity. Karnataka has more number of institutes (590) compared to Maharastra and A.P but intake capacity is 25410. The rest of the seven states constitute just 20 per cent of the total intake in India. It indicates that the presence of well established educational institutes lead to a upsurge in the knowledge economy of the leading states.

In terms of intake capacity in both diploma and degree level engineering colleges, Maharashtra takes the lead. On the other hand, intake at MCA and Degree level engineering, it is Tamil Nadu which is leading. Thus, it is clear that undoubtedly in the southern four states along with Maharashtra information Technology has played an important role in stimulating the state economies during the reform period .

The aspiring leaders in IT such as Delhi, Gujarat, Goa and Chandigarh can fulfill their desire to become leaders shortly due to large number of E-learning activities. The problem is with those states which are called Laggards. Where there is a need for establishing all kinds of network activities, in order to support both IT use and production, states need to develop capabilities in the form of human resources, business skills.

The most effective policies are those that promote use and production close to use and those have to have close consultation with private sector and academic institutions, and if the efforts of related government agencies is coordinated so that they complement, rather than compete with each other, the result can be a rapid diffusion of the technology, with broad benefits for the states.

Infrastructure Specially Bandwidth

The demands on the telecom infrastructure span an enormous range. While software firms, other exporters

and multinationals require robust high-bandwidth international links, the great majority of Indian states have little access to the most basic voice services. It may seem that the needs of this range of users are so different that they require very different solutions. This is partly true, but technological convergence, and the fact that the domestic and international networks must interconnect, imply benefits to integrated approaches to infrastructure improvements (Nirvikar Singh 2003). We therefore examined the network in several states in terms number of STPI centres and bandwidth available to different leading states in the country. From the Table 3 it is evident that the bandwidth available to different states through STPI centres vary from state to state. Karnataka is leading with 37184 kbps bandwidth available, accounting for 27.57 per cent of the total bandwidth. Followed by Uttar Pradesh with 25.58 per cent, Andhra Pradesh 21.16 per cent and Maharashtra 11.77 per cent. The second highest bandwidth available to Uttar Pradesh is due to Noida STPI Centre which covers the firms from Uttar Pradesh, Delhi and Madhya Pradesh. It is an Export Process Zone under the control of the Central Ministry. Andhra Pradesh is third in the list due to the presence of a large number of foreign companies, next only to Karnataka. Thus we can say that the performance of IT in these states is doing better compared to other states due to the presence of a large amount of available bandwidth. In future, perhaps, the growth of the state economy will be assessed not only by per capita SDP (State Domestic Production) but also by per capita bandwidth available.

The Policy Environment

Since 1991, India has pursued polices of economic liberalization, but policy reform has been uneven. Controls on private industry and non-tariff trade barriers have been removed or substantially reduced, but liberalization has been slower in certain states where there is clear interest group opposition, such as labour laws and privatization. Reform has also been slow in those states where new regulatory institutions needed to be created; there is still a substantial amount of learning by doing that is taking place. Government revenue considerations also affect policy decisions in areas such as import tariffs and telecoms privatization. The IT sector in India is important not just because of its performance and potential, but because these factors have influenced the policy environment in India. The experience of different states exhibit different pictures. The states having dynamic and IT savvy Chief Ministers have shown tremendous growth. For instance, Karnataka has achieved an 8 per cent growth rate as against 4.5 per cent all India growth rate in 2002-03, merely due to the conducive policy of the state Government and IT savvy Chief Minister, Mr. S M Krishna. The conducive policy of the state paved the way for establishing the first STP of India in Bangalore, which provided the necessary infrastructure to reinforce the formidable skill advantages the region already possessed. Bangalore became central to the expansion plans of domestic firms, and the first choice within India for the large number of foreign companies from Silicon Valley (Rao, R.L.R 1995). Therefore Bangalore is called the Silicon Valley of India.

Table 3: State wise bandwidth available at STPI centre as on 2001

States	Existing STPI Centres (No.)	Proposed STPI Centres	Bandwidth available (kbps)	% to the total
Tamil Nadu	2	4	7168	5.31
Maharashtra	2	3	15872	11.77
Karnataka	2	2	37184	27.57
Andhra Pradesh	2	3	28544	21.16
Uttar Pradesh	1	1	34496	25.58
Gujarat	1	1	10816	8.02
Kerala	1	1	768	0.56
West Bengal	-	1	-	-

Source: 1. Lok Sabha Unstarred Question No. 4609, dated 19.12.2001.

2. www.indiastat.com

E-Governance

One area where governments are interested is in indirect support for the IT sector by boosting the domestic market through its own purchases. Of course, purchases of sophisticated equipment and software that sits unused in high-level bureaucrats? offices will have little positive impact. However, there are reasons to be more optimistic about the use of IT in government. There are two broad uses of IT for improved government functioning. First, back-office procedures can be made more efficient so that internal record-keeping, flows of information and tracking of decisions and performance can be improved. Second, when some basic information is stored in digital form, it provides the opportunity for easier access to that information by citizens. The simplest examples would be e-mailing requests or complaints, checking regulations on a web page, or printing out forms from the web so that a trip to pick up the forms from a physical office can be avoided. More complicated possibilities are checking actual records, such as land ownership or transactions. Still more complicated are cases where information is submitted electronically by the citizen.

What is encouraging is the number of examples of successful pilot e-governance programmes that have made some of the above actions possible. These examples include:

- The 'Bhoomi project' of Karnataka, an e-governance project which computerized 20 million rural land records belonging to over 6.7 million farmers and delivering them through 177 government kiosks. It is a trendsetter for better governance and helped to eliminate red tapism and corruption in civic services
- Computer-aided registration of land deeds and stamp duties in Andhra Pradesh, reducing reliance on brokers and possibilities for corruption.
- Computerization of rural local government offices in Andhra Pradesh for delivery of statutory certificates of identity and landholdings, substantially reducing delays.
- Computerized checkpoints for local entry taxes in Gujarat, with data automatically sent to a central database, reducing opportunities for local corruption.
- Consolidated bill payment sites in Kerala, allowing citizens to pay bills under 17 different categories in one place, from electricity to university fees.
- E-mail requests for repairs to basic rural infrastructure such as hand pumps, reducing reliance on erratic visits of government functionaries.

While the extent of such programmes, and therefore their benefits, are still very limited, one of the essential characteristics of information is that it is a non-rival good. Hence there is every reason to believe that the economics of such projects will continue to improve, particularly if costs of access continue to fall. It is important to note that once Internet access is available, its benefits are not restricted to e-governance. Individuals can obtain job information, advice on farming techniques, and so on.

In the field of e-governance the state of MP has done an excellent work through its 'Gyandhoot? e-project even though it comes under Average Achievers category. AP is at the level-2 called 'Repeatable? level of maturity. Whereas the state of Karnataka is at level-1 that is level of initials(Jagadish 2003). Therefore the so called leaders of the IT revolution are behind the average achievers as far as ICT to the masses is concerned.

Contribution to IT by the Leading States

Export of Software and Hardware electronics

The past decade witnessed the rise of the Indian IT sector from a position of virtual non existence, to one, where it has occupied a place of pride in the global IT industry. The Indian IT sector has grown from a mere $ 6.4 billion in 1998-99 to $ 13.6 billion in 2001-02. The IT industry today accounts for 2.87 percent of India's GDP. Exports from the Indian Software industry accounted for over half the industry's revenues, accounting for US$ 5.5 bn of the total IT pie of US$ 10.5 bn in 2001. The domestic market was dominated by hardware at US$ 2.9 bn, followed by services at US$ 1.6 bn, and packaged software brought up the rear with earnings of US$ 409mn. The IT software and services export segment has a very crucial role to play in the overall IT market in the country. The IT Software and Services exports has greatly contributed to the IT sector which enlarged from US$ 1.73 billion in 1994-95 to a US$ 13.5 billion industry in 2001-02. (NASSCOM 2002).

Table 4: Region wise exports of software and electronic hardware in India

(2001-02) ($ million)

Region	Software	percentage to total	Hardware	percentage to total
South region	4087	48.15	379	31.16
a. Karnataka	2201	25.90	–	–
b. Tamil Nadu	1231	14.50	–	–
c. Andhra Pradesh	613	7.20	–	–
d. Kerala	42	0.28	–	–
North Region	2316	27.28	334	27.46
a. Uttar Pradesh	943	11.10	–	–
b. Delhi	839	9.88	–	–
c. Haryana	157	1.84	–	–
d. Other States	377	4.44	–	–
Western Region	1869	22.01	488	40.13
Eastern Region	216	2.55	15	1.25
All India	8488	100	1216	100

Source: UNI data Published in Deccan Herald dated 1-1-2003.
– not availabl

Table 4 reveals that among the various states south region is leading in software export and services while west region is leading in hardware export. Within the south region, Karnataka state is leading with 25.90 per cent of the total exports in India followed by Tamil Nadu with 14.50 per cent. Similarly in north region, Uttar Pradesh is leading with 11.10 per cent of the total

software export followed by Delhi with 9.88 per cent. In the western and eastern regions there are no break up figures available but it is Maharashtra in the west and West Bengal in the east which are the leading states in exports.

Features of Hardware Industry

- The total number of installed PC base in the country is 7.5 million.
- PC shipments were 1,881640 in 2000-01 and are estimated to be 1,650,000 for 2002-03.
- The domestic IT hardware market has grown 76 percent over the last five years, from $1.7 billion in 97-98 to $ 3 billion in 01-02, but the segment has seen a gradual shift from indigenously sourced production in favor of imports.
- MNC brands maintained a robust performance - a market share of 36%, up from 24 per cent in the first half of 2000-01, registering a growth of 44%.
- Overall the PC purchases in the top 4 metros (Delhi, Mumbai, Kolkatta and Chennai) accounted for 53 per cent of the total PCs purchased.

IT Enabled Services

The continued economic slowdown in the global market led to increase in out sourcing in the IT sector and decreased the spending on new applications development and systems integration by several IT companies in several states of India. Most of the companies focus on cost saving almost exclusively when making decisions to buy IT services. The focus on financial services increased the role of CFO in IT services. The off shore services have grown at 20 per cent in 2003 for applications out sourcing services. The major Indian companies are WIPROW, INFOSYS and SATYAM. Most of them are in Bangalore .

Some companies have struck allowances and partnerships with BPO firms. The BPO (Business Processing Out sources) is also growing at the rate of 25 per cent in 2003. ITES are mostly in (HR) human resource, finance, recruiting, shipping, distributing and logistics and indirect procurement. There is a virtual comparative advantage in terms of operating costs as well as salary costs in these activities of the companies. The possible areas of ITES are mentioned in the box.

The states which have comparative advantages due to large pool of manpower specially the south Indian states, with low cost of operation have succeeded in ITES. It is forecasted that ITES will grow by 15 fold over 2002-08 with a $21-24 million dollar of amount. They (off shore vendors) will save about 40-50 per cent with the vast availability of BPO market in the world, growing at the rate of 12 per cent per annum. The importance of ITES is highlighted by NASSCOM, as evident from Table 5.

Box: ITES – Possible areas

Speciality Services	Client Management	IT Management	HR & Benefits	Finance
Tax Planning	Call Centre Operations	Data Centre Management	Payroll Processing	Fixed Assets records
Regulatory	Customer satisfaction surveys	Network Management	Recruitment	Project Accounting
Transfer Pricing	Order processing	Application Development	Performance evaluation	A/P and A/R Management
Facility Management	Service support	Maintenance	Training Administration	Reconciliation

Table 5: Growing importance of ITES in Indian economy

(in Million Rs)

	1999-00	2000-01	2001-02	2002-03E	2008E	CAGR 02-08
Software services	147,500	242,500	294,000	358,000	1,886,500	36%
ITES	24,000	41,000	71,000	117,000	1,102,500	58%
Total (Rs.mn)	171,500	283,500	365,000	475,000	2,989,000	42%
ITES as % of t Total revenue	14%	14%	19%	25%	37%	

Source: Sudheesh Venkatesh paper presented at the IT Professionals Forum. Feb 16, 2003. Bangalore

Note: E – Expected by the author.

NASSCOM has forecasted that India's revenue from ITES during 2001-02 was Rs 7100 crores and will grow to Rs 8100 crores by 2008. It has predicted that employment in the ITES industry could increase to 1.1 million by 2008. It has also revealed that ITES sector has emerged as the leading employment generator with 68,000 people already employed and an additional 36,000 jobs will be created in the year 2002-03. The top 5 focus markets for ITES companies include insurance, e-commerce, technology vendor, financial services and telecommunication services. Since the data at the disaggregated level are not available, deliberately the comparative study among the states is not done. However, it is presumed that again leading states are leaders even in their ITES

services due to large pool of skilled manpower available at cheaper rates.

Policy Implication of the Study

In conclusion, investment in infrastructure, physical, capital and education is the key to economic development. This is, of course, an old policy prescription in the economics of development. What is new in the analyses is the view that the information technology content of these investments should be high. The use of IT is so widely spread in the world economy that no single country can ignore any longer the needs to invest in these technologies if it wants to improve the standard of living of its citizens. (Pohjola, 2003). Following Matti Pohjola's view we strongly feel that the use of IT should be so widely spread in India that no single state can ignore any longer the needs to invest in these technologies if it wants to improve the standard of living of its citizens.

This is a part of under going major research work on Economics of Information Technology – A comparative study of Leading States in India. Author is grateful to KK Birla Foundation New Delhi for awarding the Fellowship to the said project.

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http://www.nasscom.org Ten years of the Indian IT industry.

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Much good work is lost for the lack of a little more.

– Edward Harriman

Feature

Electricity Consumption & Industrial Growth: An Auto Regressive Analysis

Sanatan Nayak

This paper attempts to estimate the empirical relationship between electricity consumption and industrial output in India from 1971 to 2000 by employing the Auto regressive model. This model explains the nature of electricity consumption, industrial output, price of electricity, technological progress demand for electricity. The empirical evidence suggests the electricity demand is highly responsive to the changes of output and fuel technology but relatively unresponsive to price.

Sanatan Nayak is Fellow, Giri Institute of Development Studies, Sector 'O', Aliganj Housing Scheme, Lucknow-226 024.

The consumption of electricity is the most important input for determining the value of industrial output (Fisher, F. M. and Carl Kaysen, 1962; Banerjee, N., 1978; Singh, B. and B. Nisha, 1991). It has also been felt that the consumption of electricity depends not only on the growth of industrial output but also its own price as well as price of its substitutes (Wilson, J.W., 1969). It implies that the consumption of electricity increases with decrease of its own price as well as the increase in the price of its substitutes, viz., coal, oil and natural gas. However, the increase of demand for electricity due to modernization of industrial sector has substituted the consumption of coal and oil in the industrial sector (Baxter, R.E. and R. Rees, 1968; Mooz, W.E. and C.C. Mow, 1972; Singh, B and B. Nisha, 1991).

During the first two decades of Indian planning, the consumption of electricity grew at a faster rate than the increase in industrial output. This is mainly because electricity is used as a variable as well as a fixed factor for lighting and domestic purposes (Banerjee, Nirmala, 1978). Also, the demand for electricity is found accompanied with the variation in industrial output less than proportionate with the variation in electricity consumption (Baxter, R.E and R. Rees, 1968). In the long run, the growth rate in electricity consumption has been found to become higher than the growth rate of industrial output in the industrial sector. This is mainly due to three reasons. Firstly, electricity was used as a substitute for coal, petroleum and natural gas. Secondly, technological changes due to innovation of new machinery led to higher consumption of electricity. Thirdly, more proportionate increase in capital stock than in output in favour of more electricity intensive technology.

The discussion per se portrays the changing behaviour of electricity, which was specifically confined during the period of post economic reforms. During the period of pre-economic reforms associated with industrialization, globalization and privatization, it is essential to assess the changing patterns of electricity

consumption due to various reasons. In the light of above, an attempt has been made firstly, to study the nature of demand for electricity with industrial output, invested capital, relative price movements of substitute fuels, viz., coal, petroleum and natural gas. Secondly, to assess the importance of various determinants of electricity consumption in the industrial sector. And thirdly, to assess the existence of a structural break between pre and post liberalization of industrial policy in India.

Methodological Issues

The present study is restricted from 1971 to 2000 between the two sub periods, viz., the pre-liberalization phase from 1971-72 to 1990-91, i.e., period I, and the post-liberalization phase from 1991-92 to 2000-2001 i.e., period II.

Data from secondary sources such as Annual Survey of Industry (ASI), Centre for Monitoring Indian Economy (CMIE), RBI Bulletin and other sources have been used in the present study for identifying the demand for electricity in the industrial sector. The value of industrial output, net value added, total invested capital, price of electricity, have been considered as determinants of demand for electricity in the Indian industrial sector. The level of industrial production is taken as an index of industrial production with 1993-94 as the base year. Similarly, the price of electricity, coal, oil and natural gas have been taken with 1993-94 as a base year.

The empirical analysis examines the impact of industrial output, electricity prices, technological changes and lag value of industrial output on demand for electricity in the industrial sector. Price of electricity is included in this model mainly for two reasons. Firstly, it plays an important role for determining the demand for its own commodity. And secondly, it acts as a substitute for other fuels because electricity prices are mostly administered prices compared to the prices of other fuels. The changes in technology due to innovation are also included because it acts as an important factor for the changes in the consumption of electricity.

Besides, we also examined the responses of the levels of these variables to their rates of changes in order to capture their short run dynamics. Testing for the existence of a statistical relationship among the variables is carried out in three steps. Firstly, verification of the order of integration among the variables. The tests are valid if the variables have the same order of integration. Based on the work of Dicky & Fuller (1979, 1981), (ADF) and Phillips and Perron (1988), (PP), standard tests for the presence of a unit root is accomplished to investigate the degree of integration or to ensure the stationarity of the variables used in the empirical analysis. When the variables are found to be non-stationary, the first difference would be taken and re-estimated with the differenced data (Tuen Mun, N.T. 2002). The second step involves testing for cointegration using Johansen maximum likelihood approach (Johansen, 1992). This test rules out the possibility of the estimated relationship being spurious (Hondroyiannis, G., et al, 2002). The third step involves the utilization of Auto Regressive Model, which estimates the changes in the dependent variables as a function of changes in explanatory variables.

Analysis of the Study

The industrial sector accounts for 35.36 percent of the total electricity consumption in India, followed by agriculture which accounts for 30.75 percent, while 20.33 percent was accounted for by the domestic sector in 1997-98 (Government of India, 1998-99). The consumption of electricity in the industrial sector is not only substantial but also the rate of increase in consumption of electricity compared to other fuels in this sector is higher than that of other sectors. The electricity consumption increased by 900 percent during the first two decades of the plan period, whereas industrial production increased by only 200 percent (Banerjee, Nirmala, 1978). It happened mainly because electricity is used as both a fixed and variable factor in the industrial sector.

The rate of increase in consumption of electricity in industrial sector is higher than that of other sectors.

However, the trend of growth of electricity consumption along with industrial output after the seventies is quite different. After the seventies, the industrial output grew at a higher rate than the electricity consumption because of technological changes. The annual average growth rate (CAGR) of industrial output was 6.17 percent, whereas the same for electricity consumption was 5.31 per cent. The CAGR of invested capital was found to be 14. 56 per cent during the same period (Table 1). The direction of electricity consumption and industrial output reversed after the seventies due to various reasons. Firstly, modern, sophisticated and efficient machinery were introduced due to technological innovation through additional investment. Technological change took place through additional investment in the industrial sector in the form of additional electrified

machinery because these machineries are more efficient. Secondly, economics of scale was prevalent in the industrial sector in India, which caused the introduction of more electricity intensive machinery. Eventually, the requirement of electricity to produce one unit of industrial output was gradually decreased. Thirdly, the mode of industrial production has been changed in the industrial sector during this period in favour of more electricity intensive machinery. During this period, basic chemicals, basic metal alloy industries, transport industries and other machinery industries were developed, which required more of electrical machinery and the intensity of electricity also increased.

Table 1: CAGR of major determinants of Electricity Consumption in Industrial Sector

Items	Period I	Period II	1971-2001
Total value of output	9.29* (0.004)	7.95* (0.013)	9.35* (0.002)
Total electricity consumption	5.31* (0.002)	1.64 (0.065)	5.47* (0.006)
Total invested capital	14.56* (0.002)	14.91* (0.017)	15.60* (0.002)

Source: Various Volumes of Annual Survey of Industries, Summary Results and Factory Sectors.

Note: CAGR obtained by fitting the standard form log Y = a + bt to the time series data of Total value of output, Total electricity consumption and Total invested capital by Ordinary Least Square (OLS). The values in the parenthesis are Standard Errors, * indicating 1 percent level of significance. TVO values are converted by the index of industrial production, 1993-94 = 100 to find out the CAGR of TVO (RBI, 2001).

The higher growth of electrical machinery due to technological progress also altered the pattern of production. The demand for electricity not only grew more rapidly than that of other types of energy but also at a much higher rate than the net national product (Singh, B and Nisha, B., 1991). In other words, the demand for coal, petroleum and natural gas is being substituted by electricity. Electricity is used as a close substitute for coal and petroleum and natural gas. Such a substitution in the industrial sector became possible because of the increase in price of coal, petroleum and natural gas, which was higher than the increase in the price of electricity (see Table 2). The CAGR of price of coal, petroleum and natural gas during period I are 10.34 percent and 16.41 percent respectively, whereas the CAGR for price of electricity is 9.63 percent. Similarly, the CAGR of petroleum price is found to be higher than the CAGR of electricity prices during the nineties. Though the CAGR of coal price is quite lower than the CAGR of the price of electricity, yet demand for electricity increased because of technological innovation. Secondly, coal, petroleum and natural gas are exhaustive in nature. Also, given the supply of coal,

The higher growth of electrical machinery due to technological progress altered the pattern of production.

petroleum and natural gas is constant, the increase in demand of these products has led to an increase in their price. Thirdly, generation of electricity is renewable in nature. During this period, more hydro and thermal electricity plants were started. As a matter of government policy, electricity is provided at a subsidized rate to industries on priority basis. Most of the State Electricity Boards have been providing electricity at a subsidized rate for the industries, viz., chemical, cotton, transport equipment, cement, basic metal.

Table 2: CAGR of price of various Fuels used in the Industrial Sector

Items	Period I	Period II	1971-2001
Coal	10.34* (0.003)	8.00* (0.008)	9.95* (0.002)
Petrol	16.41* (0.016)	12.97* (0.009)	13.20* (0.008)
Electricity	9.63* (0.002)	10.96* (0.007)	10.21* (0.001)

Source: Office of the Economic Advisor, Ministry of Commerce and Industry

Note: CAGR obtained by fitting the standard form Log Y = a + bt to the time series data of price of coal, petroleum and natural gas and electricity by Ordinary Least Square (OLS). The values in the parenthesis are Standard Errors, * indicating 1 percent level of significance. The prices are converted by the index of Industrial price, 1993-94 = 100.

Discussion of Estimated Results

Numerous attempts are made to estimate the empirical relationship between demand for electricity with industrial output, its lag value and the price of electricity. The demand for electricity is treated as a dependent variable, whereas industrial output, its price, are independent variables. The relationship between the demand for electricity and industrial output are worked out by applying ordinary least square (OLS), (Fisher, F. M. and Carl Kaysen, 1962; Wilson, J.W., 1969; Banerjee, N., 1978; Singh, B. and B. Nisha, 1991). Moreover, studies attempting to examine the impact of previous years? electricity demand and technological innovation on the demand for electricity are limited. To fill this gap, the present study makes a modest attempt to examine the relationship between these variables by introducing the lag value of demand for electricity and technological change.

The model has been chosen by treating electricity

consumption as the dependent variable, while total value of industrial output (TVO), price of electricity (PELE), total electricity consumption in the last year (TEC (1)), TREND (T) are the independent variables. This is examined by using the model as discussed here under:

ITEC = f { ITVO, IPELE, ITEC(1), TREND}

Where,

ITEC = Log of Total Electricity Consumption, ITVO = Log of Total Value Output, IPELE = Log of Price of Electricity, ITEC {1} = Log of Total Electricity Consumption in the last year.

TREND indicates technological changes. The functional form of the model is as follows.

$$ITEC = a_1 + a_2\,ITVO + a_3\,IPELE + a_4\,ITEC\,(1) + a_5\,TREND$$

a_1, a_2, a_3, a_4 and a_5 are coefficients of independent variables.

In order to find the nexus among electricity consumption, the price of electricity and industrial output, it must be determined if a long-run cointegrating relationship exists among these variables. Thus, the ADF and PP procedure is used to test each variable for the unit root in its level form and then in the first difference form. The results of ADF & PP for the variables used in the analysis in level and in first difference are shown in Table 3. The results of both ADF & PP suggest that all variables are integrated at first difference 1(1). Therefore, the hypothesis that the time series contains an autoregressive unit root is accepted in all cases..

Table 3: Tests of Unit roots hypothesis

Variables	Level		First Difference	
	ADF	PP	ADF	PP
LTEC	-1.3362	-1.7209	-7.1013	-10.0128
LTVO	-1.4848	-1.1625	-5.3229	-5.3414
LPELE	-0.0110	-0.0412	-4.2530	-4.2531

Source: Computed from various volumes of ASI.

To test for cointegration, we use the Johansen maximum likelihood approach employing both maximum eigenvalues and trace statistics (Table 4). The estimated Trace statistics indicates the existence of one cointegrating vector in the system. This implies that the variables in the system are tied together by long run equilibrium relationships. The existence of two common trends in the model implied that there is a causal relationship among the variables in the system. The future fluctuations of total electricity consumption could be forecast to some extent using relevant information provided by the model.

Table 4: Johansen Cointegrating Test

Hypothesis	Eigen values	Trace Statistics	5 percent level of critical value	1 percent level of critical value
None	0.5784	34.1880	29.68	35.65
At most 1	0.2967	13.4573	15.41	20.04
At most 2	0.1883	5.0086	3.76	6.65

Source: Computed from various volumes of ASI.

- Trace statistics indicates 1 co-integrating equation at 5 percent level of significance.

The direction and the intensity of the causal effects can only be determined through Multiple Regression Analysis. The estimated results of the above equation are as follows.

ITEC = 10.52 + 0.670 ITVO – 0.0039 IPELE + 0.338 ITEC{1} + 0.0373 TREND

Standard Error = (4.49) (0.2549) (0.0018) (0.1297) (0.0143)

T.Value = (2.34) (2.63) (-2.16) (2.61) (2.60)

Adj. R^2 = .872

It is estimated in the Indian Industrial sector for the study period that the elasticity of demand for electricity consumption with respect to industrial output and electricity prices are 0.67 and -0.0039 respectively. In other words, over the period of study, holding other variables constant, 10 percent increase in total value of output lead to, on an average 6.7 percent increase in the total electricity consumption. From a purely statistical viewpoint, the estimated regression line fits the data quite well. The Adj.R^2 value of 0.87 shows that about 87 percent of the variation in the TEC is explained by TVO, PELE, TEC(1) and Trend.

In the case of electricity prices, the co-efficient in the estimated equation confirms the negative relationship between the demand for electricity and its price. Though in most of the cases electricity is provided at the administrative rate but its impacts are not felt significantly. The estimated results show that 10 percent increase in price of electricity lead to, on an average, about 0.04 percent decrease in the TEC. This shows the demand for electricity is insensitive to its price changes. In a theoretical analysis, the negative relationship between electricity price and its demand shows that installation of additional capacity in the industrial sector is

Table 5: Results of the Unit Root Tests

Name of the Industry	Variables	Level		First difference	
		ADF	PP	ADF	PP
Cotton Industry	LTVO	0.6969	0.9672	-2.7223**	-2.7823**
	LTEC	0.6145	0.5307	-4.9500*	-4.38*
Jute and other Vegetable Fibre	LTVO	0.3963	0.2365	-4.1607*	-4.2224*
	LTEC	-3.1217**	-4.270**	–	–
Paper and Paper Products	LTVO	-1.3159	-2.1089	3.9777**	-5.9363*
	LTEC	-1.0479	-0.9913	-3.5709*	-4.2316*
Basic chemical and chemical products	LTVO	-0.2851	-0.1255	-4.1476*	-5.1556*
	LTEC	-0.0012	-0.7648	-3.3314**	-6.8230*
Cement Products	LTVO	-0.4899	-1.2698	-3.3733**	-3.3747**
	LTEC	-1.6392	-1.9723	-5.0131*	4.7419*
Basic metal and alloy industries	LTVO	0.4902	-0.1241	-3.6821**	-4.9046*
	LTEC	-1.9119	-2.8416	-3.8832**	-5.5133*
Machinery machine tools	LTVO	-0.3092	-0.4558	-3.6480**	-5.2652*
	LTEC	-0.7152	-2.3922	-3.3808**	-6.3051*
Electrical machinery	LTVO	-0.1437	-0.0676	-3.1650**	-4.6860*
	LTEC	-1.1099	-1.3479	-4.4804*	-4.4951*
Transport equipment	LTVO	1.2970	1.7049	-3.6855**	-3.6837**
	LTEC	-1.4419	-2.1229	-5.3168*	-5.3710*

Source: Computed from various volumes of ASI.

Note: * represents 1 percent level of significance, ** represents 5 percent level of significance

adversely affected by higher rates of electricity prices. The less sensitiveness of price with respect to its demand is mainly due to the fact that the magnitude of investment involved in this sector for creating more capacity is very large and starting cost after closing the machine is also quite high.

There is an impact of the previous year's demand for electricity on the current year's demand in the manufacturing sector. It indicates that the current year demand for electricity retains 34 percent from the previous year. The lagged dependent variable possess is a positive coefficient and is statistically significant. It means, the expected demand for electricity is positive and significantly related with the existing demand in this sector. However, the additional demand for electricity increases at a decreasing rate as the relation being less than elastic. The Trend (T) plays an important role in order to increase the demand for electricity and the total value of the industrial output

In order to assess the impact of industrial output on the demand for electricity in different individual industries, nine major industries were selected. The net value added to the total industrial sector constitutes 69 percent of the total value added (ASI, 1998-99). These

Table 6: Estimation of Results for selected Industries

Name of the Industry	Constant	Coefficient of industrial output	Adj. R^2	T Value*	DW Statistics
Cotton Industry	-16.65	3.08	0.77	7.34	0.96
Jute and other Vegetable Fibre	8.72	-0.0012	0.37	3.79	2.24
Paper and Paper Products	7.89	0.302	0.60	4.91	1.62
Basic chemical and chemical products	0.76	1.008	0.89	11.21	2.32
Cement Products	6.69	0.49	0.55	4.43	2.14
Basic metal and alloy industries	4.88	0.73	0.44	3.57	2.06
Machinery, machine tools	6.94	0.27	0.45	3.70	2.01
Electrical machinery	5.70	0.40	0.85	9.48	1.70
Transport equipment	5.87	0.42	0.37	3.17	1.88

Source: Estimated from various volumes of ASI.

Note: * represents 1 percent level of significance.

industries were selected from Annual survey industries and respective code numbers were given. The results of the unit root test show that the time series data for all nine industries for both the variables are stationary at their level or first difference (Table 5).

The estimated result shows that the total value of industrial output is the significant determinant for the demand for electricity in the industrial sector (Table 6). It is indicated from the estimated results that the manufacturers of cotton textiles, paper and paper products, manufacturer of basic chemicals and chemical products, cement products, basic metal and alloy industries are more electricity intensive industries, which consume more units of electricity for producing one unit of industrial output. In case of cotton textiles and basic chemical products, the output elasticity is 3.80 and 1.008, respectively, which shows significant sensitiveness of demand for electricity due to change in the value of output. This shows that the sensitiveness of the demand for electricity with respect to industrial output is moderate in case of cement products, basic metal and alloy industries, electrical machinery and transport equipment industries.

The elasticity of demand for electricity with respect to industrial output was more during 1951-71 (Banerjee, N., 1979). Because of the growth rate of demand for electricity which was more than the growth rate of industrial output. On the other hand, the present study explains the less elastic nature of demand for electricity with respect to the value of industrial output. It implies that the proportionate change in the demand for electricity is less than the proportionate change in the value of industrial output during the study period.

Estimation of Structural Break

A structural change has been taking place in the industrial sector during this period. The demand for electricity has increased mainly due to an increase in the value of industrial output through technological development. Dummy Variable Model is applied, in order to test the structural break in the industrial sector in India. Based on the nature of the data, the whole period is divided into two phases, viz., pre-liberalised period (1973-91) and post-liberalised period (1992-2001). The specified Dummy Variable Model is as follows.

$$TEC = \alpha_1 + \alpha_2 D_i + \beta_1 TVO + \beta_2 (D_i .TVO) + U_i$$

Where,

TEC and TVO are mentioned earlier, $D_i = 0$ for observations in the first or pre-liberalised period and one for observations in the post-liberalised period. To see the implications of the model, it is assumed that $E(U_i) = 0$, we obtained,

$$E(TEC/D_i = 0, TVO) = \alpha_1 + \beta_1 TVO$$

$$E(TEC/D_i = 1, TVO) = \alpha_1 + \alpha_2 + (\beta_1 + \beta_2) TVO$$

Turning to the TEC and TVO data, the empirical counter part of the above model is estimated.

$$TEC = 430256 + 729837.7D_i + 1.389TVO - 1.436 TVO.D_i$$

Standard error = (47472.86) (189651.3) (0.349) (0.453)

T. Value = (9.063) (3.848) (3.98) (-3.168)

Adj. R^2 = .817

In this case, both the differential intercept and the differential slope coefficients are statistically significant. In other words, it strongly indicates that the regressions for the two periods are different. Then we can derive the two regressions as follows.

Pre-liberalised period:

$$TEC = (430256 + 729837) + (1.389 - 1.436) TVO$$
$$= 1160093 - 0.047 TVO$$

Post-liberalised period:

$$TEC = 430256 + 1.389 TVO$$

It is clearly indicated that out of the coefficients of the two regressions that the coefficients of the post-liberalised period is higher than the coefficients of the pre-liberalised period. It indicates that there is structural change during this period through technological development. It means more electricity intensive machinery are used for producing industrial output in the post-liberalised period.

Summary and Conclusions

In this paper, the proportionate variations of electricity consumption due to the proportionate variation of industrial output and electricity price are estimated. This is accompanied by examining the dynamic relationship among the variables. The evidence of cointegration between the three variables suggests that they are bound together by common trends or that a long-run equilibrium condition exists. This implies that although the variables may exhibit occasional short-run or transitory deviations from their long-run equilibrium,

eventually forces will prevail that will drive them together.

The main conclusion from the analysis is that relative price changes are not clearly an important determinant of growth in industrial electricity consumption. The main determinant is growth of industrial output. Secondly, the study also indicates that technological progress takes an important position for the increase in demand for electricity in the industrial sector. This implies that there are more electric intensive machinery and technology used in the industrial sector than before. Thirdly, in the present Indian industrial sector, significant structural changes are taking place and it will have a major impact on the demand for electricity in relation to alternate forms of energy. It signifies that industrial products are becoming towards more electricity intensive.

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□

Something new is not innovation if it does not lead to value addition.

– John Prescott

Feature

Design Optimization for Quality in Machining Process using Taguchi Approach

K. Palanikumar & L. Karunamoorthy

The present study discusses the application of Taguchi method to a composite machining process. Design optimization in machining of FRP composite is to find out the main control factors and select their appropriate levels. In data analysis, signal-to-noise (S/N) ratios are used to allow the control of the response as well as to reduce the variability about the response. The use of analysis of variance (ANOVA) is used to calculate the statistical confidence associated with the conclusions drawn. Verification of the quality improvement has been made through confirmation experiments. Confirmation test results prove that the determined optimal combination of machining parameters satisfy the real requirements of machining operation in the machining of GFRP composites.

K. Palanikumar is with Sathyabama Institute of Science & Technology, Chennai. L. Karunamoorthy is with the Department of Mechanical Engineering, Anna University, Chennai-25.

In the modern manufacturing era, Total Quality Management is the most important concept because the quality of the product makes the difference between success and failure of any organization. Quality is the priority in achieving industrial competitiveness. For the customer, it means good design, reliable performance, prompt delivery and, in short, providing goods or services that meet the customer's expectations in full, at a competitive price. This is a definition of what the organization exists to do and an aim, which it works towards. For the TQM, customer obsession, planning process, improvement cycles, daily process management and employee participation are the various aspects to be considered. Taguchi proposes a holistic view of quality, which relates quality to cost, not just to the manufacturer at the time of production, but to the customer and society as a whole (Phadke, 1989). Taguchi defines quality as, "The quality of a product is the (minimum) loss imparted by the product to the society form the time product is shipped" (Taguchi, 1986).

This article discusses the application of Taguchi method to a composite machining process. Design optimization in machining of GFRP composite is to find out the main control factors and select their appropriate levels. Typical control factors include cutting speed, feed rate and depth of cut and fiber orientation angle. In data analysis, signal-to-noise (S/N) ratios are used to allow the control of the response as well as to reduce the variability about the response. The analysis of variance (ANOVA) is used to calculate the statistical confidence associated with the conclusions drawn. In this experiment, three levels are considered for factors and the orthogonal array used is L_{18}.

Taguchi Method

Dr. Genichi Taguchi is the developer of Taguchi

method (Phadke, 1989). He developed a philosophy and methodology for continuous quality improvement in product and processes. Taguchi advocates the use of orthogonal array designs, to assign the factors chosen for the experiment. This method combines the experimental design with quality loss consideration. He proposed that the engineering optimization of a process or product should be carried out with three-step approach:

1. *System design:* The system design stage is also called primary design. It applies engineering and scientific knowledge to develop a prototype design for product or process, which meets customer requirements.
2. *Parameter design:* The Parameter design stage is also called robust design. Its main aim is to reduce cost and improve quality. It determines the design parameter settings for a product or process so that the product response has the minimum variation and is close to the target.
3. *Tolerance design:* The tolerance design establishes tolerances for the product or process parameters identified as critical during process parameter design.

In the above three steps, parameter design is the key step in the Taguchi method for achieving high quality without increasing the cost. Taguchi recommends achieving a robust process or product design. Robust design is an "engineering methodology for improving productivity during research and development so that high-quality products can be produced quickly and at low cost" (Phadke, 1989). A robust product or process is one whose response is least sensitive to all noise factors. The robust design reduces the variability around the target value and models the departure from the target value as a loss function. This aim is fulfilled by considering Signal-to-Noise ratio (S/N ratio) as the measure of performance.

Another tool used in robust design is orthogonal array which is used to study many design parameters simultaneously. An orthogonal array consists of an inner array and an outer array. The inner array represents control factors, which are to be controlled during the experiment and the outer array is meant for noise factors for which the experimenter either cannot control directly or chooses not to control. Each experimental run of the inner array is replicated according to the outer array.

It is revealed from the above that parameter design can be applicable to any process design. The parameter design of Taguchi method involves different steps. Fig. 1 demonstrates the procedure and steps of Taguchi parameter design. (Phadke, 1989).

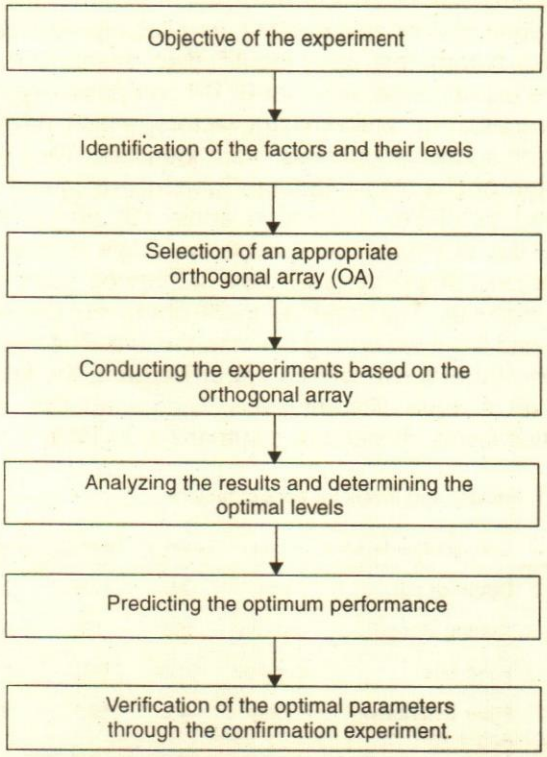

Fig. 1. Procedure and steps in Taguchi parameter design

Experimental Design, Setup and Results

The step-by-step procedure involved in experimental design, setup and results are presented as follows.

Objective of the Experiment

The objective of the experiment was to minimize the surface roughness of the machined work piece. Surface finish is an important parameter in machining process. Surface roughness has received serious attentions for many years. It has formulated an important design feature in many situations such as parts subject to fatigue loads, precision fits, fastener holes and aesthetic requirements. In addition to tolerances, surface roughness imposes one of the most critical constraints for selection of machines and cutting parameters in process planning. (Chang-Xue feng, Xianfeng, 2002). Surface finish of the work is affected by control factors and noise factors. The quality of the product can be improved by minimizing the effect of cause of variation without eliminating the cause. The best quality can be achieved by optimizing through parameter design.

Identification of the Factors and their Levels

Identification of process parameters (or control factors) is crucial for the success of any experiment. Based

on the experience in the field and from the previous work done, the independently controllable predominant process parameters were identified to enable to carry out the experimental work. In GFRP composite machining process, the predominant factors, which have an effect on surface roughness, were identified. They were (i) Depth of Cut (A) (ii) Cutting Speed (B) (iii) Feed rate (C) and (iv) Fiber orientation angle (D) of the work piece, out of which fiber orientation angle is specially applied to composite glass fiber reinforced composite work material. The orientation of fibers on the work piece had been set during the manufacture. The feasible ranges of the above factors are arrived and the factors were set at three different levels. The parameters, units and their levels chosen are summarized in Table 1.

Table 1: Factors and levels for control factors

Symbol	Controllable factors	Unit	Level 1	Level 2	Level 3
A	Depth of cut	mm	0.5	1.0	1.5
B	Cutting Speed	m/min	100	150	200
C	Feed rate	mm/rev	0.05	0.10	0.15
D	Fiber Orientation Angle	Deg	45	54.7	73

One of the important features in Taguchi parameter design is it could consider noise factor also in the analysis. Three noise factors have been identified in this experiment. The levels chosen for the noise factors were two and is given in Table 2.

Table 2: Factors and levels for noise factors

Symbol	Noise factors	Level 1	Level 2
E	Measurement location	1	2
F	Tool wear	Low	High
G	Process to process variation	Low	High

Selection of an Appropriate Orthogonal Array (OA)

Orthogonal arrays are simple and useful tools for planning and designing industrial equipments. They have the balanced property that every factor level occurs the same number of times for every level of all other factors in the experiment. This balancing property permits the use of simple arithmetic to find the effect of the experimental factors on the response under study. The selection of OA depends on the number of factors to be studied. Since four factors were studied in this research at three levels, the L_{18} ($2^1 \times 3^7$) orthogonal array was selected for experimentation. For noise factors the OA selected was $L_4(2^3)$, since it has 3 factors at two levels. The layout of orthogonal arrays for control factors and noise factors are illustrated in Tables 3 and 4. The actual values are replaced by coded values.

Table 3: Orthogonal array (L_{18} ($2^1 \times 3^7$)) for control factors (P.J. Ross, 1989)

Experiment No.	Columns							
	1	2	3	4	5	6	7	8
1.	1	1	1	1	1	1	1	1
2.	1	1	2	2	2	2	2	2
3.	1	1	3	3	3	3	3	3
4.	1	2	1	1	2	2	3	3
5.	1	2	2	2	3	3	1	1
6.	1	2	3	3	1	1	2	2
7.	1	3	1	2	1	3	2	3
8.	1	3	2	3	2	1	3	1
9.	1	3	3	1	3	2	1	2
10.	2	1	1	3	3	2	2	1
11.	2	1	2	1	1	3	3	2
12.	2	1	3	2	2	1	1	3
13.	2	2	1	2	3	1	3	2
14.	2	2	2	3	1	2	1	3
15.	2	2	3	1	2	3	2	1
16.	2	3	1	3	2	3	1	2
17.	2	3	2	1	3	1	2	3
18.	2	3	3	2	1	2	3	1

Table 4: Orthogonal array (L_4 (2^3)) for noise factors (P.J. Ross, 1989)

Experiment No.	Columns		
	1	2	3
1	1	1	1
2	1	2	2
3	2	1	2
4	2	2	1

Conducting the Experiments Based on the Orthogonal Array

The purpose of the study was to reduce the surface roughness on the machined work piece. The experiments were conducted on a milling machine and the operation carried out was end milling. Work material considered for the observation is glass-fiber-reinforced-plastic composites. (Matrix: general-purpose resin, glass fiber). The tool material is high-speed steel. The purpose of milling is to produce a good quality surface on the work piece. The average surface roughness (R_a), which is mostly used in industries, is taken for this study. The surface roughness was measured by using Surtronic 3+ stylus type instrument manufactured by Taylor Hobson.

Table 5: Results of the Experiment

								G F E	1 1 1	2 2 1	2 1 2	1 2 2	S/N ratio
Experiment No.	1	2 **A** Depth of Cut (mm)	3 **B** Cutting Speed m/min	4 **C** Feed Rate mm/rev	5 **D** Fiber angle (deg.)	6	7	8	Response				
									R_1	R2	R3	R4	
1.	1	0.5	100	0.05	45	1	1	1	9.10	9.10	9.31	8.92	-19.18
2.	1	0.5	150	0.10	54.7	2	2	2	8.58	8.22	8.17	9.40	-18.67
3.	1	0.5	200	0.15	73	3	3	3	8.78	8.72	8.42	9.22	-18.87
4.	1	1.0	100	0.05	54.7	2	3	3	5.65	5.00	6.65	5.43	-15.04
5.	1	1.0	150	0.10	73	3	1	1	7.21	7.10	6.9	7.65	-1716
6.	1	1.0	200	0.15	45	1	2	2	7.32	7.12	6.95	7.94	-17.29
7.	1	1.5	100	0.10	45	3	2	3	8.23	8.12	7.98	8.60	-18.31
8.	1	1.5	150	0.15	54.7	1	3	1	11.2	7.90	11.72	10.98	-20.98
9.	1	1.5	200	0.05	73	2	1	2	3.24	3.15	3.72	2.90	-10.21
10.	2	0.5	100	0.15	73	2	2	1	12.65	12.12	12.15	13.72	-22.04
11.	2	0.5	150	0.05	45	3	3	2	5.34	5.34	5.12	5.56	-14.55
12.	2	0.5	200	0.10	54.7	1	1	3	7.22	7.01	8.25	6.5	-17.17
13.	2	1.0	100	0.10	73	1	3	2	7.89	7.72	7.6	8.35	-17.94
14.	2	1.0	150	0.15	45	2	1	3	8.65	9.22	7.85	8.96	-18.74
15.	2	1.0	200	0.05	54.7	3	2	1	4.32	3.91	5.2	3.98	-12.71
16.	2	1.5	100	0.15	54.7	3	1	2	10.12	10.00	10.78	9.6	-20.10
17.	2	1.5	150	0.05	73	1	2	3	5.22	5.20	4.76	5.73	-14.35
18.	2	1.5	200	0.10	45	2	3	1	6.12	6.10	5.98	6.31	-15.74

The experimental run was carried out as per the orthogonal array and was presented in Table 5. The second column was assigned to depth of cut, the third column to the speed, the fourth column to feed rate and the fifth column to the fiber orientation angle. The remaining columns were assigned to the interactions. Each run has four data collected. Therefore, a total of (18 x 4) 72 data values were collected, which were used for further analysis. After the data were collected signal-to-noise ratio of each run were calculated. The procedure for S/N ratio calculations is given in the next section.

Analyzing the Results, and Determining the Optimal Levels

Analysis of Data and S/N ratio

The objective of using the S/N ratio as a performance measurement is to develop products and processes insensitive to noise factors (John L. Yang and Joseph C. Chen, 2001). The S/N ratio indicates the degree of the predictable performance of a product or process in the presence of noise factors. Process parameter settings with the highest S/N ratio always yield the optimum quality with minimum variance (Antony & Kaye, 1999).

The formulae for signal-to-noise ratio are designed so that an experimenter can always select the largest factor level setting to optimize the quality characteristic of an experiment. Therefore, a method of calculating the signal-to-noise ratio depends on whether the quality characteristic has a smaller-the-better, larger-the-better or nominal-the-best response. The smaller-the-better quality characteristics for surface roughness should be taken for obtaining optimal performance. The equation for calculating S/N ratio for LB characteristic (in decibels) is

$$S/N_{LB} = -10\log_{10}\left(\frac{1}{r}\sum_{i=1}^{r} R_i^2\right) \qquad ...(1)$$

Where R_i is the value of surface roughness for the

/th test in that trial. High signal-to-noise ratios are always preferred in a Taguchi experiment. For lower-the-better characteristic, this transiates into lower process average and improved consistency from one unit to the next, or both. The average response effects and S/N ratios for each level of process parameters are summerised in Tables 6 and 7.

Table 6: Mean response table for experimental data

Levels	Depth of cut (A)	Cutting Speed (B)	Feed (C)	Fiber Orientation angle (D)
1	8.61	8.94	5.45	7.46
2	6.84	7.70	7.54	7.84
3	7.34	6.17	9.79	7.50
Max-Min	1.77	2.77	4.34	0.34
Rank	3	2	1	4

Table 7: Mean response table for S/N ratio

Levels	Depth of cut (A)	Cutting Speed (B)	Feed (C)	Fiber Orientation angle (D)
1	-18.41	-18.77	-14.34	-17.30
2	-16.48	-17.41	-17.49	-17.45
3	-16.62	-15.33	-19.67	-16.76
Max-Min	1.93	3.44	5.33	0.69
Rank	3	2	1	4

However, the relative importance amongst the cutting parameters for surface roughness still needs to be known so that optimal combinations of the cutting parameter levels can be determined more accurately. (Yang W.H and Tarng Y.S, 1998). This will be discussed using analysis of variance in the next section.

Analysis of Variance

Analysis of variance (ANOVA) is a method of portioning variability into identifiable sources of variation and the associated degrees of freedom in an experiment. In statistics for analyzing the significant effect of the parameters on the quality characteristic, F test is used. Tables 8 show the results of ANOVA analysis of S/N ratio for surface roughness. This analysis was carried out for a level of significance of 5%, i.e. for a level of confidence of 95%. The last column of the tables shows the percentage contribution (P) of each factor on the total variation, indicating then, the influence on the result.

From the analysis of Table 8, it is apparent that, the F values of cutting speed, feed rate and depth of cut were all greater than $F_{0.05,2,63} = 3.146$ and they have statistical and physical significance on the surface roughness. Fiber orientation angle (P = 1.04%) was not a significant process parameter affecting surface roughness.

Table 8: Results of the analysis of variance for surface roughness

Factor	Cutting parameter	Degrees of freedom	Sum of squares	Mean square	$F_{\alpha=5\%}$	Contribution % (P)
A	Depth of cut	2	13.98	6.99	35.46	9.31
B	Cutting Speed	2	35.98	17.99	91.27	23.96
C	Feed Rate	2	86.21	43.11	218.66	57.42
D	Fiber Orientation angle	2	1.56	0.78	3.95	1.04
Error		63	12.42	0.20		8.27
Total		71	150.15			100

Determination of optimum factor level combination

Figure 2 shows four graphs, each of which represent the mean response and mean S/N ratio. The values for the graphs are presented in Table 6 and 7. As per Taguchi's principle, as mentioned earlier, the process parameter setting with the highest S/N ratio yields the optimum quality with minimum variance. Consequently, the level that has a higher value determines the optimum level of each factor. Based on the S/N ratio and ANOVA analysis, the optimal cutting parameters for surface roughness are A_2, B_3, C_1 and D_3. In addition, it is noticed that the error associated to the table ANOVA for surface roughness is 8.27%.

Predicting the optimum performance

After the optimal level has been selected, one could predict the optimum surface roughness using the following equation.

$$\mu_{predicted} = \mu_m + \sum_{i=1}^{n} (\mu_0 - \mu_m) \qquad (2)$$

Where μ_m is the mean response or mean S/N ratio, μ_0 is the mean response or mean S/N ratio at optimal level and n is the number of main design parameters that affect the quality characteristic.

$$\text{Predicted Mean} = 7.60 + (6.84 - 7.60) + (6.17 - 7.60) + (5.48 - 7.60) + (7.50 - 7.60)$$
$$= 3.19\ \mu m$$

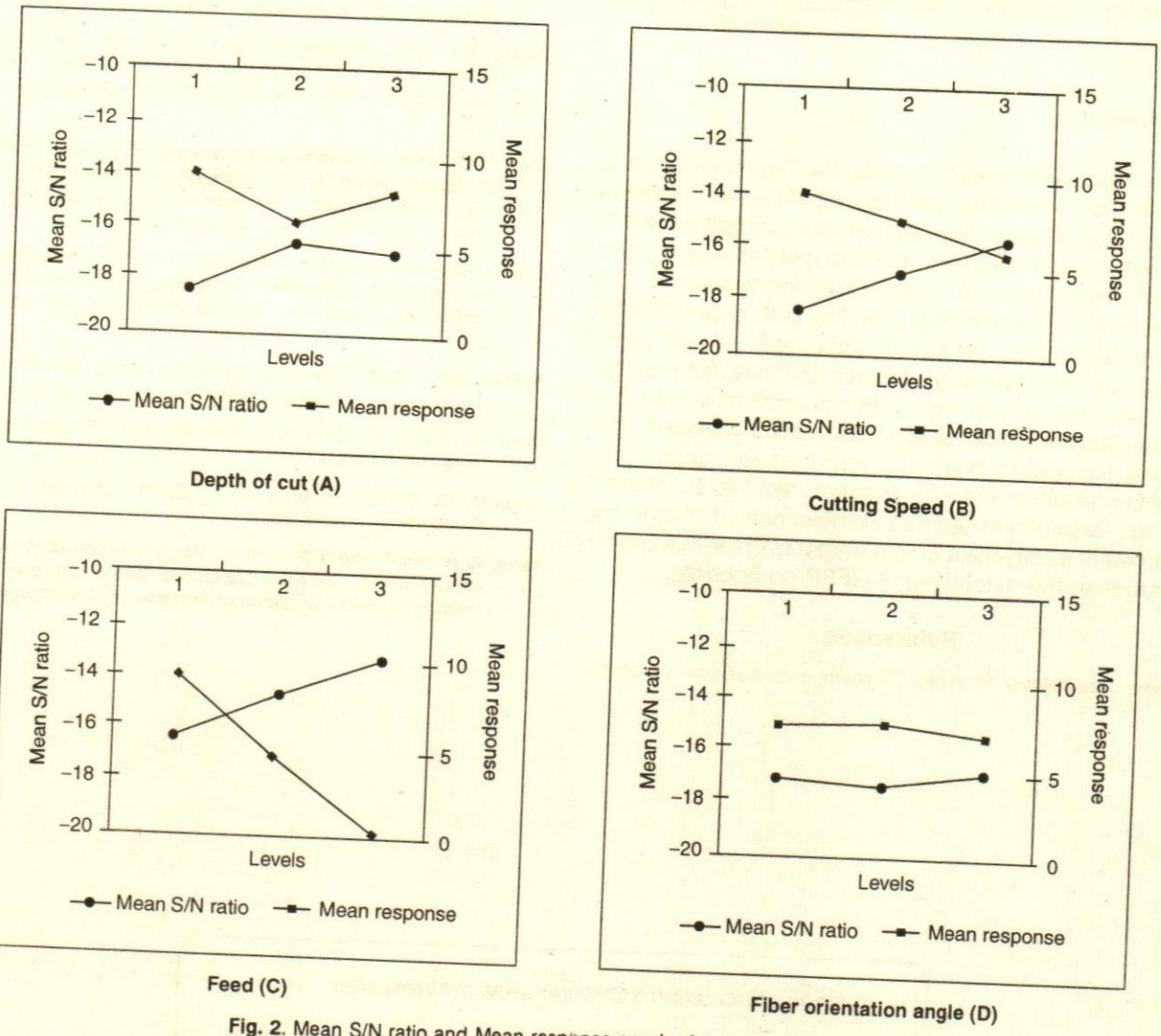

Fig. 2. Mean S/N ratio and Mean response graph of process parameters

Similarly, the S/N ratio can be predicted as,

Predicted S/N ratio = −17.17 + ((−16.48 − (−17.17)) + ((−15.33 − (−17.17)) + ((−14.34 - (−17.17)) + ((−16.76 − (−17.17))

= −11.41 dB

Verification of the Optimal Parameters through the Confirmation Experiment

The final step involved is to verify the improvement in the quality characteristic for machining of GFRP composites. Conducting the confirmation test is a crucial, final and indispensable part of the Taguchi method based parameter design. This is to demonstrate that the factors and levels chosen for the experiment do provide the desired results.

Table 9: Results of the confirmation experiment for surface roughness

	Optimal cutting parameters				
	Predicted	Experimental			
		1	2	3	4
Setting level	$A_2 B_3 C_1 D_3$	$A_2 B_3 C_1 D_3$			
Surface roughness μm	3.19	3.52	3.98	3.21	3.33
S/N ratio (dB)	-11.41	-10.93	-11.99	-10.13	-10.45

Table 9 shows the confirmation test results. It was observed that the experimental results were close to the predicted values and they were falling within the confidence limits. In other words the confirmation test results prove that the determined optimal combination of machining parameters satisfy the real requirements of

machining operation in the machining of GFRP composites.

Conclusions

In the present research study, the Taguchi method is applied for machining process optimization. Taguchi method is used as a powerful tool for optimization, which provides a systematic and effective methodology for the design optimization of process parameters. From the analysis, it is revealed that only the cutting parameters viz., cutting speed, feed rate and depth of cut, were statistical and physical significance on the surface roughness and there are no significant interactions among the control factors under study. The results revealed that surface roughness could be improved significantly for machining operations. Confirmation test results proved that the determined optimal combination of machining parameters satisfy the real requirements of the machining operation in the machining of GFRP composites.

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Change starts when someone sees the next step.

– William Drayton

Feature

E-Commerce to C-Commerce in Textile Supply Chain

Debasis Daspal

The advent of globalization has necessitated redefining business interests with more co-operation between organizations. The once adversarial relation between organizations gives way to a new paradigm of relations based on mutual trust and transparency. The simultaneous development of information system and supply chain concept has contributed towards the evolution of the collaborative management concept enabling the creation of a single value chain. This facilitates textile companies to take a global outlook towards value creation, cutting across organizations' boundaries, local interests and to focus on overall optimization of the entire value chain. The textile chain consisting of many trading partners is benefited from the practice of collaborative management.

Debasis Daspal is a technocrat based in Nagpur.

Organizations worldwide are striving to enhance value addition in order to stay competitive and face the intense global competition, ushered in by liberalization, privatization and globalization. Managing the supply chain effectively in order to reduce operational costs, increase customer satisfaction and handle dynamic scenarios of demand-supply has become inevitable.

Supply Chain Management (SCM) is mostly concerned with the linkages in the supply chain, from primary producer to final consumer. The SCM looks at the relationships between the various organizations as a chain made of solid, discrete, permanent links. With the advent of global competition and shrinking domestic market, the interfaces between these "compartments" are becoming more like permeable membranes through which critical information along with products/services are effectively passing.

The diffusion of technology into the business environment has changed the very paradigm of the existing supply chain. With the availability of different integrated business software modules providing operational, managerial and strategic information flow across the boundaries of organizations, electronic-commerce (E-Commerce) effects better synchronization across the entire supply chain with enhanced speed, increased accuracy, at reduced cost and with much better control over information.

With the growing demand of long term objectives such as more accelerated "time to market", increased flexibility to variable market demand, increased productivity with high customer retention, the individual firms realign themselves under a new collaborative paradigm. This collaborative model rests upon the very principles of supply chain management, facilitated by improved information technology and increasing trust between partners. The basis of competition is no longer limited to companies, but rather their ability to build collaborative relationships and improve the flow of materials and in-

formation throughout the entire supply chain. This collaborative management (CM), now popularly known as "C-Commerce" seeks to transform the confrontational relationship into a relationship of mutual benefit by redefining the organizational structures and contractual relationship between buyers and sellers.

The opening-up of world textile markets continues to offer huge opportunities for textile and clothing sectors. Machinery appears to be reaching functional operating limits, the industry must look to streamline other areas of its manufacturing process to continue to improve efficiencies and to achieve further cost reduction. Streamlining the decision-making processes under collaborative management will help textile manufacturers to reduce non-productive time and inventory costs from their system and thus be more competitive in the world textile economy.

Description of E-commerce

In the initial stages of e-commerce, companies started with electronic transfer of common business documents like inventories, purchase orders etc. By eliminating many of the manual processes involved, costs were significantly reduced. This had been facilitated by EDI (Electronic Data Interchange). The retail giants like Wall Mart incorporated EDI to effect substantial improvements in responsiveness.

The retail giants like Wall Mart incorporated EDI to effect substantial improvements in responsiveness.

At the next stage companies streamlined and automated processes to make co-ordination easier. There was information sharing at a higher level on production capacity, inventory position, sales etc., which made decision making easier and more accurate.

Following this, companies started making changes in their business process, which resulted in greater effectiveness, and efficiencies in the supply chain. Synergistic and well-coordinated systems incorporated in organizations resulted in redefining of roles and changes in quality of information sharing with the emergence of ERP systems.

ERP systems evolved from Material Requirement Planning (MRP) and Manufacturing Resource Planning (MRP II) systems. The first generation MRP system started using computer data bases to store lead times and order quantity and processing logic to implement Bill of Material (BOM) explosions to help in planning orders mapped across time phased priorities in a discrete manufacturing environment.

As a logical extension of MRP system, Manufacturing Resource Planning (MRP II) system evolved to cover the entire manufacturing function. This typically included machine loading and scheduling in addition to material requirement planning. It provided the mechanism to evaluate the feasibility of a production schedule under a given set of constraints.

Due to organized databases, computational logic with high processing power of computers, MRP and MRP-II were fairly successful and provided visibility into areas previously hidden. But the development of multi-point-manufacturing, final assembly activities and packaging, vast material distribution requirements in a variable global environment necessitated separate systems such as Distribution Requirement Planning. Also the manufacturers needed a system that can simultaneously solve both capacity and material constraints and quickly propagate the effects of problems and changes in both backward and forward directions throughout the supply chain. The Advance Planning and Scheduling (APSS) systems provided best of both worlds - the material focus of MRP and the short horizon rapid response scheduling power of MRP-II.

Development of Collaborative Management

The world today is in a transitory phase moving towards a new economic order, the networked or collaborative economy characterized by agility, as shown in Fig. 1. This is a new economic model where companies and individuals are linked together through electronic networks to enhance communication, conduct business

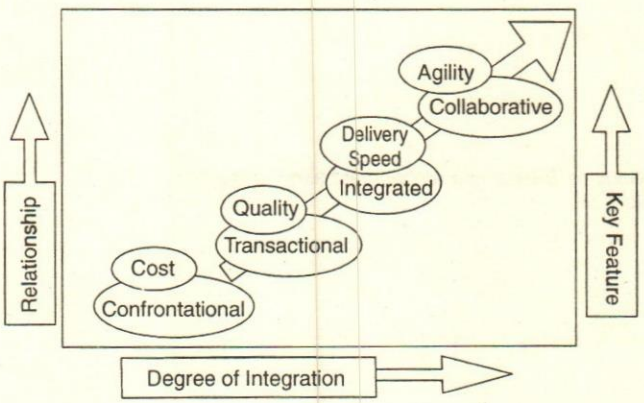

Fig. 1. Development of Collaborative Management

under co-operation and collaboration, and increase the value of their offers to consumers.

Though electronic commerce enables more efficient forms of information transaction, it has three fundamental limitations.

- **Data-centric Execution Focus**

ERP systems were developed primarily for transaction processing, data collection, and data reporting. Quite predictably, the sheer volume of contents overwhelmed users who accessed the ERP databases hoping for the insight needed to make good decisions. The true benefit of large amounts of historical transaction data could not be leveraged for business insight without sophisticated analysis tools and data reporting techniques required to make sense of the data. As a result, traditional solutions lacked the capability to support critical business decisions on real-time basis.

Certainly, ERP systems have advanced since their introduction in the early 1980s, however, most remain true to their original purpose and are not well suited to enable customers to make rapid, highly complex business decisions.

- **Poor Flexibility**

Very often, an IT enabled business reengineering project entailed a dilemma between the way clients wants to conduct business and the method supported by the particular application. More a trap than a dilemma, this situation could have been avoided if business strategy were made the first area of reengineering.

However, in cases where an implementation was already underway, project teams were often required to compromise on functionality in order to complete the project within the budgeted time. This occurred because many systems did not offer the flexibility and functionality required to accurately and realistically model the desired business processes. Large ERP vendors are historically the biggest offenders in this regard. Though the mySAP.com initiative of SAP seeks to overcome this limitation, R/3 is a prime example. These systems often have hard-code assumptions regarding operating constraints such as available manufacturing capacity and production lead times. Plans created under these assumptions can hardly be expected to produce optimal results for a given client's particular complexities.

- **One-Dimensional Planning**

ERP systems normally employed MRP (Material Requirements Planning) or MRP-II (Manufacturing Resources Planning) for internal supply chain planning. The problem with these traditional planning methodologies was their sequential nature, making them unable to consider multiple constraints simultaneously. For example, a plan that began with a demand forecast could be used to generate product requirements for the manufacturing facilities, which could then be checked against available material and capacity. However, plans created by sequential techniques were rarely optimal on the first attempt. It became necessary to refresh the system with updated constraint information and start the process anew. Because businesses change around the clock, sequential planning can never produce a truly optimal plan for a useful period of time.

The problem with traditional planning methodologies was their sequential nature, making them unable to consider multiple constraints simultaneously.

The biggest challenge of the day is not to beat the competitors, but to meet the demands of the customers. Reduced cycle time, faster and consistent responses to more versatile and segmented demands are the key drivers of today's business. The focus is on core-competencies and out-sourcing of non-core activities, partnership with strategic suppliers and providing customers with immediate access to information. This has resulted in organizations adopting a networked supply chain approach towards customer services, while minimizing the costs, rather than placing the emphasis within four walls of their organizations.

Collaborative management (CM) addresses these limitations more effectively. Where ERP systems focused on transactions, CM is geared towards analysis and planning. More significantly these collaborative efforts enabled with information technologies (E-Commerce) have the potential of unleashing the creativity and innovation of cross expertise teamwork. To understand collaborative management better, it is necessary to study a collaborative model formed under purview of textile industry as the textile supply chain is one of the most complex – manufacturers typically have many different suppliers and customers.

Collaborative Management Model in Textile Supply Chain

This model is a conceptual tool depicting a supply chain consisting of multiple trading partners, working

collaboratively to meet consumer-demand with mutual trust and with implementation of technical data security. The trading partners share information about their products, manufacturing capabilities, allocations of capacity to the partnership, and day-to-day operational status. The model has two levels of activities – Strategic level at which every organization participates to carry out few sets of actions to generate broad level agreement-called Front End Agreement. At the unit level, every organization carries out a set of functions to realize the overall goal.

- **Strategic Level Activities**

Strategic activities are mapped with the following flow chart (Fig. 2) depicting the chain of actions that are initiated to establish Front End Agreement (FEA).

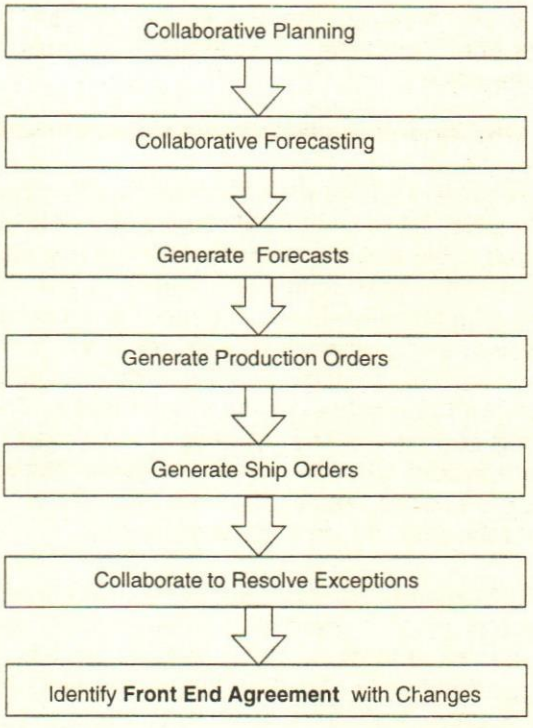

Fig. 2. Strategic Activities to develop Front End Agreement

This front-end agreement drives the common business goal of the entire chain of organizations commonly united under this paradigm.

Collaborative Planning begins when the partnership is set up. During this time, partners develop business-planning agreements that include selecting products for collaboration and establishing exception criteria. These exception criteria are used to determine when collaboration is necessary.

Taking several key inputs from trading partners, the framework of collaborative forecasting is formed. The end company (in this case Retailer) provides forecast information for this step, such as market projections, internal forecasts, and historical data. The output of the collaborative forecasting step is a commitment by each of the trading partners to meet that forecast according to the plan established by the partnership.

Once the initial collaborative forecast has been decided upon by the partnership, corporate resource planning in each company provides periodic forecast updates, which should be evaluated and processed to determine if the original forecast stands, or if an exception has occurred. The updates are used to generate forecasts. When an exception occurs, companies collaborate to resolve exceptions, and a forecast resolution is created. The forecast resolution is then processed to provide new forecast updates to each of the corporate resource planning organizations in the trading partner companies.

Corporate resource planning in each company provides periodic forecast updates, which should be evaluated and processed to determine if the original forecast stands.

Within a specified time period (established during the Collaborative Planning phase, and defined in the FEA), the Supply Chain Utility interprets the forecast, and produces production orders. These production orders incorporate lead times required throughout the product life cycle in the supply chain, and are distributed to product resource planning and production in each company unless an exception has occurred. Exceptions might include changes in lead-time, or product specifications (e.g. change in color, or size, as a result of previous forecast updates or inventory status updates). Again, exceptions require that companies collaborate to resolve exceptions and create a production order resolution. The production order resolution is then processed to provide new production orders to the product resource planning of each company.

A second time period (established during the collaborative planning phase, and defined in the front-end agreement) is defined to establish when the periodically updated forecasts are used to generate ship orders. If the Ship Orders are within the variance defined by the front-end agreement, they are translated by the bill of materials into individual Company Ship Orders and sent to each company for processing by the warehouse, order fulfillment and transportation organization. If a ship order

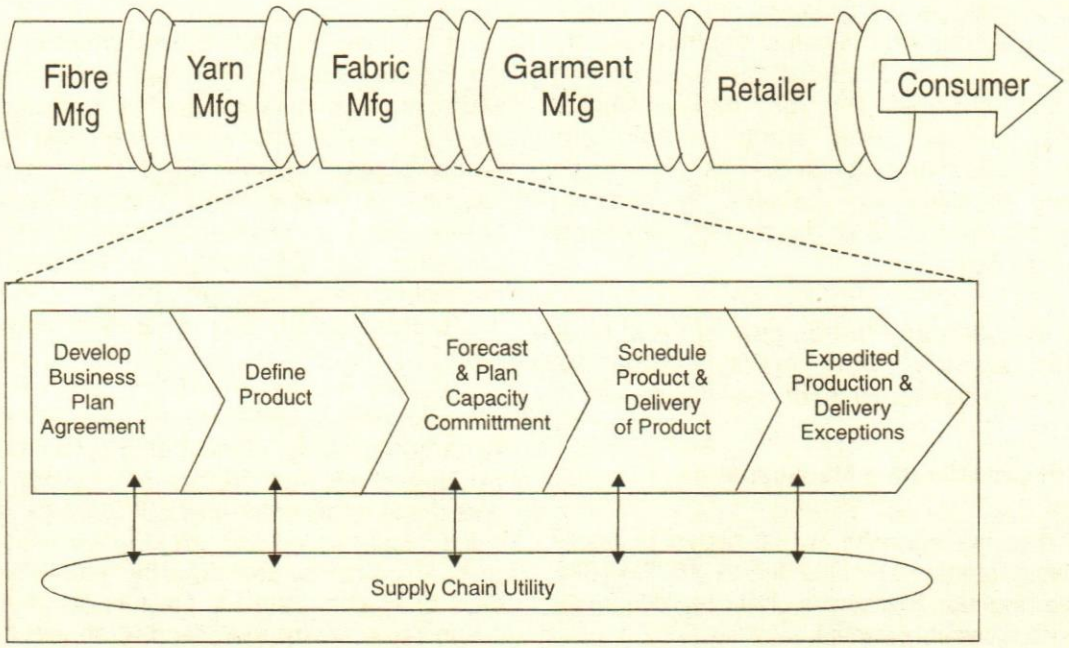

Fig. 3. Collaborative Management Model in Textile Industry

is outside the variance, it is flagged, then partners collaborate to resolve exceptions, and a ship order resolution is used to generate a new ship order for each company.

Generating forecasts, production orders, and ship orders should be automated through software, which is referred to generically in the model as the "Supply Chain Utility". This Supply Chain Utility is a conceptual software that should generate collaborative forecasts, translate Bill of Material (BOM) information across the chain, and make that information available to all companies of the collaborative partnership simultaneously and instantaneously.

Generating forecasts, production orders, and ship orders should be automated through software, which is referred to generically in the model as the "Supply Chain Utility".

Inputs to the process for planning multiple manufacturing partners under this collaborative model would include not only strategy and goals for the partnership, but also common specifications for the product being delivered, and inventory and capacity allocations to the partnership.

- **Unit Level Activities**

This model suggests that retail, garment, textile (fabric and yarn) and fibre companies within a particular supply chain share information and jointly make decisions about forecasting, planning, scheduling, product delivery and expediting orders. Following six collaborative activities are important and are employed in this model:

- Develop Business Planning Agreements (within organization),
- Define Products,
- Forecast and Plan Capacity Commitments,
- Schedule Product and Product Delivery,
- Expedite Production and Delivery Exceptions, and
- Populate Supply Chain Utility.

Above activities are integrated into following business model (Fig. 3) to be carried out by each member of the supply-pipeline to implement the common goals set under Front End Agreement. As shown, the set of initial five activities are performed by each of the companies in the chain.

For each of the first five collaborative activities, the trading partners must populate the Supply Chain Utility, the sixth activity in this model. The Supply Chain Utility is a set of applications implemented to support collaborative product definition, forecast visibility, planning, scheduling, and execution.

The value of having a single demand plan visible to all members of the chain is to better coordinate process

activities across the supply chain. Not only will trading partners better manage the development of a single, shared forecast of consumer demand, but they will also leverage that shared view of the forecast by using it to plan production schedules, inventory levels, manufacturing capacity, and ship dates throughout the chain. This ensures global optimization across the entire value chain keeping in mind the real-time demands of customer's customer as well as the current constraints of supplier's suppliers.

In order to understand the process of value creation under this new collaborative paradigm, various applications of the collaborative model are discussed.

Dimension of Collaborative Management

Collaborative management is manifested generally in the following areas to enable increased flexibility, greater speed and responsiveness under the penumbra of mutual trust between partners.

- Joint Product Development
- Vendor Managed Inventory (VMI)
- Operation Improvement
- Cross Docking
- Floor Ready Merchandise (FRM)
- Category Management
- Channel Partnership
- Quick Response System

Joint Product Development

Collaborative management promotes joint product development between manufacturer and retailer to take advantage of knowledge and experience of both of them. Before the product launch, the retailer provides the input on consumer tastes and market opportunities along with other practical considerations such as packaging. The supplier provides the optimum design to make it at the lowest cost without affecting the quality and desired features of the product.

The benefits of effective joint product development are therefore reduced new product failures, better product availability for successful launches and reduced introduction costs. By working in partnership from the start, the product can be taken from design to sales far more quickly, providing the valuable benefit of fast response to market trends.

Vendor Managed Inventory (VMI)

It focuses on maintaining agreed stock level, with the supplier deciding how frequently to replenish and what quantity to deliver. In this case, the responsibility of replenishment is shifting from the retailer to supplier. A section of buyer's plan is shipped prior to the start of the season. The retailer then makes weekly replenishment orders based on renewed demand estimation through electronic data interchange. A customer-focused organization needs to be agile enough to be responsive to this continuously changing demand and still make a profit.

As a retailer, Wal-Mart has been at the forefront of stock replenishing, offering shoppers more than a 98-per-cent chance of finding a complete selection. To speed the reorder process, Wal-Mart's suppliers are electronically linked and privy to information on the sale of their products, including the rate-of-sale. With this data, they can estimate the amount and the time at which replacement merchandise should be shipped to Wal-Mart warehouses, which in turn distribute the goods to Wal-Mart Stores.

Operation Improvement

Co-operation between various parts of the supply chain ensured the best practices in improving operations on an information-sharing basis. Previously, productivity and quality improvement were implemented in an isolated fashion resulting in cost and service benefit in a localized part of the supply chain. Working in partnerships with other supply chain players ensures global optimization of complete value chain by cutting out non-value added.

Working in partnerships with other supply chain players ensures global optimization of complete value chain.

Cross-Docking

Cross docking is the practice of receiving and processing goods for reshipping in the shortest possible time and with minimum handling and no storage. Multiple part vehicle load receipts from various vendors or deliveries to a client from various warehouses on a continuous basis can be consolidated through real time information sharing with the transporters. This kind of strategic shipment consolidation results in reduced inventory and transportation cost and increased fill rates.

The savings come from the elimination of cost related to put away, picking, handling and storage.

Wal-Mart, the world's highest retailer with sales of US$ 105 billion with a stock turnover of 6.6, 17th highest of top 200 US retailers, has successfully practiced the cross docking principle. It achieves economy of scale on distribution by purchasing full truck of loads of goods while avoiding the usual inventory and handling costs. This reduces Wal-Mart's cost of sales by 2% to 3% compared with the industry average.

Floor Ready Merchandise (FRM)

Goods can be made floor ready at any stage in the supply chain, because the process is not complex - adding product labels, price labels and security tags, preassorting and packaging. But it can be beneficial to carry out these activities at manufacturers or distribution centers, rather than at stores. Most textile fabric manufacturers practiced FRM at their respective warehouses earlier in the supplier chain to distribute goods in a more efficient and cost-effective way because goods of all stores/dealers can be prepared in larger batches and there is more floor space to work in rather than in cramped storerooms or on the shop floor itself.

Category Management

Category management encompasses many aspects of retailing – product development, merchandising, space planning, store layout and design, promotions and marketing, planning and replenishment at the retailer end. Category management involves organizing multi-functional teams around customer-oriented categories and entitling these teams with responsibilities for the strategy, operation and performance of the entire category across different functions of the business. This approach is parallel to supply chain integration - all the relevant specialists can work together to ensure an efficient and optional consumer offering, from product development to range selection through store display. The retail chains, Shoppers Stops, Park Avenue, Pantaloons, which sell multiple categories of merchandises, employ this principle.

Channel Partnerships

Channel partnership has become popular in the apparel industry. The most successful of the specialty chain, The Limited, relies entirely on private label merchandise from offshore contract suppliers. The entire system is centrally managed based on point-of-sale (POS) data captures in each store for each Stock Keeping Unit (SKU). This system has enabled The Limited to replenish store inventory of fast-selling items rapidly while reducing the process on slow movers early in the season.

The direction is now "single-sourcing", i.e. to reduce the size of the supplier base after rationalizing to establish long-term relationships that profit in further cost-reduction and better understanding to modulate supply as per elastic demand. The trend clearly is towards "partnership sourcing" concept through long-term relationships with preferred suppliers in order to visualize "win-win" philosophies. For example, IBM Rochester which started with 1,156 suppliers in 1991 has reduced its supplier base to only 321 suppliers in 1996, reducing by more than 70 percent.

Quick Response Systems

Quick Response (QR) system aims to maximize the profitability of the apparel pipeline through a set of tightly integrated processes to ensure the availability of the products irrespective of time and place. The success of QR depends on the integration of all parts of the value chain - fibre, textile, manufacturing and retail - into one consumer responsive chain enabled through rapid information transfer between various sectors in the pipeline. All this is possible through a transparent relationship between every member in the pipeline, based on mutual trust.

A number of large retail chains, many of which sell apparel, nave practiced the use of automatic stock replenishing. These include stores such as Sears, Roebuck and Co. or Wal-Mart Stores Inc. of Bentonville, Arkansas, which posted global net sales approaching $118 billion U.S. last year.

A number of large retail chains, many of which sell apparel, have practiced the use of automatic stock replenishing.

Benefits of C-commerce

The practice of collaborative management in various forms as discussed above, results in various benefits across the supply chain. Sourcing offices, garment manufacturers, factories and suppliers of fabrics, yarns, trims and accessories can all benefit from effective, real-time communications among all parties in the textile supply chain.

The extent by which benefits are realized in a typical textile supply chain has been mapped within two broad

segments - Manufacturing and Retailing and is shown in Fig. 4 and Fig. 5.

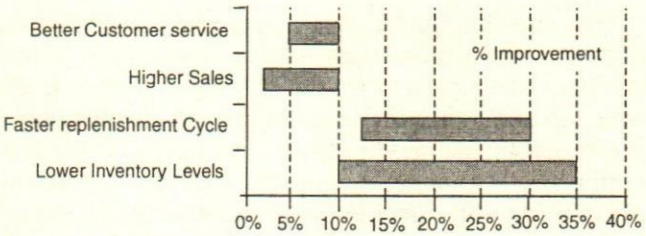

Fig. 4. Benefits of Collaborative Management in Manufacturing

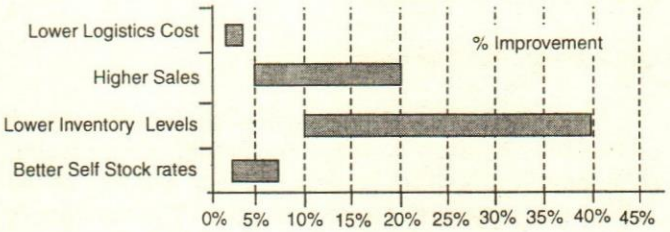

Fig. 5. Benefits of Collaborative Management in Retailing

The most immediate benefits that textile businesses can expect from strategic collaborative management are lowered inventory risks and costs, along with reductions in warehousing, distribution, and transportation costs (logistics cost). Over time, firms also experience sustainable cost savings through increased productivity and streamlined business processes in procurement and purchasing, order fulfillment, accounts receivable and payable, and exception management. Other benefits can include accelerated product delivery times, more efficient product development efforts, and lower product manufacturing costs. The scope and extent of benefits that an organization can experience depends on the extent of practice of the collaborative management, types of organizations, nature of merchandise and commitment and mutual trust between each of the members.

Conclusion

Planning under this collaborative paradigm gives one the opportunity to anticipate what is up ahead to take the appropriate turns and navigate the terrain of business more effectively.

With logistics and supply chain costs in India estimated at 11 percent of GDP, this ought to be a key area of concern. Over Rs. 1,00,000 crore is tied up in inventories in the industrial sectors alone, which is about 22 percent of annual sales, the effective management of the supply chain through collaborative understanding is essential for the growth of the economy.

Collaborative management (CM) develops as two emerging concepts—supply chain management and electronic commerce intersect each other. Once the adversarial buyer-supplier relationship has grown into a collaborative and win-win relationship with long-term interest under the ambit of an electronically enabled system.

The rapid development of retail technology and in particular the opening up of new channels of retail distribution will present a major opportunity for suppliers in the textiles and clothing supply chain. These days, purchasing clothes through credit card triggers a clockwork of activities in retail-network. These range from "automatic stock replenishing," which refills the store's shelves to alerting distant manufacturers to turn out more clothing. Moreover, electronic technology and networking systems, geared to meet customer demands, have set new standards in the industry. Instead of waiting for customer to visit their stores, retailers may simply send target e-mail, offering deals too good to refuse and initiate "automatic customer replenishing" with restocking customers' closets instead of their stores. As manufacturers and retailers scrutinize individual customer tastes, habits, and buying patterns, they directly approach consumers.

Therefore, textile companies are now beginning to perceive collaborative management as a logical and necessary extension of e-commerce to obtain competitive advantage. This collaborative paradigm also represents the best method of entry into the realm of business-to-business collaboration, which is an extension of the supply chain to include upstream and downstream trading partners (i.e., suppliers and customers).

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Feature

A Model Framework for Supply Chain Systems

M. Ananda Rao & P. Rajesh Kumar

A manufacturing supply chain is an integrated set of business functions encompassing all activities from raw material acquisition to final product delivery to customer. Delivering the right product at the right time in the right amount are essential objectives of efficient and effective supply chain systems. Thus, measures must be taken to ensure that all operational components of the supply chain systems are operating efficiently. This paper examines quality measurement in a supply chain process by developing the "Process Quality Model" (PQM) which implies the assessment, improvement and control of a manufacturing supply chain system.

M. Ananda Rao & P. Rajesh Kumar. are with the Dept. of Mechanical Engineering, Andhra University, Visakhapatnam.

A manufacturing supply chain is an integrated set of business functions, encompassing all activities from raw material acquisition to final product delivery to the customer. Today's changing industry dynamics have influenced the design, operation and objectives of supply chain systems by increasing emphasis on

- Improved customer service levels
- Reduced cycle time
- Improved quality of products and services
- Reduced costs
- Integrated information technology and process flows
- Planned and managed movement
- Flexibility of product customization to meet customer needs

Effective management of supply chain systems is achieved by identifying customer service requirements, determining inventory placements and levels and creating effective policies and procedures for the co-ordination of supply chain activities. The co-ordination of logistics functions into integrated supply chain systems has increased the need for improved process quality. Improving the quality of all supply chain process results in reduced costs, improved resource utilization and improved process results in reduced costs, improved resource utilization and improved process efficiency.

Literature Review

Most of the research in supply chain quality measurement has explored the question of how to asses the performance of individual supply chain functions. In 1978 and 1984 A.T Kearney Inc. established four stages of organisational sophistication in performance management of physical distribution activities.

Konrad and Mentzer (1991) propose that the evaluation of supply chain functions be divided into three areas.

- Productivity
- Utilization and
- Performance

The authors define productivity as the ratio of real output to real input. Real output is defined as the number of products being delivered and real input refers to the amount of raw material, sub-assemblies etc. brought in to the system. They define utilization as follows:

- Utilization = (Capacity Used/Available Capacity)

Consequently system performance is defined as:

- System Performance = (Actual Output/Standard Output).

Miller and Read (1991) examine the state of quality in supply chain systems. Detoro and Tenner (1997) provide a step-by-step approach to process improvement. Their model is based on the principles established by Crosby, Deming, Juran and Feigenbaum. The steps involved in their continuous improvement process are:

- Understand The Customer: Understand the requirements of the end customer and assess the organisation's ability to meet these requirements.
- Assess Efficiency: Gather data on internal process measures and determine whether the process is meeting such demands as cost, cycle time or variability.
- Analyzing The Process: Determine the efficiency and effectiveness of the process. The appropriate improvement path must be identified, continuous improvement, bench marketing etc. If continuous improvement is the appropriate path then step 4 is performed.
- Improve the Process: Plan-do-study-act is used as an approach to improve the process.
- Implement Changes: Make necessary adjustments.
- Standardize and Monitor: Track the performance monitor process and continuously improve.

The majority of previous studies provides insight to measuring supply chain systems. Research in supply chain process quality, however, has been limited.

The objective of this paper is to bridge the gap between supply chain systems analysis and quality control by developing a Process Quality Model (PQM) for the assessment, improvement and control of quality in supply chain systems.

Problem Description

Much of the research in the measurement of the supply chain process has focused on the development and application of productivity, utilization, efficiency and/or effectiveness equations. However, a model that provides a procedural approach to assessing, improving and controlling the quality of the supply chain process has not been found in the literature.

This paper develops a Process Quality Model (PQM) that can be used to assess the performance of a supply chain system and it's subsystem, assist in identifying problem areas and provide a frame work for continuous improvement of supply chain systems. In particular Process Quality Model (PQM) addresses the following questions:

- What aspects of quality should be measured?
- How should these aspects of quality be measured?
- How can these measures be used to evaluate, improve and control the overall quality of the supply chain system?

The Process Quality Model (PQM)

The basic frame work of the PQM is given in Fig. 1. The PQM consists of seven integrated modules. The details and procedural steps associated with each module is given below.

Objectives

Module 1

The purpose of module 1 is to define the process and all required activities. The first module in the PQM defines the current system and all activities that are tasks performed in the supply chain process, such as flow charts, flow process charts, Gantt charts and relation diagrams. But how these tools are applied is beyond the scope of this paper (refer to Straker 1995). After the activities have been identified they are as-

Module 1: Define the Process and Activities Being performed.

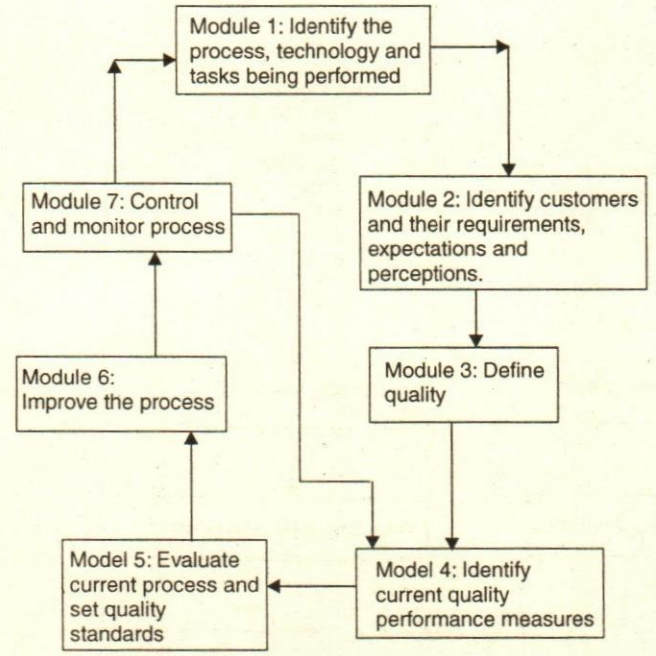

Fig. 1. Process Quality Model (PQM)

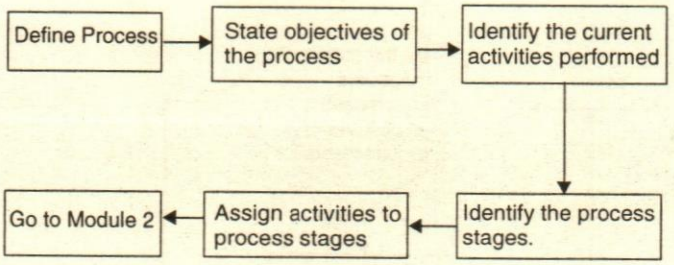

Fig. 2. (Module 1)

signed to process stages. These stages may include inbound and outbound transport, warehousing, production planning/inventory control and customer service.

Module 2: Identify Customers and their Requirements, Expectations and Perceptions.

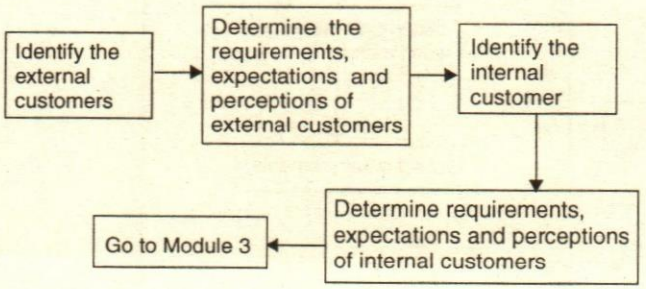

Fig. 3. (Module 2)

Module 2

The purpose of Module 2 is to identify customer expectations and perceptions in order to continuously improve customer service performance. It identifies the external and internal customers and their requirements, expectations and perceptions. The external customer(s) are the consumers of the end product. The internal customer(s) are the department(s) that require goods/services from another department within the organisation boundaries.

Module 3

The purpose of Module 3 is to establish the definition of quality in the supply chain.

There are numerous definitions of quality. For example, W. Edwards Deming defines quality as a procedure (or) service that develops somebody and enjoys a good and sustainable market. Joseph Juran coined the phrase "fitness for use by the customer" as a definition of quality. Philip B. Crosby bases his approach to quality on four absolutes: (1) Quality is conformance to requirements, (2) Quality is caused by prevention, (3) The performance standard is no defects, and (4) The measure of quality is the price of conformance. Each definition maintains at its core that it is the customer who defines quality. Therefore, each organisation should create a quality of tasks involved and the requirements of the customers.

When developing system definitions of quality, the following questions must be answered:

- What are the goals of the supply chain process?
- What are internal and external customer requirements/expectations from the supply chain process?
- What are our competitor's definitions of quality?

These questions should be used to formulate objectives for the tasks and process involved. The goals of the supply chain process should be consistent with organisational goals. If the current supply chain process has a definition of quality that does not reflect the stages of the process and the needs of the customers, then the gaps should be identified and definitions refined. The definition of quality should encompass the customer requirements and expectations for each stage in the process.

Module 3: Define Quality

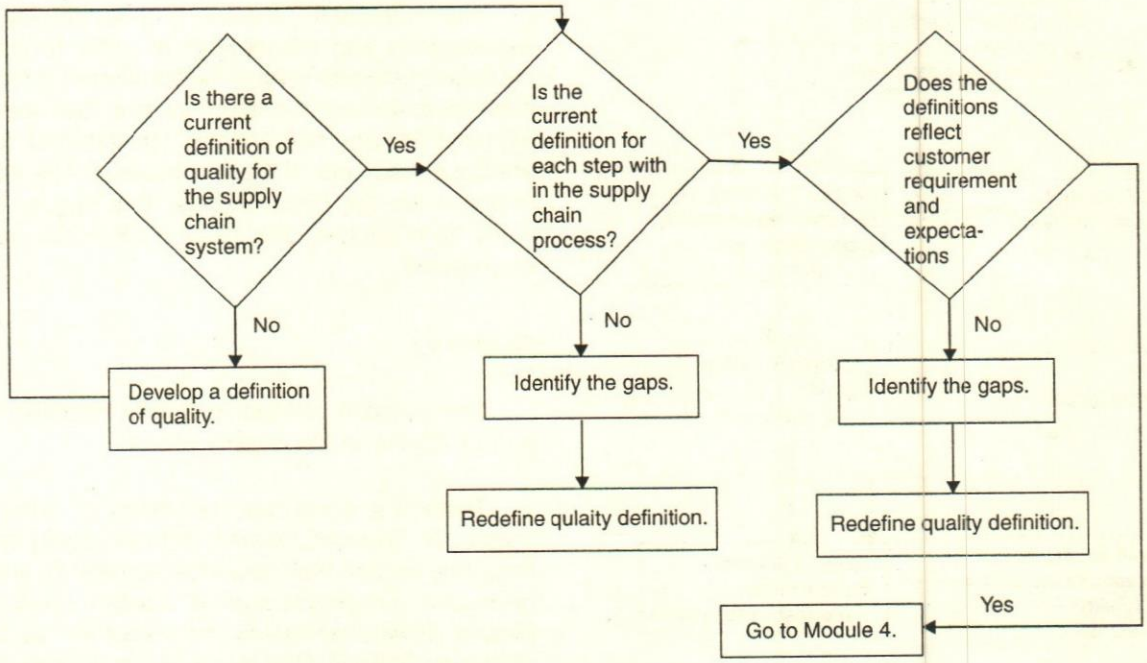

Fig. 4. (Module 3)

Module 4: Identify Current Quality Performance Measures

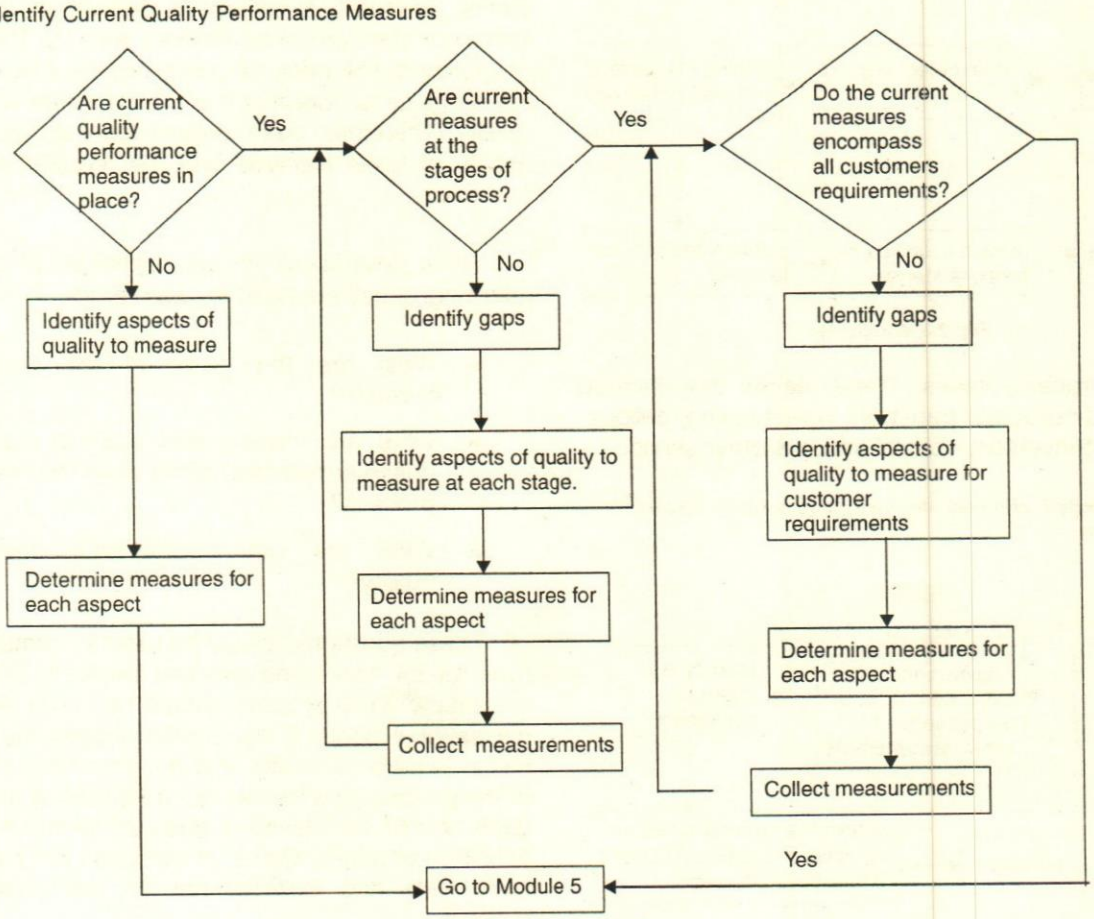

Fig. 5. (Module 4)

Module 4

The purpose of module 4 is to identify current cost, productivity and service measures and identify gaps in current measurements.

This module facilitates an understanding of the types of process quality measures that are currently being employed. First, the gap associated with the various supply chain stages and customer requirements are identified. Next, the gaps must be translated in to measurement, and then the aspects of quality for the process may be identified in a supply chain process. Some examples are listed below.

- Reliability-concerns the time between failed delivery of products
- Order occurring-concerns the probability the correct orders is taken, arrives or departs from the warehouse on time.
- Worker standards-the engineered standards for workers inside the warehouse.
- Customer Satisfaction-concerns whether the internal or external customers are satisfied with his-her service.
- Worker Quality-concerns safety issues, damaged goods etc.
- Cost-the resulting cost incurred in the supply chain system by stages or through the entire system.

After the appropriate quality measures are identified, procedures must be developed to capture these measurements. Finally measurements are collected for all supply chain stages and for the customer requirements.

Module 5: Evaluate Current Process and Set Quality Standards

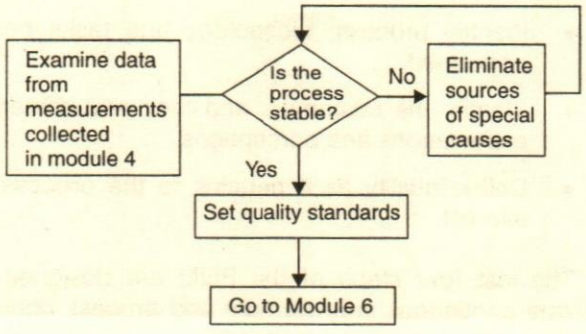

Fig. 6 (Module 5)

Module 5

The purpose of module 5 is to evaluate current performance and set standards for cost, productivity and service objectives.

In Module 5 the gaps in the measurement process were identified and quantitative quality standards developed. The first step is to examine the representative data (measurements) collected in Module 4. Before the standards are established, the process must be in control. A process is considered in control when there are no occurrences of special causes. Special causes are assignable causes of variations.

An example of special variations in supply chain process is a truck arriving late due to inclement weather. The sources of special causes are assignable to a cause that usually does not occur often within a process. The other type of variation is present in a process experience every day. When only this type of variation is present, the process is said to be in control. Therefore, all special variation should be eliminated before quality standards are established. There are several advantages associated with a process in control:

- The process performance is predictable.
- Costs are predictable.
- Output is predictable.
- The process has reached it's maximum productivity.
- Supplier relations are simplified.
- Changes in the process can be detected more quickly.

Once the process is in control, current data may be used to develop quantitative process standards.

Module 6

The purpose of module 6 is to identify and implement changes to improve overall supply chain process performances.

Module 6 of PQM aims to improve the process. The first step within this module consists of identifying and prioritizing improvement areas. Once these areas have been prioritized, then the areas that must receive immediate attention are identified, considering time and cost restrictions. The purpose of continuous improvement is to reduce the amount of common cause variation present in the process. In planning improvement, hypotheses must be made concerning the causes of

Module 6: Improve Process

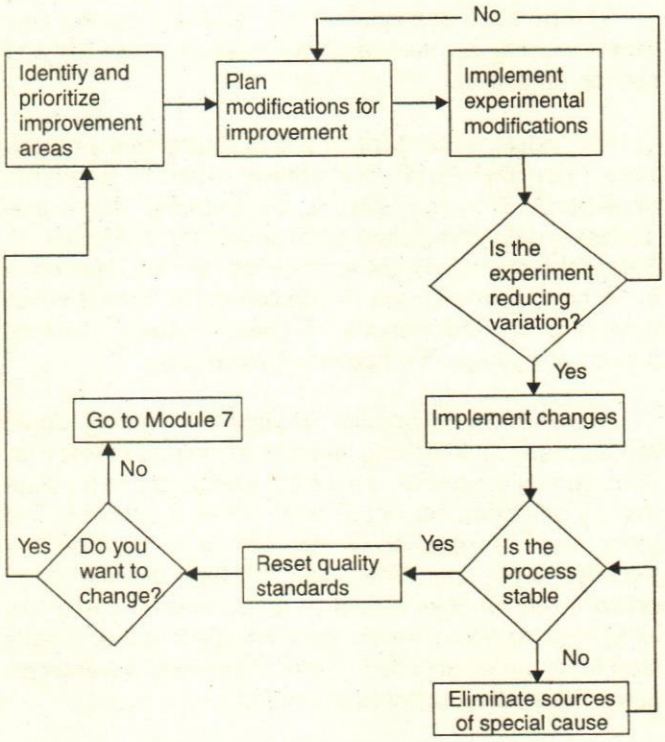

Fig. 7. (Module 6)

variations. Once the causes have been identified, then a plan should be tested to eliminate the cause. Next, these causes should be tested to determine whether the solution reduces variation. After the experiment has been tested, the improvements should be tested again to determine whether it is in control, after the process is in control, then the quality standards are reset for the improved process.

Module 7

The purpose of Module 7 is to control and monitor productivity and service performance to ensure that the process meets standards.

The final step in the PQM is to control and monitor the process, there are numerous quality tools that can be used in this step. Some examples of these tools are given in Table 1.

Conclusion

The Process Quality Model (PQM) provides a methodology for implementing a quality programme or improving an existing one. The PQM applies and extends the traditional principles of Total Quality Management (TQM) for use in a manufacturing supply chain.

Module 7: Control & Monitor Process

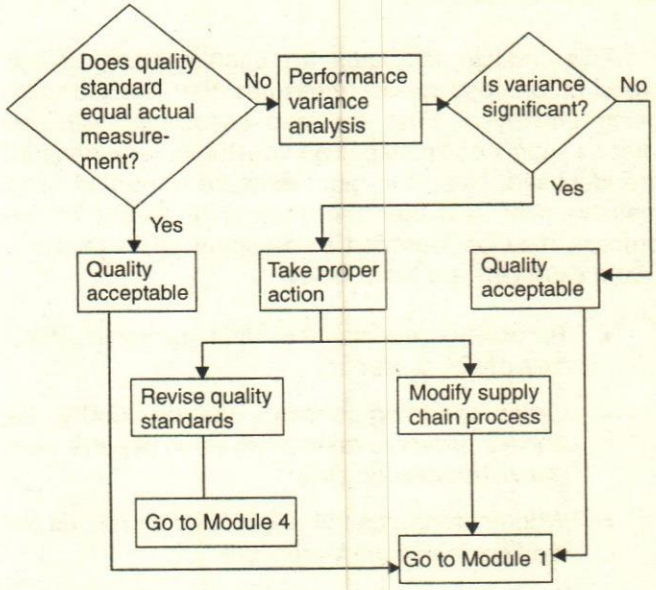

Fig. 8. (Module 7)

Table 1: Quality Tools

Tool	Purpose
Control Chart	Process Variability Analysis
Cause and Effect Diagram	Process Trouble Shooting Analysis
Histogram	Process Variability Frequency Analysis
Scatter Diagram	Process Variable Relationship Analysis
Run Chart	Process Trend Analysis

From an implementation stand point, each of the seven modules of the PQM falls in to two categories; initialization or continuous improvement. That is, the first three stages, the initialization steps, are designed to be executed infrequently (i.e., only if the process changes dramatically).

- Identify process, technology and tasks being performed.
- Identify the customers and their requirements, expectations and perceptions.
- Define quality as it pertains to the process of interest.

The last four steps of the PQM are designed to facilitate continuous improvement and process control, and thus will be executed frequently.

- Identify quality performance measures.
- Evaluate the current process and set quality standards.
- Improve the process.
- Control and Monitoring.

Thus, through a series of modules, the model provides a method of process identification, measurement and control. Moreover, PQM is a systematic methodology that prescribes:

- The specific aspects of quality that should be measured.
- A method for measuring these aspects of quality and
- A method for using such measures to evaluate, improve and control the overall quality of the manufacturing supply chain system.

In contrast, PQM emphasizes continuous improvement of the entire supply chain process.

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If necessity is the mother of invention, discontent is the father of progress.

– David Rockefeller

Feature

Inventory Management of Cooperative Sector Milk Plants

Tajinder Kaur & P.S. Khattra

The need for systematic and scientific approach to the problem of inventory management of the milk plants assumes special significance in the changed world scenario as these can help to ameliorate the problems of cost reduction and cost control. The present study was undertaken to study existing pattern of resource use and product mix and to stratify the items on the basis of their relative importance. In this article inventory turnover ratio analysis has been used to measure the efficiency of utilisation of resources and handling of products. Stratification of store and spares inventory has been done by using ABC model, VED model and FSN model. Findings of the study suggests that the milk plants can run smoothly if items of the inventory are classified according to the above models and strict control on items under important categories is exercised.

Tajinder Kaur and P.S. Khattra are with the Department of Economics and Sociology, Punjab Agricultural University, Ludhiana.

Milk is the largest enterprise after rice in Indian agriculture. Apart from the industrial dimensions and the principles governing the functioning of an industry, the dairy industry is unique in the technological and social dimensions, in the changed world scenario. There is an urgent need to reduce the milk handling cost to its minimum and to cut down the processing and manufacturing costs by evolving the most economical and efficient systems by the milk plants. Inventory management helps carry out plant operations efficiently at minimum level of investment in inventory. Out of stocks and overstocks are bound to affect adversely the competitive edge of the plant. Control over inventory is usually exercised by adopting certain techniques, which help reduce the investment without adversely affecting smooth functioning of business. The area of research for exploring the saving in costs through efficient management of inventory in milk plants stands neglected so far. The study of the existing pattern of resource use and product mix for the selected dairy milk plants is the basic pre-requisite for conducting in-depth study of inventory management. The inventory management of raw materials, mainly packing materials, fuel etc. is of special importance because of the large quantities being handled. Planning of inventory also helps reduce inventory stock and increase profits (Arcelus and Srinivasan, 1987). The objectives of this study were to study the existing pattern of resource use and product mix in the selected milk plants and to stratify the items of inventory on the basis of their relative importance in terms of investment in the existing inventory system.

Methodology

The present study was confined to co-operative sector milk plants of Punjab only. Three milk plants located at Ludhiana in central zone, Mohali in kandi zone and Sangrur in south-western zone of Punjab with milk handling capacities of 4.00, 1.00 and 1.50 lakh litre per

day, respectively, were selected. The secondary data were collected from selected milk plants which consisted of information concerning inventory of raw materials, store inventory and inventory of finished products. The data on annual consumption were taken from store section. Inventory turnover ratios and inventory turnover days were worked out to examine the efficiency of selected milk plants in managing the inventory. Inventory turnover ratio (IT) measures how many times the inventory has been turned over during the year, inventory turnover ratios were calculated as:

$$IT = \frac{\text{Cost of goods sold}}{\text{Inventory}}$$

An alternative measure of inventory activity is inventory turnover in days (ITD) and is calculated as follows

$$ITD = \frac{\text{Days in the year}}{\text{Inventory turnover}}$$

To satisfy the existing inventory, ABC (Always best control), VED (Vital, essential and desirable) and FSN (Fast, slow and non-moving) techniques were used. The ABC analysis separates the inventory into three categories. The high value items are classified as 'A' category items and are put under tight control. The 'C' category items are of relatively low value and are kept under relaxed control. The items classified as 'B' category items fall in between 'A' and 'C' categories and need moderate control. VED classification is based on critically in operation. On the basis of critically - items are classified as vital (V), essential (E) and desirable (D). This implies that V class items have to be stocked to ensure the operations of the plant, because by definition the absence of these items can result in stoppage of production (Rao and Prasad, 1981 and Reddy and Reddy, 1995). While some risk can be taken in the case of 'E' class items, stocking of desirable items can be done away with if the lead time for their procurement is low. This classification is helpful in a capital intensive industry like dairy. The frequency of issue of an item from the store was taken as the certain to classify store items into fast (F), slow (S) and non-moving (N) (Rao and Prasad, 1981 and Kesavan et. al, 1988).

Inventory Turnover Ratio Analysis

Inventory turnover ratio measures the control of inventory or the efficiency of utilisation. It is evident from Table 1 that inventory turnover ratio was the highest for the Ludhiana milk plant and it was the lowest in the case of Sangrur milk plant. This indicated that in Ludhiana milk plant, funds are utilised more efficiently as compared to the other sample milk plants. Inventory turnover ratios in 1998-99 for Ludhiana, Mohali and Sangrur milk plants were 15.66, 11.03 and 7.98, respectively, and the respective figures during 2000-01 were 16.85, 11.81 and 8.87, which witnessed perceptible improvements during the short period of three years. These results clearly suggest that rise in inventory turnover ratios over the period has helped realise better use of the money tied up in stock and gives evidence of better management.

Rise in inventory turnover ratios has to helped realise better use of the money tied up in stock.

Table 1: Inventory turnover ratios of selected milk plants from 1998-99 to 2000-01.

Milk plants	1998-99	1999-2000	2000-2001
Ludhiana	15.66 (23)	16.73 (22)	16.85 (21)
Mohali	11.03 (33)	11.51 (32)	11.81 (31)
Sangrur	7.98 (46)	8.21 (44)	8.87 (41)

Figures in parentheses are inventory turnover in days

It is evident from Table 2, the raw material (milk) inventory turnover was the highest in the case of Ludhiana plant (167.29) during 2000-2001. This was followed by Mohali (146.34) and Sangrur (89.80) milk plants. Finished and semi-finished milk products inventory are found to be the lowest in all the three selected milk plants. It varied between 1.11 to 1.78. Finished and semi-finished milk products inventory turnover ratio was the lowest in the case of Sangrur milk plant due to the problem of marketing.

Table 2: Turnover ratio of inventory components in selected milk plants for 2000-2001

Type of inventory	Ludhiana	Mohali	Sangrur
Raw material inventory	167.29 (2)	146.34 (3)	89.80 (4)
Store and spare inventory	5.52 (66)	4.96 (73)	5.41 (67)
Finished and semi-finished good inventory	1.78 (205)	1.58 (231)	1.11 (329)

Figures in parentheses are inventory turnover in days

Milk and some of the milk products being highly perishable, their inventory could not be built up for a longer period of time, so their inventory turnover ratios were very high. Store and spare inventory turnover ratio

Table 3: ABC analysis of store inventory of the selected co-operative milk plants during the period 2000-2001.

Category	Milk plant		
	Ludhiana	Mohali	Sangrur
A	Packing material (51.83)	Packing material (53.60)	Packing material (58.44)
B	Other consumable store (33.68)	Other consumable store (30.12)	Other consumable stores (27.47)
C	Machinery spare parts (4.70)	Machinery spare parts (6.29)	Machinery spare parts (5.37)
	Chemical and detergents (3.37)	Chemical and detergents (4.52)	Chemical and detergents (4.37)
	Hardware and building material (2.86)	Vehicle spare parts (2.32)	Vehicle spare parts (2.05)
	Printing and stationary (1.85)	Uniform and social welfare (1.20)	Printing and stationary (1.38)
	Vehicle spare parts (0.87)	Hardware and building material (0.97)	Medicines (1.12)
	Uniform and social welfare (0.75)	Printing and stationary (0.56)	Hardware and building material (0.74)
	Medicines (0.14)	Medicines (0.37)	Uniform and social welfare (0.25)

Figures in parentheses show per cent value of total store inventory

Table 4: ABC analysis of other consumable store items of the selected co-operative milk plants during the period 2000-2001.

Category	Milk plant		
	Ludhiana	Mohali	Sangroor
A	Refined Furnace Oil (70.46)	Refined Furnace Oil (62.16)	Fire wood/rice husk (54.67)
B	–	Petrol, Oil & Lubricants (23.79)	–
C	Petrol Oil & Lubricants (24.27)	Others (14.05)	Petrol
	Others (5.27)	–	Others (9.85)

Figures in parentheses show per cent value of other consumable store inventory

was the highest in the case of Ludhiana plant thereby indicating that in this plant store and spares management is done efficiently. Excessively high investment of funds in store and spare inventory in relation to other type of inventory can be attributed to large amount of packing material and large number of costly spare parts needed for production and packaging of finished products.

ABC Analysis

ABC analysis was undertaken on store inventory items being grouped under nine heads and the classification is given in Table 3.

Packing material was the only item of store inventory, which came under A category. It constituted 51.83, 53.60 and 58.44 per cent of total store inventory in the case of Ludhiana, Mohali and Sangrur plants, respectively. Other consumable stores fell in B category and respective figures were 33.68, 30.12 and 27.47 per cent in the case of Ludhiana, Mohali and Sangrur plants, respectively. As packing material was 'A' category item, so it required a strict inventory control therefore it was studied in detail. As per ABC analysis, annual usage value of the packing material was 75 per cent.

Other consumables stores have been categorised in 'B' category, with annual usage value of 15 percent according to ABC analysis, indicating that it should also be monitored and a limited control should be exercised on this group. The remaining six groups of store items come under C-category, which called for relaxed control on them. ABC analysis was further applied to the items of 'other consumable stores' that belonged to 'B' category, as large numbers of items of heterogeneous nature were put under this group (Table 4). The items were further classified into three categories, namely, refined furnace oil (R.F.O.), petrol oil and lubricants (P.O.L.) which included H.S.D., L.D.O., Mobile oil, etc. All other items were put under heading as 'others'. In case of Sangrur milk plant instead of R.F.O., firewood/rice husk was being used. R.F.O falls under 'A' category, which constituted 70.45 and 62.16 per cent of inventory classified under heading 'other consumable stores' in the case of Ludhiana and Mohali milk plants. So it also required special attention and tight control should be exercised over it. In the case of Sangrur milk plant firewood/rice-husk fell under 'A' category and constituted 54.67 per cent of 'other consumable stores'. Petrol, oil and lubricants constituting 23.79 per cent of 'other consumable stores' were categorized as 'B' category in the case of Mohali milk plant while in the

Table 5: ABC analysis of milk products produced by the selected co-operative milk plants during the period 2000-2001.

Category	Milk Plant		
A	Ludhiana	Mohali	Sangrur
	tandard milk (43.92)	Standard milk (65.38)	Ghee (67.50)
	Ghee (27.43)	–	–
B	–	Double toned milk (DTM) (17.78)	–
	–	Ghee (6.67)	–
C	Skimmed milk powder (SMP)	Cheese (2.81)	Skimmed milk powder (SMP) (27.46)
	Double toned milk (DTM) (4.88)	Curd (2.25)	Standard milk (4.74)
	Table butter (3.45)	Paneer (2.20)	Standard milk (4.74)
	Paneer (0.33)	High fat milk (1.76)	Milk cake (0.08)
	Milk cake (0.02)	Lassi (0.66)	
	Curd (0.02)	Skimmed milk (0.49)	

Figures in parentheses show per cent value of total product inventory

case of Ludhiana and Sangrur milk plants none of the items came under category 'B'.

All the remaining items belonging to 'other consumable stores' which were grouped under heading 'others' belonged to 'C' category and constituted 5.27, 14.05 and 9.85 per cent of total other consumable store inventory in Ludhiana, Mohali and Sangrur milk plants, respectively.

ABC analysis was also employed to categorise the milk products produced in the selected milk plants, so that more detailed study of store inventory items could be undertaken for producing 'A' and 'B' category milk products.

It is clear from Table 5 that standardised milk fell in 'A' category in the case of Ludhiana and Sangrur milk plants. Standardised milk constituted 42.92 and 65.38 percent of the total production of Ludhiana and Mohali milk plants, respectively. In the case of Sangrur and Ludhiana milk plants Ghee contribute 67.50 and 27.43 percent, respectively, towards total production.

In the case of Mohali plant, double toned milk and ghee have been categorised in 'B' category, which accounted for 17.78 and 6.67 per cent of total production, respectively. The rest of the items produced by the selected milk plants were under 'C' category. So standardised milk, double toned milk and ghee required special attention in order to control their inventories.

VED and FSN Analysis

Machinery spare parts which fell under 'C' category, constituted 19.93, 19.88, and 18.06 per cent of total inventory in Ludhiana, Mohali, and Sangrur, milk plants, respectively. Special attention had been given to machinery and spare parts as these are indispensable for running of milk plants and heavy cost is involved in purchasing and storing them. These can be controlled by applying VED and FSN analysis techniques as EOQ model could not be used efficiently in the case of machinery spare parts (Kesavan et al., 1988) and (Reddy and Reddy 1995).

In present study the VED analysis and FSN were used in conjunction and were grouped into three categories FV (Fast and Vital), SE (Slow and Essential) and ND (Non-moving and Desirable). Four items, namely back-up rubber for oil, rubber gaskets, fuse carbon connection, and pressure spring, belonged to FV group. Very strict control should be exercised for these items and a safety stock should always be maintained as the processing unit can need them any time and these should be available in store, in the case of emergency. Twelve items were classified as SE i.e., second group and the remaining (approximately 300) were classified as ND. Machinery spares belonging to ND can be put under relaxed control. Exercising less control can monitor items falling under SE.

Conclusion

Inventory turnover ratio indicated that Ludhiana milk plants used funds more efficiently. In the case of Sangrur milk plant there was excessive investment in store, spare and other inventory indicating financial inefficiency. Raw material (milk) inventory turnover ratio was the highest among all the ratios for the three milk plants. Store and spare inventory should be further studied in

Standardised milk, double toned milk and ghee required special attention in order to control their inventories.

detail as this part of the inventory can be managed efficiently as compared to raw material inventory, which is highly perishable. Taking into consideration the results of ABC analysis, it can be inferred that inventory of packing materials used for production of standardised milk, double toned milk and ghee should be watched carefully and strict control should be exercised over them. Store and spare inventory should be classified according to FSN and VED models for effective control, and modification of all items should be done.

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It is no use saying, 'We are doing our best.' You have got to succeed in doing what is necessary.

– Sir Winston Churchill

Feature

Technological Change in Dairy Farming: A Case Study of Tamil Nadu

B. Ganesh Kumar

A study was undertaken to measure the technological change in dairy farming in Tamil Nadu with the view to formulate some guidelines for increasing the growth in milk production in the State. The collected data were subjected to decomposition analysis to measure the technological change in dairy farming. The adoption of new technology, i.e., crossbred cows in place of the old technology, i.e., indigenous cows or buffaloes, led to higher per day milk yield. Consequently, the shift in technology, either from indigenous cows to crossbred cows (Case I) or from buffaloes to crossbred cows (Case II), brought about a sizeable total percentage gain in milk yield.

B. Ganesh Kumar is a Scientist (Agricultural Economics) with the Central Agricultural Research Institute, Port Blair, Andaman & Nicobar Islands.

India is predominantly an agrarian economy with more than 75 per cent of its population living in villages, depending on agriculture, animal husbandry and allied activities for their livelihood. Cattle and buffaloes have been an integral part of the crop-livestock system in the Indian farm economy. Among the many livestock enterprises, dairying is the most ancient occupation established in the rural setting of our country. The development of dairy industry in India has been acknowledged as one of the most successful processes in the world. India with a cattle population of 197.3 million accounts for nearly 50 per cent of the Asian cattle population and 15.4 per cent of that of the world. With regard to the buffalo population, India has 53.3 per cent of world's and 55 per cent of Asia's buffalo population (Patel, 1993). While the cattle population increased by about 1.8 per cent in the period 1982-87, buffalo population has grown by about 10 per cent in the same period. Yet cattle population decreased by 1.6 per cent, while buffaloes increased by 2.3 per cent in the next five years (1987-92). Despite the drop in cattle population during 1987-92, the cow milk production has registered a 7.5 per cent growth from 24 million tonnes in 1989 to 29.4 million tonnes in 1992, implying partly the productivity increase of cows through crossbreeding programmes (Prabaharan, 2000).

The introduction of crossbreds (new technology) over indigenous breeds (old technology) is normally considered as more profitable, helping to create direct employment opportunities at the farm level. The shift in dairy production technology, conceived as a shift from indigenous cow to crossbred cow and from buffalo to crossbred cow, is said to have raised the country's milk output. But the higher mean milk yield of the crossbred cattle is not necessarily a technological improvement over existing technology. It may happen that the entire gain in milk yield may occur due to the increased input use (Lalwani, 1989). The principal objective of this paper is, therefore, to decompose the output gain in milk yield occurring as a

result of shift in dairy production technology, as defined above, into its causative factors.

Methodology

The study uses primary data collected from 200 dairy households spread across 40 villages of Villupuram and Salem districts of Tamil Nadu, which were purposively chosen because Villupuram district has the highest number of cattle among all the districts in the State (411344, which is around 9.81 per cent of the total cattle population of the State) and Salem district has the highest number of buffaloes among all the districts in the State (284448, which is around 15.84 per cent of the total buffalo population of the State) according to Livestock census of Tamil Nadu, 1994, offering thereby vast opportunities for rural development through livestock tending. For selection of sample households and collection of data, a three stage random sampling design (I Stage-Block; II Stage-Village; and III Stage-Farmers) was used. The total households were post-stratified according to the land holding viz., landless, small, medium and large with a view to study various economic aspects of dairy farming in different socio-economic situations. Simple random sampling without replacement was employed for selecting sample households in each category. The data pertained to the agricultural year 1999-2000.

Concepts

New milk production technology

New milk production technology is defined to include crossbred cows and the milk production practices associated with them (viz., Jersey cross or Holstein-Friesian cross or both).

Old milk production technology

Old milk production technology is defined to include indigenous non-descript cows and buffaloes and the milk production practices associated with them.

Technological change

Technical change in the production function can be defined as a change in the parameters of the production function (Rutton, 1960). Increase in the level of milk yield with new production technology over the old technology using the same level of inputs can be attributed to technological change (Kumar and Mruthyunjaya, 1992).

Analytical Approach

Production Function Analysis

Adoption of new milk production technology results in changes of output, employment and factor shares. For determining the structural break in production relations, accounting for the sources of output growth and for evaluating the effect of new technology on productivity, the production function analysis is proposed, as relevant conceptual framework. The total change in output has been separated into its causal factors through the output decomposition model.

The transformation of a set of inputs into output is described by a production function. Production function for a milch animal per day can be written as

$$Y = f(X_1, X_2, X_3, \ldots\ldots X_n)$$

Where,

Y = Milk output in litres per milch animal per day with given set of inputs $X_1, X_2, X_3, \ldots\ldots X_n$.

Output 'Y' is treated as the dependent variable and inputs $X_1, X_2, X_3, \ldots\ldots X_n$ as independent variables. In a functional analysis, it would be essential to choose an appropriate form of production function taking into consideration the data to be analysed.

Specification of Model

Since biologically derived milk production functions have so far not been empirically evolved, choice for functional form is often guided by personal preferences. Between the Cobb-Douglas (CD) and the Constant Elasticity of Substitution (CES) specifications, although latter accommodates elasticities of substitution different from zero (Leontief case) or unity (CD case), elasticities even under this form remain constant at all levels of input use. Besides, the general appeal of the CES function is restricted due to its estimation through non-linear models. The function is also uneconomical in using the degrees of freedom and is highly sensitive to changes in data, measurement of variables and methods of estimation (Lalwani, 1992).

The Cobb-Douglas production function framework has been widely used in studies on Indian agriculture. Some of the important studies are Srivastava and Heady (1973), Sidhu (1974), Bisaliah (1975), Kunnal (1978), Lalwani (1992), Thakur and Sinha (1994) and Gaddi (1995). Cobb-Douglas specification is easy in estimation and interpretation. It is a homogenous function that provides a scale factor enabling one to measure the returns to

scale and to interpret the elasticity coefficients with relative ease. But at the same time, the Cobb-Douglas production function makes several restrictive assumptions like elasticity coefficients are constant, implying constant share for the inputs and the elasticity of substitution among the factors is unity in the Cobb-Douglas form. Moreover, this being linear in logarithm, output is zero if any of the input is zero and output expansion path is assumed to pass through the origin. Based on past studies, merits of Cobb-Douglas form and the scatter diagram, the Cobb-Douglas type of production function as stated below was employed for further investigations.

$$Y = b_0 X_1^{b1} X_2^{b2} X_3^{b3} X_4^{b4} X_5^{b5} u \quad ...(1)$$

Where,

Y = Milk yield per milch animal per day (Litre);

X_1 = Green fodder fed per animal per day (Kg);

X_2 = Dry fodder fed per animal per day (Kg);

X_3 = Concentrate fed per animal per day (Total Digestible Nutrients);

X_4 = Labour per animal per day (Manday);

X_5 = Veterinary Expenses per animal per day (Rs);

b_0 = Intercept term (Scale parameter);

b_1, b_2, b_3, b_4 and b_5 = The regression coefficients of green fodder, dry fodder, concentrate, labour and veterinary expenses, respectively and

u = Error term independently distributed with '0' mean and finite variance.

Parameters of regression equation (1) were estimated by the Least Square method, using the logarithmic form. All the five coefficients taken together measure the total percentage change in output for a given percentage change in inputs. The sum of all regression coefficients ($b_1 + b_2 + b_3 + b_4 + b_5$) is the degree of homogeneity of the Cobb-Douglas production function. The error term (u) was assumed to follow the assumptions of the Linear Stochastic Regression Model. It was further assumed that the explanatory variables in the Linear Stochastic Regression Model were not perfectly linearly correlated and were free from the aggregation error (Koutsoyiannis, 1977). The model was, besides, assumed to be free from identification and specification bias.

Structural Break in Production Relation

To identify the structural break, if any, in the production relations with the introduction of new technology in milk production per milch animal, output elasticities were estimated by Ordinary Least Square method by fitting log-linear regression separately for indigenous cows, buffaloes and crossbred cows.

The following log-linear forms of equation were used for examining the structural break in production relation.

$$\text{Ln } Y_1 = \text{Ln } A_1 + b_{11} \text{Ln } X_{11} + b_{21} \text{Ln } X_{21} + b_{31} \text{Ln } X_{31} + b_{41} \text{Ln } X_{41} + b_{51} \text{Ln } X_{51} \quad ...(2)$$

$$\text{Ln } Y_2 = \text{Ln } A_2 + b_{12} \text{Ln } X_{12} + b_{22} \text{Ln } X_{22} + b_{32} \text{Ln } X_{32} + b_{42} \text{Ln } X_{42} + b_{52} \text{Ln } X_{52} \quad ...(3)$$

$$\text{Ln } Y_3 = \text{Ln } A_3 + b_{13} \text{Ln } X_{13} + b_{23} \text{Ln } X_{23} + b_{33} \text{Ln } X_{33} + b_{43} \text{Ln } X_{43} + b_{53} \text{Ln } X_{53} \quad ...(4)$$

Where,

Subscripts 1, 2 and 3 in the above equations represent indigenous cow (old technology), buffalo (old technology) and crossbred cow (new technology), respectively. b_{11}, b_{21}, b_{31}, b_{41}, b_{51}, b_{12}, b_{22}, b_{32}, b_{42}, b_{52}, b_{13}, b_{23}, b_{33}, b_{43} and b_{53} represent individual output elasticities of respective inputs for indigenous cows, buffaloes and crossbred cows. Variables in equations (2), (3) and (4) are defined in the same way as in equation (1).

Sources of Output Growth

For any production function, the total change in output is brought about by the shifts in the parameters of production function and the changes in the volume of inputs. A rise in the total output under 'new' technology over the 'old' technology with the use of same level of inputs can be attributed to technical change. This change in total output due to technology is measured by changes in scale (intercept) and slope (elasticity) parameters. Out of this total change, shift in the intercept in equation (1) measures the neutral component of technical change and the shift in slope parameters measures the non-neutral component of technical change which together constitute technological contribution to the difference in output under the 'old' and 'new' production technologies. Another contribution to the total output is due to changes in the quantity of inputs used, which is due to the disequilibrium caused by new production relations. The total change in output due to adoption of new milk production technology (crossbred cows) is decomposed into the factors of technology and changes in the quantities of inputs. The output decomposition model developed by Bisaliah (1977) and used by Lalwani (1989) is used to decompose the difference in per animal output between old

and new milk production technologies into technological change and quantities of inputs used. Equations (2), (3) and (4) were used to find out the sources of output growth.

Taking the difference between equations (3) and (2) and similarly the difference between equations (4) and (2) adding some terms and subtracting some terms, yield decomposition models can be written for indigenous cow : crossbred cow and buffalo : crossbred cow as follows:

Indigenous Cow : Crossbred Cow

$$\begin{aligned}\text{Ln } Y_3 - \text{Ln } Y_1 &= (\text{Ln } A_3 - \text{Ln } A_1) + \\ &(b_{13} \text{Ln } X_{13} - b_{11} \text{Ln } X_{11} + b_{13} \text{Ln } X_{11} - b_{13} \text{Ln } X_{11}) + \\ &(b_{23} \text{Ln } X_{23} - b_{21} \text{Ln } X_{21} + b_{23} \text{Ln } X_{21} - b_{23} \text{Ln } X_{21}) + \\ &(b_{33} \text{Ln } X_{33} - b_{31} \text{Ln } X_{31} + b_{33} \text{Ln } X_{31} - b_{33} \text{Ln } X_{31}) + \\ &(b_{43} \text{Ln } X_{43} - b_{41} \text{Ln } X_{41} + b_{43} \text{Ln } X_{41} - b_{43} \text{Ln } X_{41}) + \\ &(b_{53} \text{Ln } X_{53} - b_{51} \text{Ln } X_{51} + b_{53} \text{Ln } X_{51} - b_{53} \text{Ln } X_{51}) + \\ &(u_3 - u_1) \qquad \ldots(5)\end{aligned}$$

Rearranging the terms,

$$\begin{aligned}\text{Ln } Y_3 - \text{Ln } Y_1 &= (\text{Ln } A_3 - \text{Ln } A_1) + [(b_{13} - b_{11}) \text{Ln } X_{11} \\ &+ (b_{23} - b_{21}) \text{Ln } X_{21} + (b_{33} - b_{31}) \text{Ln } X_{31} + (b_{43} \\ &- b_{41}) \text{Ln } X_{41} + (b_{53} - b_{51}) \text{Ln } X_{51}] + [b_{13} (\text{Ln } X_{13} \\ &- \text{Ln } X_{11}) + b_{23} (\text{Ln } X_{23} - \text{Ln } X_{21}) + b_{33} (\text{Ln } X_{33} \\ &- \text{Ln } X_{31}) + b_{43} (\text{Ln } X_{43} - \text{Ln } _{41}) + b_{53} (\text{Ln } X_{53} \\ &- \text{Ln } X_{51})] + (u_3 - u_1) \qquad \ldots(6)\end{aligned}$$

By using the logarithmic rule, the equation (6) can also be written as

$$\begin{aligned}\text{Ln } (Y_3 / Y_1) &= [\text{Ln } (A_3 / A_1)] + [(b_{13} - b_{11}) \text{Ln } X_{11} + \\ &(b_{23} - b_{21}) \text{Ln } X_{21} + (b_{33} - b_{31}) \text{Ln } X_{31} + (b_{43} - b_{41}) \\ &\text{Ln } X_{41} + (b_{53} - b_{51}) \text{Ln } X_{51}] + [\{b_{13} \text{Ln } (X_{13} / X_{11})\} \\ &+ \{b_{23} \text{Ln } (X_{23} / X_{21})\} + \{b_{33} \text{Ln } (X_{33} / X_{31})\} + \{b_{43} \\ &\text{Ln } (X_{43} / X_{41})\} + \{b_{53} \text{Ln } (X_{53} / X_{51})\}] + (u_3 - u_1) \quad \ldots(7)\end{aligned}$$

Buffalo : Crossbred Cow

$$\begin{aligned}\text{Ln } Y_3 - \text{Ln } Y_2 &= (\text{Ln } A_3 - \text{Ln } A_2) + (b_{13} \text{Ln } X_{13} - b_{12} \\ &\text{Ln } X_{12} + b_{13} \text{Ln } X_{12} - b_{13} \text{Ln } X_{12}) + (b_{23} \text{Ln } X_{23} - b_{22} \\ &\text{Ln } X_{22} + b_{23} \text{Ln } X_{22} - b_{23} \text{Ln } X_{22}) + (b_{33} \text{Ln } X_{33} - b_{32} \\ &\text{Ln } X_{32} + b_{33} \text{Ln } X_{32} - b_{33} \text{Ln } X_{32}) + (b_{43} \text{Ln } X_{43} - b_{42} \\ &\text{Ln } X_{42} + b_{43} \text{Ln } X_{42} - b_{43} \text{Ln } X_{42}) + (b_{53} \text{Ln } X_{53} - b_{52} \\ &\text{Ln } X_{52} + b_{53} \text{Ln } X_{52} - b_{53} \text{Ln } X_{52}) + (u_3 - u_2) \qquad \ldots(8)\end{aligned}$$

Rearranging the terms,

$$\begin{aligned}\text{Ln } Y_3 - \text{Ln } Y_2 &= (\text{Ln } A_3 - \text{Ln } A_2) + [(b_{13} - b_{12}) \text{Ln } X_{12} \\ &+ (b_{23} - b_{22}) \text{Ln } X_{22} + (b_{33} - b_{32}) \text{Ln } X_{32} + (b_{43} - b_{42}) \\ &\text{Ln } X_{42} + (b_{53} - b_{52}) \text{Ln } X_{52}] + [b_{13} (\text{Ln } X_{13} - \text{Ln } X_{12}) \\ &+ b_{23} (\text{Ln } X_{23} - \text{Ln } X_{22}) + b_{33} (\text{Ln } X_{33} - \text{Ln } X_{32}) + b_{43} \\ &(\text{Ln } X_{43} - \text{Ln } _{42}) + b_{53} (\text{Ln } X_{53} - \text{Ln } X_{52})] + (u_3 - u_2) \ldots(9)\end{aligned}$$

By using the logarithmic rule, the equation (6) can also be written as

$$\begin{aligned}\text{Ln } (Y_3 / Y_2) &= [\text{Ln } (A_3 / A_2)] + [(b_{13} - b_{12}) \text{Ln } X_{12} + \\ &(b_{23} - b_{22}) \text{Ln } X_{22} + (b_{33} - b_{32}) \text{Ln } X_{32} + (b_{43} - b_{42}) \\ &\text{Ln } X_{42} + (b_{53} - b_{52}) \text{Ln } X_{52}] + [\{b_{13} \text{Ln } (X_{13} / X_{12})\} \\ &+ \{b_{23} \text{Ln } (X_{23} / X_{22})\} + \{b_{33} \text{Ln } (X_{33} / X_{32})\} + \{b_{43} \\ &\text{Ln } (X_{43} / X_{42})\} + [\{b_{53} \text{Ln } (X_{53} / X_{52})\}] + (u_3 - u_2) \\ &\qquad \ldots(10)\end{aligned}$$

The decomposition of equations (7) and (10) involves decomposing the logarithm of the ratio of 'new' to 'old' milk production technology. It is approximately a measure of percentage change in output with the introduction of new technology. These equations are the output decomposition models used for decomposition of total output into its causal components, i.e., technological change and increased level of inputs used.

The equations (7) and (10) decompose the total difference in per animal milk yield between 'old' and 'new' milk production technologies (on left-hand side of equation) into

- Neutral technological change (First bracketed expression on right hand side)
- Non-neutral technological change (Second bracketed expression on right hand side)
- Changes in the level of inputs (Third bracketed expression on right hand side).

On the right hand side of the equation, the first two bracketed expressions, summed up, measure the joint contribution of the component of technology.

The first bracketed expression on the right hand side is a measure of percentage change in output due to shift in scale parameters (A) of the production function. The second bracketed expression is the sum of the arithmetic changes in output elasticities, each weighted by the logarithm of volume of that input used under old technology, as a measure of change in output due to shifts in slope parameters (output elasticities) of the production function.

The third bracketed expression is the sum of the logarithm of the ratio of input used in new technology to input used in old technology, each weighted by the output elasticity of that input under new technology. This expression is a measure of change in output due to changes in the per animal quantities of feed, fodder, labour and capital used, given the output elasticities of

these inputs under new production technology. The last bracketed expression is related to the difference in error terms.

In the decomposition equations (7) and (10), the underlying Cobb-Douglas milk production function followed the restrictive assumptions of unitary elasticity of substitution between all pairs of inputs and the constant returns to scale. The limitation of such assumptions was that while decomposing the observed total percent change in milk yield into its constituent forces, one may be ascertaining changes in elasticity to changes in technology and to the extent that economies of scale exist, the rate of technological progress will be over-estimated in the production function studies which constrain the homogeneity of the function to unity. The only offset to this is that some economies may be of a technological nature (Kennedy and Thirlwall, 1972).

Results and Discussion

Production function

The parametric estimates of milk production functions, homogenous of degree one for all species of milch animals namely, indigenous cows, buffaloes and crossbred cows were calculated using Ordinary Least Square (OLS) technique and presented in Table 1.

Table 1: OLS estimates of milk production function, homogenous of degree one

Particulars	Species		
	Indigenous cows	Buffaloes	Crossbred cows
OLS estimates			
A	4.8640	1.9430	1.8270
b_1	– 0.2610	– 0.0397	– 0.0139
b_2	– 1.2020**	– 0.0088	– 0.1990**
b_3	0.0691**	– 0.0147	0.0518*
b_4	0.6880**	0.1110*	– 0.0475*
b_5	– 0.0795**	– 0.0310*	0.0446**
R^2	0.85	0.74	0.93
Sample size (No. of Animals)	80	76	596

A, b_1, b_2, b_3, b_4 and b_5 stand respectively for intercept, green fodder, dry fodder, concentrates, labour and veterinary expenses

* Significant at 5 per cent level

** Significant at 1 per cent level

It could be observed from the table that the OLS estimates of green fodder (X_1) were found to be negative and statistically non-significant for indigenous cows, buffaloes and crossbred cows, which is contrary to the expected positive sign. Similarly, the OLS estimates of dry fodder (X_2) were found to be negative for all the three species of milch animals, but it was statistically significant in case of indigenous cows and crossbred cows and insignificant in case of buffaloes. Hence, it could be inferred that milk production would be reduced if dry fodder was fed more and more to the cattle. The output elasticity of concentrates was found to be positive and statistically significant for both types of milch cattle, while it was negative and statistically insignificant for buffaloes. Here, the OLS estimates bear the expected sign in case of both indigenous and crossbred cows, except in the case of buffaloes. This showed that there was a positive relationship between milk yield and concentrates fed to cattle in the study area. Similarly, the regression coefficients of labour were found to be positive and statistically significant in case of indigenous cows and buffaloes, but it was negative and statistically is significant for crossbred cows. This indicated that the farmers maintaining indigenous cows and buffaloes were in general under employed, while in case of crossbred cows milk production and labour are negatively related. The OLS estimates of veterinary expenses were significant for both cows and buffaloes. While it was positive in case of crossbred cows, they were found to be negative in case of indigenous cows and buffaloes. These findings reinforced the fact that the crossbred cows were disease susceptible and hence the veterinary expenses and milk production were positively correlated and conversely, indigenous cows and buffaloes were disease tolerant and adopted well in prevailing indigenous climatic conditions.

Crossbred cows were disease susceptible and hence the veterinary expenses and milk production were positively correlated.

Geometric Mean Levels of Milk Yield and Inputs

The geometric mean levels of milk output and input use estimated independently under the three variants of dairy technology are presented in Table 2.

It is evident from the table that the milk yield in case of crossbred cows was found to be 7.01 litres per day, which was higher than that of indigenous cows (1.40 litres per day) and buffaloes (4.50 litres per day). With regard to inputs, farmers maintaining crossbred cows utilised about 59.59 per cent and 7.58 per cent more of green fodder, 21.38 per cent less and 26.26 per cent more of dry fodder, 645.53 per cent and 178.84 per cent more of concentrates, 30.89 per cent and 2.22 per cent more of

labour and incurred 576.19 per cent and 89.82 per cent more of veterinary expenses over the farmers maintaining indigenous cows and buffaloes, respectively.

Table 2: Geometric mean levels of milk yield and input use per day

Items	Species				
	Indi-genous cows	Buffaloes	Crossbred cows		
		Value		Increase over indi-genous cows (%)	Increase over buffalo-es (%)
Milk (Litres)	1.402	4.496	7.010	160.94	44.42
Green fodder (Kg)	6.024	10.134	10.932	59.59	7.58
Dry fodder (Kg)	14.074	8.740	11.365	– 21.38	26.26
Concentrates (TDN)	1.165	123.916	741.000	645.53	178.84
Labour (Mandays)	0.268	0.357	0.365	30.89	2.22
Veterinary expenses (Rs.)	0.797	103.214	253.410	576.19	89.82

Decomposition of Output Gain in Milk Yield

The decomposition of output gain in milk yield into its constituent forces i.e., technological change and changes in the level of inputs while shifting from old dairy technology to new dairy technology was done and the figures are presented in Table 3. For this purpose, the decomposition equations (7) and (10) were given and the OLS estimates of production function from Table 1 and the geometric mean levels of milk yield and inputs from Table 2 were used. The R^2 value in both technologies was found to be significant and hence the explanatory power of the model employed was established.

The adoption of new dairy production technology, i.e., crossbred cows in place of the old dairy production technology, i.e., indigenous cows or buffaloes, led to higher per day milk yield. Consequently, the shift in dairy technology, either from indigenous cows to crossbred cows (Case I) or from buffaloes to crossbred cows (Case II), brought about a sizeable total percentage gain in milk yield, represented in decomposition equations (7) and (10) by the bracketed term on its left hand side.

Case I (Indigenous Cows: Crossbred Cows)

Under Case I of the shift in dairy technology, the observed total gain in per day milk yield was found to be 160.94 per cent, while the estimated total gain in milk yield was 160.72 per cent of which, 99.66 per cent occurred due to technological change and 61.06 per cent was due to the difference in the levels of input use. This means that 99.66 per cent more output could be produced with new milk production technology with the same level of inputs used under the old technology. Among the components of technological change, the contribution of neutral technological change (shift in the intercept term) was estimated to be –303.70 per cent in contrast to the positive contribution of 403.36 per cent by the non-neutral technological change (sum of shift in slope elasticities) to the total gain in milk yield. Thus, the negative contribution of neutral technological change implied that mere adoption of crossbred cows in place of indigenous cows did not bring about an upward shift in milk yield. However, as was evident by the positive contribution of non-neutral technological change, the dairy farmers in the study area benefited in consolidating such technological gains as they were able to adjust to the new requirements of the dairy technology. With regard to the difference in the level of input use, the

99.66 per cent more output could be produced with new milk production technology.

Table 3: Decomposition of total gain in milk yield

Case	Total gain (per cent)	Sources of change									Total estimated gain (per cent)
		Technological change			Input use						
		NTC	NNTC	Total	Green fodder	Dry fodder	Concent-rates	Labour	Veterinary expenses	Total	
Case I	160.94	–303.70	403.36	99.66	–0.83	4.25	33.41	–1.47	25.70	61.06	160.72
Case II	44.42	–11.60	48.15	36.55	–0.11	-5.23	9.26	–0.11	4.01	7.82	44.37

Case I: Change of technology from Indigenous cows to Crossbred cows
Case II: Change of technology from Buffaloes to Crossbred cows
NTC: Neutral technological change
NNTC: Non-neutral technological change

individual contribution of green fodder, dry fodder, concentrates, labour and veterinary expenses were found to be –0.83, 4.25, 33.41, –1.47 and 25.70 per cent to the total gain in milk yield, respectively.

Case II (Buffaloes: Crossbred Cows)

Under Case II of the shift in dairy technology, the observed total gain in per day milk yield was found to be 44.42 per cent, while the estimated total gain in milk yield was 44.37 per cent of which, 36.55 per cent occurred due to technological change and 7.82 per cent was due to the difference in the levels of input use. This means that 36.55 per cent more output could be produced with new milk production technology with the same level of inputs used under old technology. As regards the component of technological change, the contribution of neutral technological change was estimated to be –11.60 per cent in contrast to the positive contribution of 48.15 per cent by the non-neutral technological change to the total gain in milk yield. Thus, the negative contribution of neutral technological change implied that mere adoption of crossbred cows in place of buffaloes did not bring about an upward shift in milk yield. However, as was evident by the positive contribution of non-neutral technological change, the dairy farmers in the study area gained in consolidating such technological change as they were able to adjust to the new requirements of the dairy technology as observed in Case I. With regard to the change in the level of input use, the individual contribution of green fodder, dry fodder, concentrates, labour and veterinary expenses were found to be –0.11, –5.23, 9.26, –0.11 and 4.01 per cent to the total gain in milk yield, respectively.

The findings of this analysis in both the cases (Case I and Case II) were found to be different from those observed by Lalwani (1989), who found that the neutral technological change was positive and the non-neutral technological change was negative.

Conclusions

The production function analysis indicated that milk production would be reduced if dry fodder was fed more to the cattle. There was a positive relationship between milk yield and concentrates fed to cattle in the study area. And the farmers maintaining indigenous cows and buffaloes were in general under employed, while in case of crossbred cows milk production and labour were negatively related. The estimates of veterinary expenses explained the fact that crossbred cows were disease susceptible and conversely, indigenous cows and buffaloes were disease tolerant and adopted well in prevailing indigenous climatic conditions.

From the geometric mean levels of milk yield and input use, it was evident that crossbred cows were being maintained better and hence they yielded more than buffaloes and indigenous cows in the study area.

The decomposition analysis revealed that the contribution of technological change was more than that of change in input level to the output gain in milk yield in both the cases i.e., while shifting from indigenous cows to crossbred cows and from buffaloes to crossbred cows. The negative contribution of neutral technological change implied that mere adoption of crossbred cows in place of indigenous cows or buffaloes did not bring about an upward shift in milk yield. However, as was evident by the positive contribution of non-neutral technological change, the dairy farmers in the study area benefited in consolidating such technological gain as they were able to adjust to the new requirements of the dairy technology.

In consonance with the results obtained and the conclusions drawn from the study, the following policy implication is suggested. The study clearly indicated the economic advantage of rearing crossbred cow because of their higher milk yield. As the shift in milk production technology from indigenous cows and buffaloes to crossbred cows is resulting in a tremendous growth in output, current upgradation of non-descript local breeds through crossbreeding should be continued rigorously by official machineries uniformly throughout the State along with necessary supporting services to foster the growth and sustenance of crossbred cattle population.

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If you risk nothing, then you risk everything.

– Geena Davis

Feature

Seed Production: Trends & Constraints

S.R. Asokan & Gurdev Singh

Quality seed is an important input to increase agricultural productivity. Government of India realizing its pivotal role initiated various policy measures, which helped in the growth of the seed industry in the country. Seed production, which was just 0.18 million quintal in 1953-54 had risen to 8 million quintal in 2000-01. Despite such impressive gains, seed production is far short of demand for all major crops of cereals and oilseeds. Indian seed industry contributed enormously in the past in raising agricultural productivity. To face the challenges of the future the constraints prevailing in the subsystems of seed industry such as research, multiplication, legislation and marketing need, to be addressed. Further, the Government has to follow a right policy mix to meet the challenges without compromising the interest of the small farmers.

S.R. Asokan is a Research Associate in the Centre for Management in Agriculture, Indian Institute of Management, Ahmedabad. Prof. Gurdev Singh is a Professor in the same Centre.

Seed is a vital input in augmenting agricultural production. Most of the breakthroughs in agricultural research are packed in the form of seed and delivered to the farmers. Inputs like fertiliser, water and improved agronomic practices help to realize the potential in seed. Viewed in the context of limited possibility of expansion of area to increase production, as is the case in India, the importance of quality seed becomes all the more prominent. There is a need to continuously improve the quality of seed in terms of higher yields, resistance to pests and diseases. Further, as the quality of seed deteriorates over successive generations, seed has to be replaced every 3-4 years, which necessitates fresh supply of seed to the market. This calls for a vibrant seed industry not only to develop new seeds but also for an efficient and effective delivery system to make them available to the farmers in time.

The Government of India introduced various policy measures to vitalise the seed sector. The launching of an All India Coordinated Maize Project (1957) followed by similar projects for bajra and sorghum (1960) by ICAR, establishment of National Seed Corporation (1963), implementation of Seed Act (1966), setting up of state seed corporations with World Bank assistance under the National Seed Project in 1975, setting up of the National Bureau of Plant Genetic Resources in 1976, are some of the important milestones in the development of the industry. The 1980s marked significant development in the seed sector. In 1983 the Government of India decided to provide public bred breeder seeds to the private seed companies for multiplication and distribution. In 1986, the Department of Biotechnology was established in the ministry of science and technology. In 1987, the government abandoned its earlier protectionist stand towards the sector and allowed MRTP and FERA companies to participate in seed activity. New Policy on Seed Development was announced in 1988, which allowed import of seeds of coarse cereals and horticultural crops. The New Industrial Policy announced in 1991 marked a radical departure from the earlier stance of foreign investment in the seed sector. Under the policy, seed industry was identified as

Table 1: Certified/Quality Seed Production in India

('000 quintls)

Year	Wheat	Paddy	Maize	Jowar	Bajra	Pulses	Oilseeds	Fibres	Total
1983	1570	674	123	345	200	207	165	135	3419
1984	1729	888	114	142	147	160	495	80	3755
1985	1860	1203	155	272	214	240	471	178	4593
1986	1270	1038	105	484	152	283	483	301	4116
1987	1584	1321	153	492	236	448	619	225	5078
1988	1386	1383	160	381	120	553	801	117	4901
1989	1654	1981	199	369	186	348	722	148	5307
1990	1703	1740	184	379	146	367	763	189	5471
1991	1420	1366	149	346	168	341	859	216	4865
1992	1404	1447	150	346	168	329	966	203	5013
1993	1515	1428	150	391	169	340	1075	209	5277
1994	1823	1358	135	369	168	362	1138	201	5554
1995	2021	1463	135	325	161	360	1201	220	5886
1996	2241	1537	155	273	166	356	1264	258	6250
1997	2322	1657	188	273	171	419	1253	318	6601
1998	2442	2022	136	283	163	329	1287	321	6983
1999	2614	2405	226	257	187	406	1383	292	7770
2000	2300	1870	480	675	240	550	1600	380	8095
Compound Growth Rate	3.01	4.68	3.62	0.85	0.34	3.55	9.76	5.59	4.16
CGR 1990-91-1999-00	6.25	3.75	6.33	0.06	2.61	2.87	6.46	6.72	4.73

Data Provisional

Source: Govt. of India, Ministry of Agriculture and Cooperation

a high priority sector and foreign collaboration with Indian seed companies was encouraged. This was further modified in 1998 paving the way for 100 per cent equity participation of foreign companies in the seed sector.

The entry of multinational seed companies was expected to lead to an overall increase in investments in the sector, especially in private sector research in developing new varieties/hybrids. The Government of India had passed "The Plant Variety and Farmer's Right Act" in 2001 as per the WTO requirements. In March 2002, the department of biotechnology approved the genetically modified cotton known as Bt cotton developed by Mahyco-Monsanto for commercial use, thus, marking another vital step in the evolution of the Indian seed industry. The developments in the last decade necessitated the review of the Seed Act 1966 to incorporate many new provisions.

The entry of multinational seed companies was expected to increase investments in private sector research.

The policy initiatives undertaken in the past had helped enormously in the growth of the nascent seed industry. From a few units, the industry had grown to more than 160 seed companies/corporations. This included two central seed corporations, 13 state seed corporations, four fully owned subsidiaries of foreign companies, besides a score of joint ventures with foreign companies. There are 27 state agricultural universities and 15 central research institutions, which are involved in seed research and development.

Seed Requirement and Availability

Seed production which was just 0.18 million quintal in 1953-54 had risen to around 8 million quintal in 2000-01. The compound growth rate of seed production was 4.16 between 1983-2000 and improved to 4.73 in the

Table 2: Seed Requirement and Deficit for Cereal crops

(million kgs)

Year	Rice			Wheat			Jowar			Bajra			Maize		
	Seed Req.	Deficit	Percent of Deficit to Req.	Seed Req.	Deficit	Per-cent of Deficit to Req.	Seed Req.	Deficit	Percent of Deficit to Req.	Seed Req.	Deficit	Per cent of Deficit to Req.	Seed Req.	Defi-cit	Per cent of Deficit to Req.
1984-85	308.70	219.90	71.23	589.00	416.00	70.63	77.87	63.67	81.77	25.92	11.22	43.29	59.00	47.60	80.68
1985-86	308.55	188.25	61.01	575.00	389.00	67.65	85.85	58.65	68.32	25.65	4.25	16.57	56.00	40.50	72.32
1986-87	308.77	204.67	66.38	575.25	451.25	78.04	81.12	32.72	40.34	27.17	11.97	44.06	62.60	52.10	83.23
1987-88	291.08	158.98	54.62	576.50	418.50	72.59	85.00	35.80	42.12	20.71	–2.89	–13.95$	59.30	44.00	74.20
1988-89	312.97	174.68	55.81	602.75	464.75	77.10	82.32	44.22	53.72	29.74	17.74	59.65	67.00	51.00	76.12
1989-90	316.27	148.18	46.85	587.50	452.50	77.02	88.55	51.65	58.33	27.7	9.1	32.85	64.10	44.20	68.95
1990-91	320.17	146.18	45.65	604.25	434.25	71.87	88.77	50.87	57.31	27.58	12.98	47.06	68.50	50.10	73.14
1991-92	319.87	183.28	57.30	581.50	439.5	75.58	81.67	47.07	57.64	26.23	9.43	35.95	71.30	56.40	79.10
1992-93	313.35	168.65	53.82	614.75	474.75	77.23	84.35	49.75	58.98	27.42	10.62	38.73	68.80	53.80	78.20
1993.94	319.05	176.25	55.24	628.75	477.75	75.98	82.40	43.30	52.55	25.15	8.25	32.80	75.00	60.00	80.00
1994-95	321.08	185.27	57.70	642.50	460.50	71.67	83.52	46.62	55.82	25.82	9.02	34.93	81.70	68.20	83.48
1995-96	321.30	175.00	54.47	625.25	423.25	67.69	84.57	51.67	61.10	26.12	10.02	38.36	83.90	72.40	83.91
1996-97	325.73	172.03	52.81	647.25	423.25	65.39	90.82	63.52	69.94	28.28	11.68	41.30	88.30	72.80	82.45
1997-98	325.88	160.17	49.15	667.50	435.50	65.24	94.50	67.20	71.11	30.67	13.57	44.25	85.60	66.80	78.04
1998-99	334.50	132.30	39.55	685.00	441.00	64.38	94.70	66.40	70.12	30.73	14.43	46.96	84.40	60.80	72.04
1999-00*	334.58	94.07	28.12	668.50	407.50	60.96	26.30	0.60	2.28	8.79	–9.91	–112.74$	32.55	–	–

* Calculated from Provisional data for area under the crop and seed production.

$ Surplus

The seed requirement and deficit is worked out as follows.

The area under the crop for the year multiplied by the seed rate per unit of land gives the requirement of seed for the year for that crop.

Seed production in the year with the time lag of one year i.e. t- l is taken for seed availability.

In case of open pollinated cro as the seed has to be replaced at least once in four years, a 25 per cent replacement is taken as requirement.

period 1990-2000 (Table 1). Despite the impressive gains in production of seed the gap between requirements and production of quality seed is consistently high for major cereals and oilseeds crops as is evident from Tables 2 and 3. For wheat the shortfall had been nearly two thirds of the requirement in recent years and for rice it was between 40 and 50 per cent. The situation with regard to jowar and maize was still worse. In case of bajra there was surplus in the availability of seed for a couple of years but the situation overall had been one of shortfall. With regard to oilseeds the shortfall is reduced in recent years for sunflower, however, for groundnut and mustard the gap is persisting at around 90 and 70 per cent, respectively. The situation is no better with regard to vegetable seeds (Table 4).

Ironically, while the seed production is lower than the requirement, seed enterprises are facing the problem of carryover of unsold seeds almost every year. The reason could be that the seed replacement rate is very low for all important crops. This means that the farmers used crop produce as seed or exchanged it with fellow farmers or even purchased unbranded seed. The Expert Group on Seeds (1989) computed the seed replacement rate for major crops and found that for almost all major crops the replacement rate was not at all close to the recommended value. The problem of low SRR was prevalent in all states. The main reason for low SRR could be the low difference in yield between seed from a formal source and informal source (Singh and Asokan 1997) thus providing no incentive for the farmers to replace the seeds regularly. The SRR can be improved by producing quality seed and providing it to the farmers at affordable prices. The use of seed should be cost effective. Farmers must be made aware of the importance of replacing the seed at the recommended schedule. The extension department of the government as well as the marketing departments of the seed companies has a crucial role to play in improving the SRR.

Table 3: Seed Requirement and Gap for Major Oilseeds

(million kgs)

Year	Gnut			Mustard			Sunflower		
	Seed Requirement	Deficit	Percent of Deficit to Requirement	Seed Requirement	Deficit	Percent of Deficit to Requirement	Seed Requirement	Deficit	Percent of Deficit to Requirement
1986-87	698	660	94.60	18.60	13.80	74.19	5.10	2.30	45.09
1987-88	984	938	95.38	23.10	18.60	80.51	8.25	5.75	69.69
1988-89	853	806	94.47	24.15	19.65	81.36	5.50	2.80	50.90
1989-90	871	781	89.69	24.85	19.15	77.06	5.95	2.25	37.81
1990-91	831	769	92.50	28.90	23.10	79.93	8.15	3.05	37.42
1991-92	867	807	93.06	32.75	25.35	77.40	10.55	6.45	61.13
1992-93	817	750	91.77	30.95	23.25	75.12	10.45	4.95	47.36
1993-94	832	762	91.59	31.45	23.95	76.15	13.35	7.05	52.80
1994-95	785	718	91.43	30.05	22.15	73.71	10.00	2.70	27.00
1995-96	752	682	90.68	32.75	25.25	77.09	10.60	3.80	35.84
1996-97	759	690	90.97	32.75	24.15	73.74	9.65	1.45	15.02
1997-98	708	635	89.73	35.20	25.00	71.02	8.70	2.90	33.33
1998-99	757	689	91.00	32.55	22.05	67.74	9.10	1.60	17.58
1999-00*	687	625	90.98	30.35	19.05	62.76	6.65	0.45	6.76

*Based on Provisional data

Calculated as described in Table 2.

Seed Production

Seed companies/corporations undertake seed production in a decentralised manner by organising individual farmers in contiguous areas. Though the ostentatious reason is that land-ceiling legislation and other land related state laws prevent seed companies from owning large tracts of land the fact is that seed companies save enormously by decentralised production under contract. The seed companies/corporations enter into an agreement with the farmers for the area committed, compensation to be paid, terms of payment and practices to be followed. The companies supply foundation seed, make visits at critical stages of crop growth to ensure that the farmers strictly adhere to the recommended practices to maintain quality. The major attraction the companies offer to lure the farmers is higher compensation or procurement price compared to the existing commercial crops. But seed companies find it difficult many times to persuade the farmers to take up seed production and sustain their interest in the activity.

The companies supply foundation seed, make visits at critical stages of crop growth to ensure that the farmers strictly adhere to the recommended practices.

Table 4: Seed Scenario of Major Vegetable Crops during (1997-98)

Crop	Area (Million hec)	Market Potential (Tons)	Percent of area Under Hybrid	Percent of area under Open Pollinated Crops	Percent of area under unidentified seeds
Chillies	0.57	143	2.44	37.56	60
Eggplant	0.47	58.75	17.8	50	32
Cabbage	0.24	59.93	31.39	68.61	–
Cauliflower	0.45	112	3.6	50	46.4
Cucumber	0.25	93	3.0	15	80
Guards	0.04	2000	2.44	20	77.56
Melons	0.17	128	7.0	25.98	67.02
Okra	0.37	1950	15.85	69.53	14.62
Tomato	0.48	60	31.5	50	18.49

Source: Proagro Seed Company, New Delhi.

There are several reasons for the reluctance of farmers to take up seed production. Seed crops needs specific cultural operations such as sowing of male and female parent seed in separate rows, hand pollination in cotton, detaselling in maize, rouging, harvesting male and female rows separately and threshing in a clean

yard. In addition, some operations like irrigation, weeding, pesticide applications are carried out more intensively in seed crop compared to commercial crops. All these special operations involve additional labour, material and hence, cost. The cost of production of seed is higher compared to grain crop (Table 5). As is evident for wheat, an open pollinated crop, the cost of production was 9.4 per cent higher than the commercial crop. However, in case of castor seed (hybrid) it was one third (32.8 per cent) compared to commercial castor. Since institutional source of credit such as co-operatives and commercial banks do not appreciate the need for higher scale of finance for seed production, farmers have to meet additional expenditure from non-institutional sources at a higher rate of interest. Further, the seed crop like any other crop is prone to risks of adverse weather, pest attack, disease etc. The coefficient of variation in yield of castor seed was 37 per cent and that of commercial crop 16 per cent, in case of wheat 14.9 per cent for seed crop and 14.5 per cent for commercial crop. In addition to higher variation in yield seed crops face the risk of rejection for failing to meet the minimum standards prescribed for certification. Insurance cover for seed crops was recommended as far back as 1976 by the National Commission on Agriculture. An insurance scheme was announced by the Government only in 1999, however, it is yet to be operationalised.

Table 5: Costs and Returns of Seed Production in Gujarat

(Rs/acre)

	Castor		Wheat	
Operation	Seed	Commercial	Seed	Commercial
Human Labour	2410	1085	2240	2200
Bullock Labour	70	70	130	130
Machine Charges	480	480	420	420
Seed	425	280	750	450
Fertilisers	1426	740	1054	957
Manure	420	315	650	500
Pesticides	400	180	100	100
Irrigation	900	900	700	700
Interest	261	162	120	109
Sub Total	6792	4214	6160	5566
Rental Value of Land	2340	2340	1165	1165
Land Revenue	15	15	6	8
Certification	625	–	100	–
Sub total	2980	2355	1273	1173
Grand Total	9772	6567	7433	6739
Yield (Qtls)	3	11	19	17
Price/qtl	3800	1050	850	700
Returns	11400	11550	16150	11900
Yield of male seeds	4	0	0	0
Return from male seeds	4200	0	0	0
Gross Returns	15600	11550	16150	11900
Cost of Cultivation	9772	6567	7433	6739
Net Returns	5828	4983	8717	5161
C.V.	37	16	14.9	14.5
Risk Free Returns	1610	3135	6303	3435

Source: Gurdev Singh, S.R. Asokan and S.N. Chokshi, Economics of Seed Production at Farm Level, Oxford and IBH Publishing Ltd., 2000.

Research and Development

In recent years, there has been an increasing participation of the private sector in agricultural research. Appropriability of gains is a major determinant of private sector participation in research. The public good character of the research output in agriculture discourages private sector participation in its production unless mechanisms exist to enable private firms to capture exclusively the returns to their research efforts. Till the 1930s, the private sector involvement in agricultural research was confined to agro chemicals and machinery. The development of hybrid technology in seed production solved the problem of appropriability and paved the way for the entry of the private sector in seed research. The passing of the Plant Variety Protection Acts and extension of patent like protection to seed in many countries enabled more and more seed companies to undertake varietal research and invest in frontier technology such as genetic engineering or biotechnology.

The National Policy on Agriculture (2000) aims for an annual 4 per cent growth rate for the next two decades. In India, where the gains in agricultural production have to come largely from improvement in seed development rather than expansion of area, agricultural research is very crucial. Till recently agricultural research in India was primarily confined to the public sector. There are 39 central research institutes of which 15 are involved in research related to seed, 27 agricultural universities combine agricultural research, teaching and extension. The breeded and foundation seed produced by the public sector seed corporations are provided to private seed companies for further multiplication and distribution. "The private sector is better than the public sector in finishing and distributing varieties based on publicly funded research" (Ramaswami B et al, 2002). The success of green revolution and the enormous gains in food grain production which touched a record 211 million tonnes in 2002 was based

on high yield varieties (HYVs) technology. The contribution of National Agricultural Research (NAR) system and the CGIAR institutes such as CIMMYT and IRRI to the green revolution technology is well known.

The National Policy on Agriculture (2000) aims for an annual 4 per cent growth rate for the next two decades.

The private seed companies realised that there was little room for product differentiation in a crowded market by multiplying and distributing public bred varieties/hybrids, hence some started investing in research to have distinct products. The private sector research concentrated on hybrids and vegetable crops. There are quite a large number of hybrids of pearl millet, cotton, sunflower, maize, mustard etc developed by the private sector and well received by the farmers. The private sector's share in vegetable is much higher than the public sector. There are several GM crops such as mustard, tomato, cabbage etc in which the private sector is at an advanced stage of research. The first GM crop, Bt cotton, to be commercialised in the country came from the private sector. The Plant Variety Protection and Farmers' Right Act 2001 has been passed as per requirements of WTO. At least "in theory protection is a powerful incentive for private investment in research that can lead to superior varieties" (Tripp and Byrelee, 2001). However, there is skepticism about the adequacy of the Indian PVP act in encouraging private investment research. The act recognises the farmers' right to retain, exchange and sell his produce as seed but not in packets or containers. The act allows access to researchers to the protected variety to a limited extent but repeated use needs the permission of the original breeder.

The Plant Variety Protection and Farmers' Right Act 2001 has been passed as per requirements of WTO.

Apart from intellectual protection more private sector involvement in research can be ensured by innovative funding. The finance for research is now clubbed along with investment in plant and machinery. Since separate finance to set up research facilities are not available it hinders venture capital type undertakings where research is carried out but the product is offered to others for multiplication. There are few cases where SIDBI has financed venture capital activities in biotechnology, especially in pharmaceuticals. Such innovations need to be introduced in agricultural research to enable more technocrats to undertake research.

The Future of Public Sector Research

The increased involvement of private sector in research raises a question about the role and future of public sector research. The average size of holdings in the country is 1.55 hectares and 59.4 per cent of farmers own less than one hectare of land. Therefore, expecting market forces i.e. private sector alone to address their problems is not desirable. As the private investment in seed research will be tilted towards commercially important crops, the onus is on the public sector to continue research in those crops which are commercially less but socially more important. Lessor (1990) in a study of Plant Variety Protection Act in U.S. found that investment in private agricultural research was spread unevenly among crops. Minor crops, including several vegetables, had received no investment at all. Butler and Marion (1983) found that the prices of seeds had increased in the post PVPA period in the U.S. but they felt the increase was not unreasonable and attributed it to the farmer seed and the availability of public developed varieties which kept a check on prices. Therefore, in India, the public sector must continue their work on important crops because the small seed companies, which flourish by multiplying them, can help to keep a check on prices.

According to Echeveria et al, (1996) "With the swing towards privatisation, decentralisation and competitiveness in the late 1980s and 1990s the public monopoly of the NARI is now an obsolete institutional model for building NARs capacity" (op. cit Byrelee and Alex, 1998). There should be increased flexibility in managing finance and human resources in the public sector.

The vast facilities hitherto created in the ICAR institutes and state agricultural universities can be better utilised by undertaking sponsored research for the private sector. There are already a couple of sponsored research programmes by the private seed companies in the state agricultural universities. Further, public sector institutions must develop strategic linkages with the private sector to market their produce under some revenue sharing arrangements. This will boost the funds flow, which is under stress due to dwindling contribution from international donors and budgetary constraints of the government.

Marketing of Seeds

It is essential to make the seeds available to the

Table 6: India's Seed Exports over the Years

Seed	1990-91		1994-95		1995-96		1996-97		1997-98		1998-99		1999-00	
	Qty	Value	Qty	Value	Qty	Value	Qty	Value	Qty	Value	Qty	Value	Qty	Value
	Tons	Rs (lakhs)	Tons	Rs (lakhs)	Tons	Rs (lakhs)	Tons	Rs (lakhs)	Tons	Rs (lakhs)	Tons	Rs (lakhs)	Tons	Rs (lakhs)
Sugarbeet	2.0 (0.04)	0.8 (0.08)	–	–	–	–	8 (0.29)	3.6 (0.09)	5.5 (0.12)	0.7 (0.01)	–	–	–	–
Other Beet	0.9 (0.02)	5.5 (0.57)	20 (0.56)	80.1 (3.81)	0.2	0.2	0	0.0	8.3 (0.18)	2.9 (0.05)	–	0	64.4 (1.4)	39.8 (0.54)
Forages	2140.7 (48.3)	81.3 (8.5)	590.2 (16.6)	53.3 (2.5)	1006.7 (14.9)	159.8 (3.9)	265.2 (9.5)	31.2 (0.7)	756.6 (16.2)	148.7 (2.73)	1189.2 (21.89)	210 (3.3)	38.2 (0.9)	76.2 (1.0)
Herbaceous Plants	0.6 (0.01)	4.0 (0.41)	65.2 (1.83)	36.5 (1.74)	42.7 (0.63)	219.9 (5.34)	36.0 (1.29)	237.1 (5.63)	124.2 (2.66)	198.5 (3.64)	36.6 (0.67)	213.3 (3.33)	24.0 (0.52)	216.7 (2.95)
Cabbage	19.3 (0.44)	2.1 (0.22)	36.4 (1.02)	15.8 (0.75)	128.1 (1.89)	50.1 (1.22)	43.9 (1.57)	15.5 (0.37)	29.5 (0.63)	21.7 (0.4)	2.9 (0.05)	6.2 (0.10)	31.3 (0.7)	42.9 (0.58)
Cabbage	19.3 (0.44)	2.1 (0.22)	36.4 (1.02)	15.8 (0.75)	128.1 (1.89)	50.1 (1.22)	43.9 (1.57)	15.5 (0.37)	29.5 (0.63)	21.7 (0.4)	2.9 (0.05)	6.2 (0.10)	31.3 (0.7)	42.9 (0.58)
Cauliflower	3.0 (0.07)	0.5 (0.05)	0.0	0.0	3.7 (0.05)	2.5 (0.06)	1.3 (0.05)	5.9 (0.14)	0.2	1.1 (0.02)	3.1 (0.06)	34.3 (0.54)	11.1 (0.24)	31.9 (0.43)
Onion	0.0	0.0	12.1 (0.34)	3.6 (0.17)	8.5 (0.13)	25.6 (0.62)	0.0	0.0	0.0	0.0	49.8 (0.92)	31.1 (0.49)	147.9 (3.31)	56.6 (0.76)
Pea	1292.3 (29.15)	135.7 (14.13)	55.0 (1.55)	11.1 (0.53)	6.5 (0.10)	2.7 (0.06)	91.4 (3.28)	10.6 (0.25)	11.0 (0.23)	48.3 (0.89)	38.9 (0.72)	39.7 (0.62)	93.8 (2.1)	38.5 (0.52)
Radish	0.0	0.0	61.5 (1.73)	13.4(0.6 4)	176.7 (2.61)	42.3 (1.03)	145.5 (5.22)	43.7 (1.04)	87.1 (1.87)	23.0 (0.42)	48.2 (0.89)	13.7 (0.21)	5.6 (0.12)	1.8 (0.02)
Pomegranate	0.0	0.0	7.4 (0.21)	5.0 (0.24)	4.9 (0.07)	4.4 (0.11)	8.8 (0.32)	5.7 (0.14)	14.4 (0.31)	10.8 (0.20)	10.6 (0.20)	9.3 (0.15)	17.5 (0.4)	20.4 (0.27)
Tomato	0.0	0.0	20.7 (0.58)	492.7 (23.42)	28.0 (0.41)	1016.7 (24.69)	33.1 (1.19)	1720.2 (40.88)	51.9 (1.11)	1889.3 (34.64)	608.8 (11.21)	1379.3 (21.56)	60.2 (1.34)	1580.0 (21.43)
Other Vegetables	517.7 (11.68)	344.8 (35.9)	1944.8 (54.77)	778.3 (37.01)	3793.2 (56.12)	1366.8 (33.19)	1111.2 (39.9)	836.6 (19.88)	2086.2 (44.66)	1977.5 (36.26)	2380.0 (43.82)	1922.4 (30.05)	2198.7 (49.16)	2473.3 (31.62)
Fruit	23.0 (0.52)	15.1 (1.57)	3.8 (0.11)	18.1 (0.86)	56.9 (0.84)	72.9 (1.77)	18.7 (0.57)	236.7 (5.63)	10.2 (0.22)	54.1 (0.99)	24.7 (0.46)	77.8 (1.22)	30.3 (0.68)	96.2 (1.31)
Other	435.8 (9.83)	371.4 (38.68)	734.1 (20.67)	595.4 (28.31)	1502.6 (22.23)	1154.8 (28.04)	1029.83 (36.98)	1065.1 (25.31)	1491.2 (31.93)	1077.7 (1029.8)	1038.5 (19.12)	24 60.0 (36.45)	1749.5 (39.12)	2682.4 (36.46)
Total	4433.2	960.3	3551.1	2103.1	6758.7	4118.7	2784.9	4208.3	4670.9	5453.7	5431.3	6397.2	4472.4	7356.7

Figures in the parentheses are percentages to the total

Source: DGCIS (Ministry of Commerce and Industry, GOI) Monthly Statistics of the Foreign Trade of India, Exports and Re- exports (data are for March of relevant years)

millions of farmers in remote parts of the country at the right time and in right quantities. As seed is a live organism its quality deteriorates fast. Another important feature is the need for advanced planning to meet the demand for a particular seed, its production has to be organised at least two years in advance. The changes in weather, price of the crop, prices of competing crops may change the prospects of demand for a seed at the commencement of the sowing season.

The private seed companies as well as public sector corporations market seed through a network of distributors and dealers, who operate on commission basis. The National Seed Project (NSP) envisaged at least four sale points of seed per block, which means creating a network of minimum 20,000 sale points for the 5000 community development blocks. However, many blocks are still not covered by such a network. Though many seed companies/corporations have marketing departments they actually distribute seed rather than market them. Marketing involves building a brand image, which inspires the confidence of the farmers about the quality and performance of the seed. Further, seed companies must be receptive to complaints from the consuming farmers and take appropriate and timely action.

Exports

India exported 4433 tons of seed worth Rs. 9.6 crores during 1990-91. Though the exports in terms of volume remained the same during 1999-00 in terms of value it increased to Rs. 73.56 crores (Table 6). Exports in 1990-91 constituted mainly high volume but low value forage crops. Over the years exports of forage crops declined and of low volume high value vegetable crops increased.

However, the share of India's export in the total seed trade is a mere 0.4 per cent. India has distinct advantages over many countries in producing seed. The climatic conditions in India are so diverse that it has been divided into 120 agro climatic sub zones. The variations in the climates make it possible to grow a particular crop for seed production all the year round in one or the other part of the country (Sindhu). There is a vast pool of high caliber agricultural scientists as well as cheap agricultural labour. However, this potential is hardly exploited to carve a niche for India in the world trade on seeds. Further, there is enormous scope for custom production of seeds by the Indian companies for foreign clients (NSP I). Barring a couple of private companies others have not tapped the potential. If India wants to be a big player in the international market on seed it has to chalk out a strategy assessing its strength in catering to different markets for different crops. The government must desist from ad hoc decisions and spell out a comprehensive policy, which would enable the seed companies to plan their activities accordingly.

The private seed companies as well as public sector corporations market seed through a network of distributors and dealers.

Conclusions

There has been a lot of mergers and takeovers of seed companies in the last decade, especially in Europe and US. Rural Advancement Fund International (RAFI) of Canada documented the takeover of 226 seed companies by 11 seed companies in the 1990s. Thus, the world seed market is changing from a perfectly competitive environment to an oligopolistic situation. The development of biotechnology and the prospects of its application in varied fields like agriculture, chemicals, pharmaceuticals etc prompted a convergence of these industries to form a "life science" industry.

Indian seed industry over the years has made enormous contributions to enhance agricultural productivity. The decades ahead pose a new set of challenges for the industry. Therefore, the constraints faced by the industry need to be addressed. At the same time the predominance of small and marginal farmers in Indian agriculture necessitates a right mix of policies to meet the challenges and opportunities. Hence, India has to strike the right balance in pursuing more private sector participation and carve a role for public sector institutions to cater to the disadvantaged farmers and region.

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Feature

Horticultural Production in the Free Trade Regime

K.N. Selvaraj & T. Samsai

The challenges and prospects of the horticulture industry under the present free trade regime are discussed in this article. Trade policies as well as production strategies that will ensure globally competitive products and also afford adequate protection to farmers are outlined. At the same time, the importance of the domestic market and small economic units is also emphasised in the article.

K.N. Selvaraj and T. Samsai are with the Department of Agricultural Economics, Centre for Agricultural and Rural Development Studies, Tamil Nadu Agricultural University, Coimbatore.

Development of high yielding varieties of food crops and high production technologies and better extension for their adoption in areas of assured irrigation paved the way towards food security in India. A large range of horticultural crops such as fruits, vegetables, potato and other tropical tuber crops; ornamental, medicinal and aromatic plants; plantation crops; spices, cashew and cocoa grow in India. The ideal method of achieving sustainability of small holdings, increasing employment, improving environment, providing an enormous export potential and above all achieving nutritional security lie in the development of the horticulture industry. Due emphasis was given on diversification to horticultural crops during the last one decade (Table 1), as a result, a large number of high yielding varieties were developed and low cost environment friendly storage system and other marketing infrastructure facilities for fruits, vegetables, potato and onion were created.

Table 1: Budgetary Support for Horticulture Development

(Million Rupees)

Five year plans	Total for Agriculture Research	Share of Horticulture (Per cent)	Total Development Support
IV (1969-74)	6105	N.A	20.50
V (1974-78)	7292	6.10	76.18
VI (1980-85)	10684	6.50	146.37
VII (1985-90)	8445	6.67	250.00
VIII (1992-97)	15165	7.70	10,000.00

Source: http://commin.nic.in

Status of Horticultural Commodities

Fruits

India is the second largest fruit producer next to China with a share of eight per cent in world fruit production. India produces 65 per cent and 11 per cent

of the world's mango and banana, respectively, ranking first in the production of both the crops. It has the highest productivity in grape in the world. Significant expansion has also been taking place in apple, anola, ber, pomegranate and sapota cultivation. Arid fruits like pomegranate, ber, custard apple, tamarind, dates, anola and mango have vast potential for export in the international market. The requirement of these fruits is at present estimated at 11.1 lakh tons while the production is estimated at around 5.56 lakh tons due to low productivity of these crops in the arid regions and the productivity ranging between 6.68 tons per ha to 9.8 tons per ha due to cultivation of these crops in marginal lands. Australian and Chinese apples are now competing with the domestic varieties with prices as low as Rs. 40-70 per kg. Apple imports were allowed for the first time in 1999 and Australian apples account for around 40 per cent of the total Indian apple imports, New Zealand apples account for 35 per cent and US apples another 15 per cent. Imports of apples do not pose any major threat to domestic apple production (Economic Times, 2001).

Vegetables

India ranks second in world vegetable production after China. India occupies first position in the production of cauliflower, second in onion and third in cabbage in the world. Vegetable production has increased three times during the last 50 years due to technological innovations. India has attained self-sufficiency in seed production of temperate vegetables and a large area is now covered with F1 hybrids in vegetable crops resulting in increased yield and better socio-economic status of farmers. Due to availability of cold set and hot set varieties in certain crops like tomato, throughout the year cropping has become possible. Vegetables like tomato, cabbage, cauliflower, radish and onion are now produced almost round the year and vegetable farming is highly economical particularly for marginal and small farmers, who dominate the peasantry. Post harvest technology in certain crops like potato, onion, tomato, peas and others have been perfected and are within easy reach of the average growers. Intensive research and entry of many corporate firms in vegetable seed business has contributed to the growth of the vegetable industry. It has also become possible to establish a sound tomato processing industry due to production of suitable processing varieties with high productivity.

India ranks second in world vegetable production after China.

Floriculture

The floriculture industry in India covers trade of (i) cut flowers (ii) nursery and potted plants, seeds and bulbs (iii) micro propagated plants and (iv) essential oils from flowers for perfumes. Flower cultivation is carried out on smallholdings and commercial floriculture has assumed importance recently. It is estimated that about 70 thousand ha is covered under flowers for cut-flower use. About 500 ha of climatically controlled greenhouses is reported to be available for growing quality flowers for export. Traditional flowers like marigold, jasmine, aster, rose, chrysanthemum, crossandra are grown in more than two third of the area under flowers, while modern day cut flowers with stems e.g. rose, carnation, gladiolus, tuberose, orchids etc. occupy the rest of the area. In addition to cutflower use, ornamental plants are now increasingly in demand for interior decoration and landscape use.

Flower seed production and multiplication of planting materials are also on the increase. Several flower seed producing companies have set up production facilities in India for targeting domestic as well as export markets. Some of these companies took up custom production of specific varieties for their clients abroad. More than 30 commercial micro propagation units with production capacity exceeding 40 million plants have been set up. Flowers and ornamental crops are the major product range in these units. Tissue culture raised plants of carnation and gerbera already gained popularity with flower growers. Production of bulbs/tubers of crops like gladiolus, lilliums, tulips, liatrice, is also picking up fast. A good number of export oriented floriculture units have been established and statistics show that more than 200 such units have been approved to be set up, which include 157 units with foreign collaboration and direct foreign investment. The total investment in this sector is approximately Rs. 1000 million. The flowers exported from these units are receiving consumer's acceptance for high quality. A good number of such export-oriented units with greenhouse production have been set up in various parts of the country. Out of the total global production of jasmine concrete, India's share was approximately 25 per cent.

Demand and Supply of Horticultural Commodities

The demand of horticulture produce is on the rise due to increasing population, changing food habits, realization of high nutritional value of horticultural crops and greater emphasis on value addition and export (Table 2 and 3). Demand-supply gap show that surplus exist for turmeric, banana, mango, grapes and tea in the state and this surplus would be exported if the minimum

Table 2: Estimated Production of Principal Horticultural Crops (Million Tonnes)

Crops	1997-98*	1998-99*	1999-2000*
Fruits	42.3	44	46.5
Vegetables	72.7	87.5	95
Spices	2.2	2.9	3.1
Cashew	0.4	0.5	0.5
Areca nut	0.3	0.4	0.4
Coconut**	13.1	14.6	16.9
Others	1.5	1.6	2

* Provisional ** Billion nuts

Source: Agricultural Statistics at a Glance 2000

Table 3: Production, Demand and Projections of Horticultural Crops

Particulars	Demand		Target 2002	
	Area*	Production**	Area	Production
Fruits	5.24	59.47	4.93	56.00
Vegetables	6.96	131.2	5.73	108.00
Spices	2.94	4.43	2.60	3.90
Coconut	2.67	15.60	2.57	15.00
Cashew	0.69	0.80	0.60	0.70
Arecanut	0.24	0.39	0.25	0.39
Total	18.74	211.89	16.68	183.99

*Area in million hectares; **Production in million tonnes

Source: http://commin.nic.in

market access and reduction in tariff by the developed countries are ensured. It is estimated that the annual growth rate of domestic trade of floriculture products is about 25-30 per cent. The demand for flower extracts for perfume trade is growing. The natural concretes of jasmine, tuberose and rose are produced in large quantity and this sector has considerable potential, both for the domestic and export market. Dry flowers and plants are also comparatively new products. Some commercial units for production of value added products like collages and flower pictures, flower balls, cards and covers, pomanders, festive decorations, sweet smelling pot-pouries etc. have been established both in eastern and southern India. In the domestic market, consumption of flowers in the southern states is much higher than in the northern region. For jasmine, only 31 to 36 per cent of consumers' price goes to the growers. In case of roses, however, about 50 per cent of consumers' price is realised by the growers. Analysis of the composition of cost price of rose show that labour, propagating material, fuel and materials cover 33, 26, 26, and 4 percent respectively. Price analyses also indicate that the domestic market has shown higher price fluctuations as compared to the international market. So the farmers must be benefitted from an assured market and prices for further development of the horticulture industry (Table 4-7).

Table 4: Domestic Price Instability of Major Horticultural Commodities*

Commodity	Coefficient	T value	Probability
Pepper	2.1929	1.1939	0.2775
Chilli	0.0965	0.15	0.8853
Coffee	0.0741	0.06	0.95
Tea	0.5756	1.33	0.23
Cashew	3.3737	0.9186	0.40

* 1991-92 to 1998-99

Table 5: International Price Instability of Major Horticultural Commodities*

Commodity	Coefficient	T value	Probability
Pepper	4.01	1.83	0.12
Chilli	0.2487	0.227	0.83
Coffee	1.2971	0.8199	0.45
Tea	0.5756	1.3250	0.2333
Cashew	0.4608	0.45	0.6759

* 1991-92 to 1998-99

Table 6: Total Variability of Detrended Price Series of Major Horticultural Commodities*

Commodity	1970-71 to 1990-91		1991-92 to 1998-99		1970-71 to 1998-99	
	Domestic	International	Domestic	International	Domestic	International
Pepper	39.15	42.90	30.39	28.88	78.14	70.23
Chilli	32.39	22.09	32.11	23.17	36.81	28.39
Coffee	25.41	30.23	9.51	24.47	66.64	41.52
Tea	22.54	23.64	13.54	11.82	25.53	31.08
Cashew	16.13	14.69	23.54	4.66	34.49	23.72

* Coefficient of Variation

Export Growth and Exim Policies

Export of fresh as well as processed fruits has been increasing. Exports of horticultural products increased in the post-liberalized era and exports of these products witnessed higher growth in value terms with variation in quantity term. The major exports of horticultural products are spices, cashew, tea and coffee. Value of agricultural exports to the total exports was 15 per cent in 1999-2000 (Economic Survey, 2000-2001). Of the total

agricultural exports cashew forms 10.3 per cent, followed by tea (7.4 per cent), spices (7.2 per cent), coffee (5.7 per cent), fruits and vegetables (3.7 per cent) and processed fruits and juices (2.1 per cent). The figures in Table 8 and 9 indicate that exports of horticultural commodities tended to increase in value terms, particularly cashew kernels, spices, fruits and vegetables and processed foods and increase in these commodities is manifold. Though there is favourable trend in exports in value terms, sustainable export base is the worrying factor as evident from the trend in quantum of exports of these commodities.

Table 7: Estimates of cross product residual trend regression for testing transfer of price variability*

Commodity	Coefficient	T value	Probability
Pepper	7.8640	7498	0.4817
Chilli	– 1.596	– 0.1056	0.9193
Coffee	1.0069	0.0308	0.9766
Tea	10.0559	2.2564	0.0648
Cashew	3.2474	0.3556	0.74

1991-92 to 1998-99

* The approach is given by, $Wt = \beta_0 + \beta_1 + u_t$ Where, Wt is the world price and t is the time variable. $Dt = b_0 + b_1 t + u_t$ Dt = Domestic price. Regressing the absolute value of the residuals from the initial trend regression against time and testing for significant trend to indicate the variability. The residual trend regression model is given $|u_t| = \alpha_0 + \alpha 1 t + v_t$ $|u_t| = a_0 + a_1 t + v_t$. The slope coefficient $_1$ and a_1 are tested for significant difference from zero, where the slope coefficient $_1$ denotes world price variability and a_1 indicates domestic price variability. The extent of transmission of world price instability to domestic prices was studied using correlation coefficients of detrended data. The following cross product trend regressing model was followed to test the changes in covariance patterns over time. $Wt = b_o + b_1 t + u_t$ $D_t = a_0 + a_1 t + v_t$ $|u_t v_t| = \gamma_0 + \gamma_1 t + e_t$ The slope coefficient 'γ' is tested for significant difference from zero in order to test for changes in covariance patterns over time.

Among the vegetable crops maximum export potential remains with onion and potato. The seasonal vegetables and high value crops like beans, peas, green chilli, broccoli, asparagus, mushroom, capsicum, lettuce etc., also have good scope for export. Less pungent white/yellow varieties of onion possess good demand in European markets. Although India exports considerable quantity of onions, level of production and prices prevailing within the country cause hindrances in promoting export on large scale. India has the potential of becoming a major exporter of both ware and seed potatoes. There is a great potential of exporting processed potato also. It is estimated that presently only 0.5 per cent of the potato production of the country is processed. More than 80% of Indian potato is grown in the winter months when there is no potato crop in the Western temperate countries. India, therefore, is favourably placed so far potato production and marketing is concerned. Intensive research and entry of many corporate firms in vegetable seed business has contributed to the growth of the vegetable industry tremendously. Vegetable seed business is another area where India may do well. It was estimated that demand for vegetable for processing and export is approximately 4 million tonnes. Without discounting post harvest loss, total demand of about 130 million tonnes of vegetables had been projected for the country for the year 2002, showing ample scope of vegetable farming. Coconut contributes 700 billion rupees to the GDP of the country. The contribution of the crop to the total edible oil pool in India is around 6 per cent. India also exports coir and coir products derived from coconut husk to the tune of 2260 million rupees.

Table 8: Export Growth in Horticultural Commodities – Value Terms

(Rs. Crores)

Commodity	1960-61	1970-71	1980-81	1990-91	1999-2000
Coffee	7	25 (257.14)	214 (756.00)	252 (17.76)	1364 (441.27)
Tea*	124	148 (19.35)	426 (187.84)	1070 (151.17)	1766 (65.00)
Cashew kernels	19	57 (129.40)	140 (145.61)	447 (219.29)	2451 (448.32)
Spices	17	39 (129.41)	11 (–71.79)	239 (2072.72)	1702 (612.13)
Fruits and vegetables**	6	12 (100.00)	80 (566.67)	216 (170.00)	1212 (461.11)
Processed foods***	1	4 (300.00)	36 (800.00)	213 (491.67)	760 (256.81)

(Figures in parentheses denote percentage change over earlier years)

* Tea and mate

** Excluding cashew kernels, processed fruits and juices and including pulses

*** Including processed fruits and juices

More than 80% of Indian potato is grown in the winter months when there is no potato crop in the Western temperate countries.

Protected cultivation of cut flowers started a decade back. Micro propagated ornamental foliage plants are being exported in millions internationally. Export of dried flowers and ornamental foliage plants of decorative value from India is increasing. The natural extracts of certain flowers have good demand and concretes of jasmine, tuberose and rose are produced. Dry flowers and plants trade is a comparatively new venture in India and is gaining popularity. Presently, most of the dry

products are exported to Germany, USA, Netherlands, U.K., Italy and Japan. Such products constitute nearly 60 per cent of India's exports of floriculture products at present. The major export markets and competitors are produced in Table 10.

Table 9: Export Growth in Horticultural Commodities – Quantity Terms

Commodity	1960-61	1970-71	1980-81	1990-91	1999-2000
Coffee	19.7	32.2 (6.45)	87.3 (171.12)	86.5 (–0.92)	165.3 (92.00)
Tea*	199.2	199.1 (-0.05)	229.2 (15.12)	199.1 (–20.29)	183.8 (–7.68)
Cashew kernels	43.6	60.6 (38.99)	32.3 (–46.69)	55.5 (71.83)	92.5 (66.67)
Spices	47.2	46.9 (-0.64)	84.2 (79.53)	103.3 (22.68)	195.8 (89.54)

(Figures in parentheses denote percentage change over earlier years)

* Tea and mate

Table 10: Major Export Markets and Competitors

Products	Major Export Market	Major Competitors
Spices	East Asia, USA, West Europe, West Asia, and South Africa	Guatemala,Thailand, Indonesia, Malaysia, Brazil, China, Mexico, Morocco, Sri Lanka, Vietnam and Spain
Cashew	Australia, Germany, Hong Kong, Japan, Netherlands, Singapore, USA, UK, CIS and UAE	Brazil, Vietnam, Mozambique, Ivory Coast,Guinea Bissau
Fruits	Middle East, UK, France, USA and Netherlands	Chile, Pakistan, Philippines, Colombia, South Africa, Australia and Israel
Vegetables	Sri Lanka, Saudi Arabia, Russia, UAE, Kuwait, USA, UK and Germany	China, Turkey, Thailand, Philippines, Israel and South Africa
Floriculture	USA, Netherlands, UK, Germany, Japan and Italy	Kenya, Israel, South Africa, Netherlands and Denmark

Source: Ministry of Commerce and Industry (2000), India and the WTO – A Monthly New Letter

The significance and consequences of trade liberalization on the domestic economy has been debated for a long time. Measures have been undertaken to strengthen the export production base, upgrade technology and improve competitiveness of horticultural products in the world market. A number of horticultural products have been placed in the free list of imports. Commodities like citrus fruits (prepared/ preserved) and other fruits including apricot, cherry, peaches, strawberries, grapes, apple, guava (frozen/ preserved) have been shifted from the negative and restricted list to the open general list. In the exim policy the peak rate of basic custom duty was reduced from 40 per cent to 35 per cent and the number of slabs in the custom duty rates was rationalized from five to four, namely, 35, 25, 15 and five per cent. Duty on various items on which quantitative restrictions have been removed has been placed under the peak rate of 35 per cent. A number of horticultural products placed on the free list of imports in the earlier years have also been brought to the peak rate to ensure adequate protection to farmers (Table 11-14).

Table 11: Import Structures of Horticultural Commodities

Commodity	Duty on import	Import Policy
Vegetables (except onion)	15 per cent	Free
Onion	Zero per cent	Free
Dates	35 per cent	Free
Fresh grapes	35 per cent	Free
Apples	50 per cent	Free

Source: Agricultural Statistics at a Glance, 2000

Table 12: Bound Tariffs and Applied Rates for Horticultural Commodities

H.S. Code	Description	New Bound Tariff Rate (per cent)	Applied Rates (per cent)
0806.10	Grapes fresh	40	40
0809.40	Plums and sloes	35	25
0713.10	Dried peas	50	–
0802.11	Almonds in shell	Rs. 35 per kg	Rs. 35 per kg
0805.10	Oranges	40	35
0805.30	Lemons and limes	40	35
0805.40	Grape fruit	25	25
0808.10	Apples	50	50
0808.20	Pears and quinces	35	35
0813.20	Prunes	25	25
2004.10.09	Other potato preparations – frozen	35	35
2009.11	Frozen orange juice	35	
2009.19	Other orange juice	35	

Source: Ministry of Commerce and Industry (2000). India and the WTO – A Monthly News Letter

Production Strategies

Inadequate supply of quality planting material and biotic and abiotic stresses, lead to low productivity per unit area, resulting in high cost of production. The post harvest losses continue to be high. Biotechnology, protected cultivation, integrated nutrient management,

leaf nutrient standards, biofertilizers, integrated pest management and mycorrhiza play a crucial role for growth in the industry. Private sector participation in production of hybrids, green house production of flowers, biotechnology, value addition and export, will also have higher pay-offs. The future growth of the horticulture industry will largely depend on new and globally competitive technologies.

Table 13: Tariff Structure of Horticultural Commodities in India

Item	Previous tariff (per cent)	Revised tariff (per cent)
Areca nut	35	100
Apples	35	50
Tea	15	35
Coffee	15	35

Source: Ministry of Commerce and Industry (2000), India and WTO - A Monthly News Letter.

Overall development of horticulture in the country would require substantial improvement in the productivity and quality of the produce and reduction of post harvest loss of perishable commodities through better handling and organised marketing. Since the scope for expansion of area is limited, further growth of horticulture industry and its sustainability will largely depend on new and emerging technologies. Strong support of basic and strategic research in conjunction with conventional technologies will only enable rapid growth. The present research system should also provide necessary training support to entrepreneurs for enhancement of skills for various agribusiness activities. Further, in the era of globalisation, produce has to be of international quality and globally competitive.

Export Strategies

The export potential of horticultural products is unlimited. Providing infrastructure would boost export. Market development and promotion with an assurance of continuity in supplies of horticultural products will be a long-term strategy for increasing the exports of these commodities. Several factors like acidic nature, strong astringent taste, poor quality, improper post harvest techniques and poor packaging are the major bottlenecks in arid fruits export. Low exportable surplus, protective tariffs, stiff competition in the global market, poor market intelligence, lack of brand status to the commodities, lack of publicity and export in the form of raw materials are the major market related constraints inhibiting export of these fruits. Technical standards, environmental and social concerns and non trade barriers like anti dumping duties, countervailing duties, safe guard measures and sanitary and phyto sanitary measures have affected market access for export of horticultural commodities like floricultural produce.

The export potential of horticultural products is unlimited.

The use of Hazard Analysis Critical Control Point (HACCP) system needs to be promoted as a basis for regulatory food control and a standard for international food trade. To ensure safety of commodities like fruits, vegetables and processed products exported from India, the HACCP system will help minimize the problem of contaminants, thereby increasing the competitiveness of the products in major importing countries like Australia, Canada, New Zealand, USA and the European Union. Specification of quality/codex standard for export of indigenous fruits and vegetables need to be developed. Phytosanitary regulations for importing vegetatively propagated materials need a relook/ revision and rigorous enforcement. There is a need for development of bulk handling system of tropical fruits, including pre-cooling and CA/MA storage and post harvest protocols for sea transport of major fruits like banana, mango, litchi, sapota, kinnow and pomegranate. Disinfestation technology, including vapour heat treatment (VHT), for export of fresh fruits and extension of shelf life by preventing desiccation of vegetables should help in further export promotion.

HACCP system needs to be promoted as a basis for regulatory food control.

The major factor for the revival of floriculture is the growth in the domestic market and the appearance of smaller units. The reason for latter is economic, smaller units have lower overheads. For a smaller farmer, production costs per flower are about Re. 0.80 while it is as high as Rs. 2.10 for a larger unit (Economic Times, 2001). The domestic market has reduced sole dependence on the vagaries of export market, with its too short season, providing a longer season within the country. While the overseas season lasts from December to mid-February, the domestic market begins in August and goes on to mid-February. Training and extension work play a crucial role in the development of this sector.

The products are listed in descending order of their approximate importance in the order of the values of their products. When some products under a general

Table 14: Quantitative Restrictions, tariffs and tariff bindings under Uruguay round agreement on major horticultural commodities

Commodity	QR status	Operative tariff	Bound tariff
Vegetables	QR	12	100,35
Fruits	QR	42,32	100,30,55
Spices: Cassia, cinnamon, cloves	QR-ST	32	100,150
Spices: all other	QR	32	150,100,35
Tea	QR	12	150
Natural rubber	QR	22	25
Coffee beans, processed coffee	QR	12	100,150
Cocoa beans, processed cocoa	QR-ST, F	42, 43	100,150

Source: Pursell (1999), Gulati (1999) quoted by Athukorala (2000)

heading are subject to QRs and some are free (F), the relatively more important status is mentioned first. Tariff rates are indicated following the same principle. Tariffs separated by commas indicate the rates for different tariff lines under a general heading. Tariffs separated by hyphens imply that there are a number of tariff rates between the two indicated bounds. Tariffs are shown only for imports intended for consumption, not for imports of seeds or cuttings (which are normally duty free). QR – There is some form of quantitative restrictions, QR-ST – The restriction has been judged to fall under the UR definition of state trading, usually in the form of a parastatal import monopoly or in a few cases, a private import monopoly, enforced by the government and F- trade is free of QR.

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□

If you hire mediocre people, they will hire mediocre people.

– Tom Murphy

Feature

Growth Analysis of Maize in Punjab

S.S. Chahal, Poonam Kataria & Harpreet Kaur

Requisite data for the period 1950-51 to 1997-98, was collected from the major maize growing districts of Punjab to examine the factors determining maize acreage in the state. Different statistical models were applied to analyse growth patterns, the decomposition of growth analysis and acreage response. The need to develop new technology to see that maize can compete with rice is stressed.

S.S. Chahal, Poonam Kataria and Harpreet Kaur are with the Department of Economics and Sociology, Punjab Agricultural University, Ludhiana.

Maize, once one of the most important crops in terms of area and production, played a leading role in augmenting food grain production in Punjab. The area under maize was 255 thousand hectares during TE 1952/53, and increased to 400 thousand hectares in the TE 1966/67. The corresponding figures for maize production were 251 and 616 thousand tonnes respectively. However, during the Post-Green Revolution period, there was a continuous and substantial decline in maize acreage, which led to decline in production also. Whatever little possibility of any significant increase in maize area exists, it has to be preceded by significant increase in productivity. Efforts were, therefore, made to bring about technological breakthrough in the maize crop. As a consequence, during the mid-sixties, high bred maize was introduced in Punjab, but even the increasing maize productivity could not help to sustain the maize acreage in the state. The crop production profile of the state shows that after the introduction of high-yielding-varieties (HYVs) and associated technologies, the area under rice, the main competing crop of maize, increased by 40 times, with production more than 27 times during the past 50 years. A continuous decline in the maize acreage in Punjab has been observed in spite of the fact that maize possesses tremendous potential in terms of feed for dairy, poultry, piggery and agro-industries. The diversified use of maize in the starch industry, corn-oil production, baby corns, popcorns, etc. is a positive factor to bringing about changes in the state's cropping pattern. It has thus, provided the much-needed impetus to undertake a detailed study to examine the state of maize economy and its dynamics in Punjab. More specifically the objectives of the present investigation were:

- To study the temporal and spatial performance of maize in terms of its area, production and yield in Punjab and
- To examine the factors responsible for determining maize acreage in Punjab.

Methodology

All the major maize growing districts, namely Amritsar, Gurdaspur, Jalandhar, Ludhiana, Hoshiarpur, Ropar, Patiala and Kapurthala, together having more than 70 per cent of maize area of the state, were included in the study sample for an in depth analysis of the problem. The requisite data for the study period (1950/51 to 1998/99) has been collected from the various issues of the Statistical Abstracts of Punjab. The data relating to the area, yield and production of maize and its competing crop viz. rice, farm harvest prices of maize and rice, the net irrigated area and area under HYVs of maize and rice and rainfall for the months May-June have been collected for the study period. The information pertaining to the cropping patterns at four points of time i.e., TE 1952-53, TE 1966-67, TE 1986-87 and TE 1998-99 was also compiled from the Statistical Abstracts of Punjab.

Growth Analysis

The compound growth rates for area, production and yield of maize were estimated for three periods viz. Period I: 1950-51 to 1965- 66, Period II: 1966-67 to 1985-86 and Period III: 1986-87 to 1998-99.

The growth model adopted is as under:

$$Y_t = AB^t$$

Where,

Y_t = Area/production/yield of a crop for the year 't'.

t = Time variable (1, 2...n) for each period.

A = Constant

Log transformation of the above function is:

$$\ln Y_t = \ln A + t (\ln B).$$

Where,

$$\ln B = \ln (1 + r), \text{ and}$$

$$r = [\text{antilog } (\ln B) - 1]$$

$$\text{CGR } (\%) = [\text{antilog } (\ln B) - 1] \times 100.$$

The Decomposition of Growth Analysis

The observed increase/growth in production of a crop can be decomposed into area effect, yield effect and interaction effect. The following additive scheme of decomposition has been used:

$$\Delta P = A_1 . \Delta Y + Y_1 \Delta A + \Delta A . \Delta Y$$

Where,

ΔP = Difference in average production during two periods.

ΔY = Difference in average yield during two periods.

ΔA = Difference in average area during two periods.

A_1 = Average area under maize crop during the base year.

Y_1 = Average yield of maize crop during the base year.

Thus, the change in production (ΔP) is due to:

(i) $Y_1 \Delta A$ represents an area effect,

(ii) $A_1 \cdot \Delta Y$ represents yield effect, and

(iii) $\Delta A . \Delta Y$ represents an interaction of area and yield effect.

Acreage Response

The following model was applied to estimate acreage response as under:

$$A_t = b_0^* \left(A_{t-1}\right)^{b1} * \left(RLYIELD_{t-1}\right)^{b2} * \left(RLFHTP_{t-1}\right)^{b3} * \left(NIRRIA_{t-1}\right)^{b4} * \left(RAIN_{t-1}\right)^{b5} * \left(RLYRISK_{t-1}\right)^{b6} * \left(RLPRISK_{t-1}\right)^{b7} * e^{ut}$$

Where A_t is acreage under maize crop during the current period, A_{6-1} is one year lagged maize acreage, $RLYIELD_{T-1}$ is previous year relative yield of maize crop with respect to rice of the district, $RLFHP_{t-1}$ is previous year relative farm harvest price of maize crop with respect to rice of the district, $NIRRIa_{t-1}$ is previous year net irrigated area of the district, RAIN is average of two pre-sowing months' rainfall (for Karif, average of May-June months' rainfall), RLYRISK is relative yield risk of maize with respect to rice of the district (calculate relative yield of maize, then take standard deviations for three years and put the results for the fourth year), RLPRISK is relative price risk of maize w.r.t. rice of the district (calculate relative farm harvest price of maize, then take standard deviations for three years and put the results for the fourth year), b_0 is intercept, $b_1 ... b_7$ are elasticities/regression coefficients of respective independent variables and U_t is disturbance term. The Ordinary Least Squares (OLS)

method was used for the purpose of estimation.

Results and Discussion

The results obtained from the analysis of data pertaining to maize production in Punjab are discussed under the following sub-heads:

Shift in Cropping Pattern

Table 1 shows that during the period TE 1966-67 to TE 1998-99, the cropping pattern in the selected districts of Punjab favoured mainly rice and wheat at the cost of oilseeds, sugarcane and pulses. In the case of Jalandhar district, the marginal decline in wheat area was due to shift in area to potato crop. There is shift of maize area to rice in the selected districts due to relatively higher yield and price advantage and consequently higher profitability of rice crop.

Table 1: Shift in Cropping Pattern in major maize growing districts of Punjab, TE 1966/67 to TE 1998/99.

District	Crop					
	Rice	Maize	Wheat	Oil-seeds	Sugar-cane	Cotton
Gurdaspur	213.7	(-) 52.5	103.5	(-) 48.0	(-) 17.2	(-) 45.8
Amritsar	334.1	(-) 84.5	61.6	(-) 29.0	(-) 25.9	(-) 62.9
Kapurthala	449.5	(-) 71.8	121.1	(-) 81.7	7.3	217.5
Jalandhar	1390.1	(-) 75.7	(-) 07.5	(-) 73.0	(-) 21.6	50.7
Hoshiarpur	99.3	(-) 05.5	5.4	41.7	29.1	399.0
Ropar	696.3	(-) 05.1	296.2	(-) 75.2	0.8	38.5
Ludhiana	6112.4	(-) 93.9	98.4	(-) 94.9	(-) 45.5	(-) 76.6
Patiala	451.6	(-) 77.5	42.0	(-) 91.9	(-) 71.8	(-) 64.3

The data presented in Table 2 pertaining to three time periods shows that the area under all the crops

Table 2: Shift in Cropping Pattern in major maize growing districts of Punjab, TE 1952/53 to TE 1966/67 to TE 1986/87 and 1986/87 to 1998/99.

Districts	Rice	Maize	Wheat	Oilseeds	Sugarcane	Cotton
	TE 1952/53 to TE 1966/67					
Gurdaspur	86.7	35.4	22.4	24.2	67.4	(-) 24.5
Amritsar	135.3	58.7	19.4	122.9	16.9	29.3
Kapurthala	304.5	97.2	45.5	2216.7	16.3	10.5
Jalandhar	425.0	90.9	33.0	466.7	35.8	44.1
Hoshiarpur	79.3	4.0	-6.5	144.4	(-) 25.8	(-) 47.5
Ludhiana	66.0	100.7	73.5	147.8	65.5	107.7
Patiala	293.6	14.5	39.4	258.7	117.4	91.4
	TE 1966/67 to TE 1986/87					
Gurdaspur	160.6	(-) 31.6	60.6	(-) 9.2	(-) 20.9	(-) 87.5
Amritsar	238.1	(-) 66.7	102.2	33.0	(-) 20.9	(-) 87.5
Kapurthala	357.9	(-) 52.9	95.2	(-) 61.7	(-) 58.0	(-) 82.5
Jalandhar	1473.1	0.6	67.4	(-) 58.1	(-) 16.7	(-) 77.2
Hoshiarpur	76.5	19.3	49.1	53.0	(-) 36.2	(-) 62.5
Ropar	418.5	27.7	108.4	(-) 57.6	(-) 2.3	(-) 69.2
Ludhiana	4687.6	(-) 47.1	72.4	(-) 81.8	(-) 65.2	(-) 84.2
Patiala	476.0	(-) 63.0	127.3	(-) 49.1	(-) 58.4	(-) 87.2
	TE 1986/87 to TE 1998/99					
Gurdaspur	20.4	(-) 30.6	26.7	(-) 42.7	4.8	333.3
Amritsar	28.4	(-) 53.5	(-) 20.1	(-) 46.6	130.6	172.9
Kapurthala	20.0	(-) 40.0	13.2	(-) 52.2	155.6	1718.2
Jalandhar	(-) 5.3	(-) 75.8	(-) 44.8	(-) 35.5	(-) 5.9	561.2
Hoshiarpur	12.9	(-) 20.8	(-) 29.3	(-) 7.4	102.2	1230.6
Ropar	53.6	(-) 25.7	90.1	(-) 41.4	3.1	350.0
Ludhiana	29.8	(-) 88.4	15.1	(-) 72.2	56.8	48.0
Patiala	(-) 3.9	(-) 39.0	(-) 37.5	(-) 84.0	(-) 32.1	(-) 179.4

increased due to the development of irrigation facilities and other inputs in the state during the period TE 1952/53 to TE 1966/67. Profitability plays a major role in the adoption of any enterprise/crop and this has proved true in the case of Punjab agriculture. As is clearly indicated by the results pertaining to the second period (TE 1967/68 to TE 1986/87), there was a major shift in area in favour of rice in five out of eight maize growing districts selected for the present study. There was an increase in area under maize in Jalandhar, Hoshiarpur and Ropar districts over this period.

The overall scenario clearly indicates that rice and wheat were the major gainers as far as shift in area was concerned. It can be seen from Table 2 that area under maize has declined substantially during the period TE 1986/87 to TE 1998/99. This area was allocated to rice crop, as it was more remunerative compared to maize crop. An overview of the analysis shows that rice and wheat were the major gainers at the cost of other crops like oilseeds, cotton, sugarcane, etc. On the whole, maize lost the ground in terms of its share in gross cropped area in the state and was substituted by other relatively profitable crops.

Maize Acreage

The perusal of Table 3 reveals that area under maize during the TE 1952/53 was 254.7 thousand hectares, which increased during the TE 1966-67 in Punjab. Thereafter, the area declined in TE 1986/87 and then to as low as 161.7 thousand hectares in TE 1998/99. This shows that with the advent of high yielding varieties of rice along with the development of other inputs, the area under maize has been declining substantially after TE 1966/67. The highest maize acreage figure was 64 thousand hectares in Hoshiarpur district and the lowest figure stood at 7.7 thousand hectares in Kapurthala district during the TE 1952/53. The area under maize has registered an increase in all the major maize growing districts in TE 1966/67 over TE 1952/53.

The maize acreage varies between 13.7 (Kapurthala district) to 68 thousand hectares (Hoshiarpur district) during the TE 1966/67. There was an overall decline in area under maize during the TE 1986/87 for all the selected maize growing districts except for Hoshiarpur district, where it registered an upward trend. However, during the TE 1998/99 there was further decline in area for maize growing districts in Punjab. The highest area under maize was recoded in Hoshiarpur district (63.3 thousand hectares) and the lowest in Kapurthala district (4 thousand hectares).

Table 3: Status of maize acreage in the major maize growing districts of Punjab, 1952/53 to 1998/99.

Districts	Acreage (000'ha)			
	TE 1952/53	TE 1966/67	TE 1986/87	TE 1998/99
Gurdaspur	22.3	29.3	20.7	14.3
Amritsar	27.3	39.7	14.3	6.7
Kapurthala	7.7	13.7	6.7	4.0
Jalandhar	31.0	59.7	59.3	14.3
Hoshiarpur	64.0	68.0	80.0	63.3
Ropar	–	29.0	36.3	27.0
Ludhiana	26.7	54.7	28.7	3.3
Patiala	33.7	36.3	13.7	8.3
Punjab	254.7	399.7	284.0	161.7

Maize Yield

The results presented in Table 4 reveal that there was continuous increase in productivity of maize in Punjab during the study period. The yield of maize has shown an upward trend in all the major maize growing districts of Punjab during the study period.

An inter district comparison clearly shows that the yield of maize was highest in Kapurthala district (1555.6 kg/ha) and lowest in Hoshiarpur district (662.1 kg/ha) during the TE 1952/53. The higher yield in the former district could be attributed to better quality of land as compared to the latter, where crop was taken on the marginal land, with heavy dependence on rainfall.

The results reveal that the yield of maize increased further during the TE 1966/67. During this triennium, Ludhiana district leads with 2159.5 kg/ha. The lowest

Table 4: Status of maize yield in the major maize growing districts of Punjab, 1952/53 to 1998/99.

Districts	Yield kg/ha			
	TE 1952/53	TE 1966/67	TE 1986/87	TE 1998/99
Gurdaspur	836.8	1056.3	1730.5	1796.8
Amritsar	1152.1	1314.0	2167.4	2301.6
Kapurthala	1555.6	1313.2	2222.2	2583.3
Jalandhar	1401.0	1885.7	2064.4	2605.1
Hoshiarpur	662.1	1503.2	1622.1	2183.4
Ropar	–	–	1790.1	1892.0
Ludhiana	1151.1	2159.5	1994.4	2833.3
Patiala	852.9	1258.6	1725.3	2099.7
Punjab	990.7	1539.9	1819.3	2180.1

figure (1258.6 kg/ha) was recorded for the Patiala district during the TE 1966/67. It was encouraging to note that the yield of maize increased over the period 1966/67 to 1986/87. The yield of maize continued to show improvement even during the nineties. The highest figures were found to be 2222.2 and 2833.3 kg/ha during the TE 1986/87 and TE 1998/99, respectively. From all these, it is clear that there has been spectacular increase in the productivity of maize during the last five decades. This continuous surge in the yield of maize across the districts of Punjab seems mainly due to the extensive research efforts put in the development of improved and highbred maize in the state.

Maize Production

The results pertaining to the maize production bear testimony to the fact that in spite of ever increasing productivity levels, the production has decreased due to continuous fall in the area under maize. The results clearly exhibit that the production did increase from 251 to 616.3 thousand tonnes from the TE 1952/53 to TE 1966/67, which was made possible by the improvement in the maize productivity coupled with augmentation of area under maize during this period at the state level (Table 5).

Table 5: Status of maize production in selected districts of Punjab during the period 1952/53 to 1998-99.

Districts	Production, 000 t			
	TE 1952/53	TE 1966/67	TE 1986/87	TE 1998/99
Gurdaspur	18.0	31.0	36.0	25.7
Amritsar	32.0	52.3	31.0	15.3
Kapurthala	11.3	180	14.7	10.3
Jalandhar	42.7	110.3	124.0	37.3
Hoshiarpur	42.3	103.7	129.7	138.3
Ropar		41.0	65.3	51.0
Ludhiana	30.3	119.7	56.0	9.3
Patiala	28.7	46.3	23.7	17.3
Punjab	251.0	616.3	519.3	352.0

The production data pertaining to the period after the mid-seventies showed a persistent decline. The maize production in the state declined to 519.3 thousand tonnes in the TE 1986/87 from 616.3 thousand tonnes in the TE 1966/67 in spite of the perceptible increase in the yield. Similar results were noticed during the TE 1998/99 when the production declined to 352 thousand tonnes compared to 519.3 thousand tonnes in the TE 1986/87 (Table 5). The decline in maize production could be attributed to the higher profitability of the competing crop, namely rice, because profitability of rice was appreciably higher as compared to maize, due to both productivity and price of rice being significantly higher than for maize.

Growth Performance of Maize

The area under maize has shown an upward trend during the period 1950/51 to 1965/66 both at the state level as well as in the major maize growing districts of Punjab. This happened because rice was cultivated on less area, as it requires more irrigation water compared to the maize, and the irrigation facilities were not so developed in the state at that time.

However, for the period 1966/67 to 1985/86, statistically significant compound growth rates (CGRs) were found in the Hoshiarpur (0.57 per cent) district. The CGRs were found to be negative and significant statistically in the remaining maize growing districts in the state, except Ropar, where it turned out to be non-significant statistically. Similarly the CGRs were found negative in all the districts for the period 1986/87 to 1998/99. These CGRs relating to area under maize were highly significant in the above period. There was a persistent decline in area under maize during the post Green Revolution period because the attention shifted to the cultivation of wheat and rice in the state.

There was a persistent decline in area under maize during the post Green Revolution period.

The productivity of maize has shown an all-round improvement in all the major maize growing districts of Punjab except Kapurthala during 1950/51 to 1965/66 and Ludhiana district during the period 1966/67 to 1985/86 (Table 6). This improvement could not help boost the cultivation of maize in the state on a large scale due to its lower profitability as compared to rice. The results pertaining to maize production show that there was an erratic trend during the period 1950/51 to 1965/66. The CGR for the state as a whole for the period 1950/51 to 1965/66 showed that production increased at a statistically significant rate of 5.81 per cent annually during the period. The CGRs of maize production during the period 1966/67 to 1985/86 were positive only in the case of Jalandhar, Hoshiarpur and Ropar districts.

The production of maize increased at an annual compound growth rate of 1.93 and 2.21 per cent in Hoshiarpur and Ropar districts, respectively. The CGR

Table 6: Growth performance of maize in Punjab, 1950/51 to 1998/99.

Districts	Time period		
	1950/51 - 1965/66	1966/67 - 1985/86	1986/87 - 1998/99
		Acreage	
Gurdaspur	0.88^{NS}	-3.60**	-2.96***
Amritsar	3.04***	-6.48**	-6.22***
Kapurthala	4.70***	-4.82**	-3.03***
Jalandhar	4.27***	-1.26**	-11.24***
Hoshiarpur	0.98**	0.57**	-2.27***
Ropar	-	0.48^{NS}	-2.48***
Ludhiana	5.17***	-4.18***	-16.17***
Patiala	0.38^{NS}	-6.18***	-4.45***
Punjab	3.13***	-3.31***	-4.19***
		Yield	
Gurdaspur	2.26^{NS}	1.91^{NS}	1.63^{NS}
Amritsar	0.58^{NS}	1.78^{NS}	1.38^{NS}
Kapurthala	-3.48**	2.03***	5.65**
Jalandhar	2.02***	1.41***	2.83**
Hoshiarpur	6.40***	1.35**	3.29***
Ropar	-	1.72**	3.08**
Ludhiana	3.42**	-0.93**	3.16**
Patiala	1.17	-0.47^{NS}	1.19^{NS}
Punjab	2.60**	0.74**	2.48**
		Production	
Gurdaspur	3.16^{NS}	-1.76^{NS}	-1.38^{NS}
Amritsar	3.64**	-4.81***	-4.92***
Kapurthala	1.05^{NS}	-2.89***	2.44^{NS}
Jalandhar	6.38***	0.14^{NS}	-8.73***
Hoshiarpur	7.44***	1.93***	0.95^{NS}
Ropar	-	2.21***	0.52^{NS}
Ludhiana	8.76***	-5.07***	-13.52***
Patiala	1.56^{NS}	-6.62***	-3.31**
Punjab	5.81***	-2.59***	-1.82**

*** and ** Significant at 0.01 and 0.05 per cent.
NS: Non-significant.

were found to be significant statistically. The loss in production was highest in Patiala district (-6.62 per cent), followed by Ludhiana (-5.9 per cent), Amritsar (-4.81 per cent), Kapurthala (-2.89 per cent) and Gurdaspur (-1.76 per cent), respectively, during the period 1966/67 to 1985/86. The CGRs were found to be significant statistically in all the districts except Gurdaspur. The rate of growth had even declined during 1966/67 to 1985/86 for the Jalandhar and Hoshiarpur districts as compared to the preceding period (1950/51 to 1966/67). The production of maize registered a fall in all the districts except Hoshiarpur and Ropar during the period 1986/87 to 1998/99. It is interesting to note that production in these districts declined too in comparison to the preceding period (Table 6).

The CGRs for area, yield and production were found to be 3.13, 2.60 and 5.81 per cent annum, respectively, for the period 1950/51 to 1965/66 in the state. The corresponding figures for the period 1965/66 to 1985/86 were estimated to be -3.31, 0.74 and -2.59 per cent, respectively. A similar trend was observed during the period 1986/87 to 1998/99. All these CGRs were found to be significant statistically. This shows that the positive yield effect was more than offset by the negative area effect on the production during the study period.

Decomposition of Maize Production

The decomposition of maize production is presented in Table 7. The results clearly show that area remained a major contributor to the increased production of maize in the period 1950/51 to 1965/66 in all the maize growing districts, except Hoshiarpur, in Punjab. The yield effect contributed to increasing production in all the districts except Kapurthala district. The interaction effect in this district was also found to be negative (-13.8 per cent). However, both the negative yield and interaction effects were more than compensated by strong positive area effect in the case of Kapurthala district.

The results pertaining to the decomposition of maize production for the period 1966/67 to 1985/86 indicate that yield remained a major contributor to the increased production in all the major maize growing districts of Punjab except Ludhiana. It was found that in the case of Hoshiarpur and Ropar districts, area effect, yield effect and interaction effect were contributing positively towards increased production. In the remaining districts, the strong negative effects of the area and interaction of area and yield, except Jalandhar, nullified the positive effect of the yield on production. In Jalandhar district, the strong positive yield effect nullified the negative effects of area and interaction on production during the TE 1986/87 over TE 1966/67 (Table 7).

The study of the production profile of maize for the period 1966/67 to 1985/86 reveals that maize production increased in four selected districts viz. Gurdaspur,

Jalandhar, Hoshiarpur and Ropar. In the case of Gurdaspur and Jalandhar districts, the yield effect was quite strong so as to offset the negative area effect and bring about increase in production. The districts where the production has been found to decline are Amritsar, Ludhiana and Patiala. It is only in the case of Ludhiana district that the yield effect has come out to be negative in the period 1966/67 to 1985/86.

Table 7: Decomposition of maize production in Punjab, 1950/51 to 1998/99.

Districts	Area Effect	Yield Effect	Interaction Effect	Increase (+)/ Decline (–)
		1950/51-1965/66		
Gurdaspur	43.5	43.0	13.5	+
Amritsar	71.6	19.5	8.9	+
Kapurthala	131.4	–17.7	–13.8	+
Jalandhar	58.5	21.6	20.0	+
Hoshiarpur	4.0	90.8	5.2	+
Ropar	–	–	–	–
Ludhiana	35.5	31.5	33.0	+
Patiala	12.6	81.2	6.3	+
		1966/67-1985/86		
Gurdaspur	–182.0	399.1	–117.2	+
Amritsar	–157.1	158.5	–101.4	–
Kapurthala	–278.7	365.4	–186.7	–
Jalandhar	–5.4	106.1	–0.7	+
Hoshiarpur	70.4	25.2	4.4	+
Ropar	42.5	46.0	11.6	+
Ludhiana	–89.3	–20.4	9.7	–
Patiala	–127.5	73.0	–45.4	–
		1986/87-1998/99		
Gurdaspur	–108.1	11.7	–3.6	–
Amritsar	–104.9	10.5	–5.6	–
Kapurthala	–134.6	58.0	–23.4	–
Jalandhar	–108.5	35.4	–26.9	–
Hoshiarpur	–314.8	524.3	–109.4	+
Ropar	–117.0	22.8	–5.9	–
Ludhiana	–106.1	53.3	–47.2	–
Patiala	–146.0	75.9	–29.9	–

The analysis of maize production data corresponding to the period 1986/87 to 1998/99 reveals that in all the districts except Hoshiarpur, the production has fallen. This fall in production can well be attributed to considerable negative area effect, which outweighed the positive yield effect (Table 7). From all these, it is clear that yield of maize improved in the state over time but its benefits could not be sustained due to continuous fall in the area under maize cultivation, especially during the post Green Revolution period.

Yield of maize improved in the state over time but its benefits could not be sustained due to continuous fall in the area under maize cultivation.

Acreage Response of Maize

The results corresponding to acreage response of maize presented in Table 8 show that the lagged maize area has significant positive effect on the allocation of area to maize crop during the current year in all the major maize growing districts of Punjab, except Ropar.

The results reveal that one per cent increase in previous year's acreage leads to less than one per cent increase in area allocated to maize crop in the current year in all the sample districts except Ludhiana where this coefficient indicated more than one per cent (1.036 per cent) successive increase in area. The corresponding figures for Patiala, Jalandhar, Hoshiarpur, Amritsar, Gurdaspur and Kapurthala were 0.975, 0.957, 0.733, 0.623, 0.613 and 0.524 per cent, respectively. The results further reveal that lagged relative yield of maize with respect to rice has significant positive effect on the allocation of area to maize crop in Patiala district only. The area increased by 0.237 per cent with one per cent increase in the relative yield of maize with respect to rice in the said district. The relative farm harvest price of maize with respect to rice does not have any effect on allocation of area in favour of maize as shown by the result presented in Table 8.

It is interesting to note that with one per cent increase in net irrigated area the allocation of area to maize decreased by 0.447, 2.637 and 1.617 per cent in Gurdaspur, Amritsar and Kaputhala district, respectively. This shows that with improvement in the irrigation facilities, area from maize is squeezed out in favour of rice crop. Rainfall has been found to have significant positive effect on maize acreage in the case of Gurdaspur district only. This may be due to the reason that the maize is cultivated on the marginal lands, which are dependent on rainfall. The results further reveal that relative yield and price risk of maize with respect to rice have no effect on the allocation of area to maize in all the major maize growing districts of Punjab. On the whole, all selected variables together explained more than 90 per cent of the variation

Table 8: Acreage response of maize in the selected districts of Punjab, 1967/68 to 1988/99.

Variables	Districts							
	Gurdaspur	Amritsar	Kapurthala	Jalandhar	Hoshiarpur	Ropar	Ludhiana	Patiala
Intercept	3.658	17.440	8.124	2.033	1.182	2.033	1.182	3.887
Lagged maize acreage (A_{t-1})	0.613*** (0.118)	0.623*** (0.184)	0.524*** (0,126)	0.957*** (0.096)	0.733*** (0.176)	0.211^{NS} (0.239)	1.036*** (0.038)	0.975*** (0.066)
Lagged relative yield of maize w.r.t. Rice ($RLYIELD_{t-1}$)	0.006^{NS} (0.080)	0.075^{NS} (0.102)	-0.102^{NS} (0.130)	0.023^{NS} (0.186)	0.045^{NS} (0.095)	-0.060^{NS} (0.112)	0.083^{NS} (0.073)	0.237** (0.131)
Lagged relative farm harvest price of maize w.r.t. Rice ($RLFHTP_{t-1}$)	0.271^{NS} (0.373)	0.221^{NS} (0.518)	-0.478^{NS} (0.575)	0.103^{NS} (0.571)	-0.034^{NS} (0.232)	0.315^{NS} (0.428)	0.322^{NS} (0.523)	0.172^{NS} (0.528)
Lagged net irrigated area of the district ($NIRRIA_{T-1}$)	-0.447** (0.162)	-2.637** (1.259)	-1.617*** (0.434)	$-0,350^{NS}$ (0.476)	-0.071^{NS} (0.070)	-0.155^{NS} (0.190)	-0.353^{NS} (0.309)	0.376^{NS} (0.442)
Average of two months' (May-June) rainfall (RAIN)	0.068** (0.033)	-0.046^{NS} (0.057)	0.032^{NS} (0.021)	0.054^{NS} (0.032)	0.030^{NS} (0.026)	0.036^{NS} (0.071)	0.036^{NS} (0.048)	0.011^{NS} (0.034)
Relative yield risk of maize w.r.t. Rice of the district (RLPRISK)	0.034^{NS} (0.029)	-0.009^{NS} (0.053)	0.019^{NS} (0.045)	-0.006^{NS} (0.055)	-0.015^{NS} (0.023)	0.028^{NS} (0.038)	-0.059^{NS} (0.052)	-0.035^{NS} (0.044)
R^2	0.989	0.943	0.905	0.914	0.507	0.348	0.987	0.959

Figures in parentheses are standard errors.

*** & ** Significant at 0.01 and 0.05 per cent level.

NS: Non-significant.

in maize acreage in all the selected districts, except Hoshiarpur and Ropar districts.

With improvement in the irrigation facilities, area from maize is squeezed out in favour of rice crop.

Conclusion

There was a major shift of maize areas to rice in all the maize growing districts due to higher profitability of rice as compared to maize in Punjab. There was continuous upward surge in the yield of maize, which seems to be the result of effort put in for the development of improved and highbred varieties of maize in the state. Decline in production can be attributed to a continuous decline in area under maize in spite of the increase in its productivity during the study period. The decomposition in maize production shows that yield contributed positively but its benefits could not be sustained due to continuous downward change in maize acreage especially during the post Green Revolution period. The decomposition results were found to be in conformity with the results of growth analysis in the state, which shows that yield is a major contributor to increased maize production. The lagged maize acreage has positive and significant effect on the allocation of area to maize during the current year. An increase in the net irrigated area has negative and significant effect on the allocation of area to maize in Gurdaspur, Kapurthala and Amritsar districts. This shows that with improvement in the irrigation facilities, farmers were inclined to cultivate rice instead of maize. The lagged farm harvest prices, relative yields and price risk of maize with respect to rice have no effect on the allocation of area to maize in all the major maize growing districts of Punjab. It seems that the lack of technology (especially HYVs of maize) has caused a decline in the maize acreage over a period of time, thus there is need to put concerted effort to develop HYVs of maize so that it can compete with rice.

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Feature

Oilseeds Production in India

Shrikant S. Kalamkar

India is one of the leading oilseed producing countries in the world. However, the productivity of oilseed crops in India is one of the lowest in the world, except in the case of castor. Achieving self-reliance in oilseed assumes paramount importance. To increase production and decrease the productivity gap, efforts are needed to raise productivity through adoption of improved technology with effective extension, education and research efforts to develop disease resistance high yielding varieties, suitable to the agro-climatic conditions of the region.

Shrikant S. Kalamkar is a faculty member of Gokhale Institute of Politics and Economics, Pune.

Oilseeds, the second largest agricultural commodity after cereals in India, play a significant role in India's agrarian economy, sharing 14 per cent of the gross cropped area and accounting for nearly five per cent of gross national product and 10 per cent of the value of all agricultural products (Mandal et al, 2002). Being employment intensive, about 14 million persons are engaged in the production of oilseeds and another one million in the oilseed processing industry. The edible oil industry is one of the most vibrant sectors of the Indian agriculture economy with an annual turnover of Rs. 60,000 crores. In the global scenario, with 19 per cent of world's area and ten per cent of world's production, India is one of the leading oilseed producing countries in the world (DOR, 1999). India is the fourth largest producer of oilseeds in terms of output and second in terms of area under oilseed. India ranks first in the world in the production of castor, safflower and sesame and it is the second largest producer of groundnut and rapeseed mustard and ranks third in linseed and fifth in soybean and sunflower (Hegde, 2002).

India is blessed with diverse agro-ecological conditions ideally suited for growing nine annual oilseed crops. The production of oilseeds increased from 5.90 million tonnes in the 1950s to 21.35 million tonnes in the 1990s (Table 1). The yields of oilseeds almost doubled during the last four decades. The vegetable oil consumption in the country is continually rising and has sharply increased in the last couple of years touching roughly 12.4 kg/head/year. This is still lower than the World average consumption of 17.8 kg and that in neighbouring countries like Pakistan (16.1 kg). The oilseed scenario in India has undergone a dramatic change in the last fifteen years with the setting up of the Technology Mission on Oilseeds (TMO) in May, 1986. In the span of the decade from 1985-86, oilseed production increased to more than double. The main contributing factors have been availability of production technology and its proper use, expansion of cultivated areas, price support policies and institutional support through oilseed missions. But the tempo could not be sustained because large-scale cultivation of oilseeds

takes place in rainfed conditions. Of late, the country had to import over 4 mt of edible oil costing over Rs. 9000 crores annually, which points to continuing lack of self sufficiency in spite of impressive domestic production increases. In the last couple of years, oilseed production has declined with the production of just 18.2 million tonnes during 2000-01 against a target of 28 million tonnes, which is the lowest in the last decade. The production is a short fall to the previous year's (1999-2000) figure of 20.9 million tonnes. In the post liberalization period, large-scale imports of oils also discouraged growth in area. The growth rates in area, production and productivity of oilseeds, which were much higher than other crops during the 1980s, were drastically reduced during the 1990s.

Table 1: Decadal trends in area, production, yield of oilseeds in India-Averages

Year	Area (million ha)	Production (million tonnes)	Yield (kg/ha)
1	2	3	4
1950s	12.13	5.90	486
1960s	14.92	7.31	490
1970s	16.91	9.19	543
1980s	19.44	12.68	652
1990s	22.65	21.35	832
2000-01	23.25	18.40	791
2001-02*	23.32	21.16	907

*Advance estimates

Source: Directorate of Economics and Statistics, Ministry of Agriculture, GOI,

Availability of Edible Oils

The situation of the oilseed sector in the country is perplexing, with a sluggish and erratic growth in the production of oilseeds in the face of a relatively higher growth of population. There has been a considerable increase in the production of oilseeds in the past, due to the commitment and dedication of oilseed research workers coupled with the high integrated Mission Mode and time bound approach of the government through TMO. The unprecedented response of farmers resulted in the 'Yellow Revolution', but present production is short of demand due to increase in population. This has resulted in gap between demand and supply and has necessitated a large-scale import of edible oils causing depletion in foreign exchange reserves (Table 2). The share of imports, which was around 4 per cent in the early 1990s, went up to around 30 per cent of the total available oil in the late nineties (Kajale, 2002). The demand for edible oils being highly income and price elastic, the increase in population coupled with rise in income levels have led to demand growth at a little over 6 per cent per annum in the last couple of years. As per NCAER projections, the per capita consumption of edible oils by 2009-2010 is likely to be 13.95, 14.83 and 16.17 kg, if the per capita income grows by 4, 5 and 6 per cent, respectively. This will be equivalent to the oil demand of 174, 190 and 207 lakh tonnes and oilseeds requirement of roughly 51, 56 and 61 million tonnes, respectively. The country may require anywhere from 51 to 60 million tonnes of oilseeds by 2009-2010. This means that we have to increase our oilseed production by almost 150 to 200 per cent. (Hegde, 2002).

Gap between demand and supply has necessitated a large-scale import of edible oils causing depletion in foreign exchange reserves.

Table 2: Production, imports and availability of edible oils (lakh tonnes)

Year	Estimated production of seeds	Domestic availability of oil	Demand for oil	Gap (Col.4-Col. 5)	Imports
1	2	3	4	5	6
1994-95	213.40	62.54	69.80	7.26	10.00
1995-96	221.10	64.28	72.54	8.26	14.00
1996-97	283.80	70.89	75.32	4.43	17.50
1997-98	220.20	62.00	78.16	16.16	20.80
1998-99	256.80	72.60	91.99	19.39	23.79
1999-00	208.70	63.64	116.00	52.36	44.90
2000-01	182.00	53.06	N.A.	–	48.30

Source: GOI, 2000

Therefore, it is necessary to examine the oilseed economy of India in order to explore the possibility of enhancing their production and productivity so that the minimum requirement could be ensured to the growing population of the country. In this study, an attempt has been made to analyse the growth and instability in area, production and productivity of nine oilseed crops encompassing the period from 1950-2000.

Data and Methodology

The data on area, production and productivity of oilseed crops were collected from various issues of Agricultural Statistics at a Glance and Oilseed Situation in India 1999, Govt. of India publications. The study pertains to the period from 1950-51 to 1999-2000. The en-

tire study period was split into four sub periods to evaluate the impact of new production technology on growth in area and production and to assess the changes in relative contribution of different factors to the output growth. The sub periods formed were as below (Kalamkar et al, 2002; Kiresur et al, 2001).

Period I:	1950-51 to 1964-65	Pre-green revolution period
Period II:	1965-66 to 1979-80	Green revolution period
Period III:	1980-81 to 1999-2000	Post green revolution period
Period IV:	1986-87 to 1999-2000	Post TMO period
Overall:	1950-51 to 1999-2000	Overall period

The compound growth rates of area, production and yield for oilseed crops for each period were estimated to study the growth in area, production and yield of these crops. Triennium ending average of the above variables was worked out. Compound growth rates were estimated with the following exponential model.

$$Y = a\, b^t$$

$$C.G.R.\ (r) = [\text{Antilog } b\text{-}1] \times 100$$

The 't' test was applied to test significance of 'b'

To measure the instability in area, production and productivity, coefficient of variation (C.V.) was worked out.

$$CVt = \frac{\delta\ (\text{Standard deviation})}{\bar{x}\ (\text{Mean value})} \times 100$$

In order to measure the relative contribution of area, yield and their interaction to production, decomposition technique has been adopted. Minhas (1964) component analysis redeveloped by Narula and Vidyasagar (1973) and Sharma (1977) and several research workers, used this model and studied growth performance on state level viz. Mundinami et al, (1995), Gupta and Saraswat (1997).

Let Po and Pn be the production in the base year and nth year respectively. They are given by

$$Po = Ao \times Yo \text{ and } Pn = An \times Yn \quad ...(I)$$

Where Ao and An represent the area and Yo and Yn represent the yield in the base year and nth year respectively

$$Pn - Po = \Delta P,\ An - Ao = \Delta A,\ Yn - Yo = \Delta Y \quad ..(II)$$

from equation I and II we can write

$$\Delta P = Ao\,\Delta Y + Yo\,\Delta A + \Delta A\,\Delta Y$$

Production = Yield effect + Area effect + Interaction effect.

Thus the total change in production can be decomposed into three effects viz. yield effect, area effect and the interaction effect due to change in yield and area.

Results and Discussion

Growth trend

The compound growth rates of area, production and productivity of individual and total oilseed crops is given in Table 3. It could be seen from the table that during the overall period of study, the area under total oilseeds increased significantly at the rate of 1.74 per cent per annum. Mostly all oilseed crops recorded significant increase in area. Soybean crop recorded highest tremendous growth of 19.46 per cent followed by sunflower, rapeseed-mustard, safflower, castor, groundnut and niger. However, area under sesamum and linseed declined at the rate of 0.34 and 1.32 per cent per annum. Inter period comparison revealed that, during pre green revolution period (period I), area under total oilseed crops increased significantly at a higher rate of growth of 2.59 per cent per annum compared to other periods. Except castor, all other oilseed crops recorded increase in area as evident from positive growth rates. Area under groundnut crop increased significantly with the magnitude of 3.77 per cent per annum followed by linseed and rapeseed-mustard. There was significant decline in area of castor. During the second period of study, area under groundnut and sesamum registered a decline. Soybean crop recorded highest increase in area at 31.76 per cent per annum followed by safflower (3.03) and rapeseed-mustard (1.23), whereas remaining crop area were almost stagnant/declined in second period. During third period of study, area under rapeseed-mustard, soybean, sunflower (3.03) and rapeseed-mustard (1.23), where as remaining crop area were almost stagnant/declined in second period. During third period of study, area under rapeseed-mustard, soybean, sunflower and castor increased at the rate of 3.51, 12.10, 3.66 and 1.81 per cent annum, respectively. Soybean crop again recorded highest growth rate as

Table 3: Compound growth rates of area, production and productivity of nine oilseed crops in India. (Per cent)

Crop	Period I			Period II			Period III			Period IV			Overall		
	A	P	Y	A	P	Y	A	P	Y	A	P	Y	A	P	Y
Total Oilseed	2.59**	3.50**	0.91	1.09**	2.64*	1.54*	2.06**	4.63**	2.57**	2.43**	5.02**	2.59**	1.74**	3.10**	1.36**
Groundnut	3.77**	4.28**	0.50	–0.22	1.95*	2.17**	–0.54	0.52	1.07	0.29	1.68*	1.38*	0.80**	1.59**	0.79**
Rapeseed-mustard	2.81**	3.43**	0.61	1.23**	1.84	0.61	3.51**	4.37**	0.86	3.44**	5.79**	2.34**	2.20**	4.25**	2.00**
Soybean	–	–	–	31.76**	37.49**	5.73	12.10**	16.38**	4.28**	13.68**	16.53**	2.85**	19.46**	21.11**	1.64**
Sesamum	0.01	1.11	–1.12	–0.84*	0.07	0.92	–2.61**	–0.42	2.19**	–1.54**	1.09	2.65**	–0.34**	0.88**	1.22**
Sunflower	–	–	–	0.93	–2.14	–3.08	3.66**	7.27**	3.61**	10.88**	12.40**	2.55**	11.51**	11.07**	–0.44
Linseed	3.28**	1.71	–1.58*	1.15	2.04	0.88**	–3.38**	–2.43**	0.95	–4.23**	–2.80**	0.14**	–1.32**	–0.57**	0.74**
Niger	–	–	–	2.12**	3.28**	1.15	–1.13**	0.02	1.15	–0.33	0.79	1.13**	0.53**	2.05**	1.51**
Castor	–1.75**	–0.30	1.44**	0.69	6.45**	5.75**	1.81**	9.60**	7.79**	1.68**	7.14**	5.46**	0.86**	4.84**	3.98**
Safflower	–	–	–	3.03**	9.47**	6.44**	–3.65**	–3.49	0.15	–1.86**	–2.25**	–0.39	0.89*	4.27**	3.38**

*Significance at 5 per cent level, **Significance at 1 per cent level.

For Soybean and Sunflower - Period II: 1970-71 to 1979-80, overall 1970-71 to 1999-2000

compared to others. Area under linseed, sesamum and safflower decrease significantly. During fourth period of study i.e. post TMO period, sunflower crop recorded tremendous increase in area as compared to other periods whereas, the area under sesamum, linseed, niger and safflower decreased at the rate of 1.54, 4.23, 0.33 and 1.86 per cent per annum. The positive effect of TMO has been seen only in the case of sunflower and groundnut crops.

Table 3 presents the growth rate of production of total oilseeds and individual oilseed crops in the country over a period of time. It is revealed from the table that during the overall period of study, production of total oilseeds crop increased significantly at the rate of 3.10 per cent per annum. During the overall period, all oilseed crops recorded increase in production except linseed. Production of soybean crop registered highest rate of growth of 21.11 per cent per annum followed by sunflower and rapeseed-mustard. The increase in production of soybean may be due to increase in area. Inter period comparison revealed that during the first period of study, production of total oilseed crop increased significantly at the rate of 3.50 per cent per annum which may be due to expansion in area. Production of groundnut and rapeseed-mustard increased significantly with magnitude of 4.28 and 3.43 per cent respectively, whereas sesamum and castor production declined. During the second period of study, except sunflower, all other crops recorded increase in production, in which soybean crop registered the highest rate of growth of 37.49 per cent per annum, followed by safflower. During the third period of study, production of linseed, sesamum and safflower decreased as evident from the negative growth rates whereas all other crops recorded increase in production. Highest growth recorded by Soybean crop was of 16.38 per cent per annum. Sunflower crop recorded impact of TMO as evident from its positive significant high growth (12.40 per cent) which was much more than any other oilseed crop. It may be due to significant increase in area under this crop. Except linseed and safflower, all other crops recorded significant increase in production in the post TMO period.

Sunflower crop recorded impact of TMO as evident from its positive significant high growth.

The growth in yield of nine oilseed crops is presented in Table 3. It is observed from the table that during the overall period of study, productivity of total oilseed crop increased significantly at the rate of 1.36 per cent per annum. Inter-crop comparison revealed that during the overall period, except sunflower, all other oilseed crops recorded growth in productivity. Castor crop recorded highest growth of 3.98 per cent followed by safflower, rapeseed-mustard, niger, soybean and sesamum. Inter-period comparison revealed that castor crop recorded significant increase of 1.44 per cent in first period of study while other crops were either constant or decreased in productivity. During the second period of study, productivity of all oilseed crops increased except sunflower. Castor recorded a remarkable increase of

Table 4: Coefficient of variation for area, production and productivity of nine oilseed crops in India.

Crop	Period I			Period II			Period III			Period IV			Overall		
	A	P	Y	A	P	Y	A	P	Y	A	P	Y	A	P	Y
Total Oilseed	12.03	16.68	7.78	6.48	15.89	11.10	15.31	29.87	16.68	10.40	20.08	12.30	26.65	51.77	24.21
Groundnut	17.43	19.97	8.15	2.66	15.06	14.67	8.27	19.40	15.39	8.57	16.40	13.72	14.34	27.46	17.66
Rapeseed-mustard	13.89	20.71	12.63	7.80	17.49	13.59	[illegible]			[illegible]			[illegible]		
Soybean	-	-	-	[illegible]		28.22	68.42	82.05	20.25	[illegible]			[illegible]	[illegible]	22.98
Sesamum	7.33	16.98	11,95	6.54	12.64	13.92	12.82	16.70	18.00	14.13	15.72	13.88	10.25	21.82	25.68
Sunflower	–	–	–	47.46	51.15	11.69	50.88	58.49	16.95	25.55	34.04	17.50	81.56	86.06	16.94
Linseed	16.99	14.44	12.15	10.40	23.72	15.44	27.10	18.88	11.12	15.49	13.29	8.63	27.48	22.52	17.54
Niger	–	–	–	12.01	20.76	13.58	6.41	12.88	10.32	5.99	10.68	9.11	10.25	24.47	18.22
Castor	9.84	9.03	9.15	13.67	30.98	28.24	14.01	43.56	35.52	13.02	35.76	30.94	21.65	84.84	64.64
Safflower	–	–	–	16.01	43.32	31.09	18.02	27.00	21.33	20.47	30.42	23.95	20.96	50.16	39.50

For Soybean and Sunflower – Period II: 1970-71 to 1970-71 to 1999-2000

6.44 per cent while sunflower productivity declined drastically at the rate of 3.08 per cent. During the third period of study, all crops recorded increase in productivity in which soybean crop for the first time recorded a higher rate of growth of 4.28 per cent. After TMO, except safflower, all oilseed crops registered significant increase in productivity. Steeper decrease in production than in area resulted in the decrease in productivity of safflower.

Variability in Area, Production and Productivity

With a view to determine the degree of variability over time in area, production and productivity of nine oilseed crops; an attempt was made through the coefficient of variation. The results are presented in Table 4. The coefficient of variation in area, production and productivity were estimated to be 26.25, 51.77 and 24.21 per cent for total oilseeds crop. For individual crops, it ranged between 10.25 to 105.18 per cent. The variability was found to be more in production as compared to area and yield. However, variability in area and yield was highest in case of linseed and sesamum, respectively. Inter period comparison revealed that all the crops recorded highest variability in production except soybean in the second period and linseed in the first, third and fourth period. This may be because oilseeds are generally grown on marginal and dry and rainfed land. The crop yield variability in general was the highest in dry farming areas due to poor managerial ability and poor resource base and it was lowest in the assured irrigated area. The oilseeds are generally grown on rainfed areas, therefore area, production and productivity of oilseed crops are affected by the amount and distribution of rainfall.

Components of Change in Production

The relative contribution of area, yield and their interaction to changes in production of individual crops as well as total oilseeds are presented in Table 5. With regard to the change in total oilseeds production during the overall period, a significant increase in production of total oilseeds was noticed which was mainly due to expansion in area (36.35 per cent) followed by near about same contribution of interaction effect of area and productivity (35.82) and lastly the increase in productivity (27.83 per cent). Inter period comparison revealed that during the first period of study, area was the main factor in increasing production of total oilseeds crop, contributing 64.04 per cent followed by productivity (26.59 per cent). However in all other periods, increase in production of total oilseed was mainly due to increase in productivity which ranged from 44.58 to 56.54 per cent, followed by area ranging from 36.12 to 37.42 per cent. The interaction effect contributed significantly in the third period only. Among the various crops, except linseed crop, all other oilseed crops recorded increase in production over a period of time. The production of groundnut, increased mainly due to 39.55 per cent of area and remaining by yield (3.86 per cent) and their interaction (20.58 per cent). The area was the major factor in increasing production of soybean, contributing 51.60 per cent while contribution of yield was negligible. Thus, contribution of area has a major role in increasing production of groundnut, soybean and sunflower. Production of linseed decreased due to negative contribution of area (148.21 per cent) and interaction effect (35.22 per cent). However, though productivity effect was much higher (84.43 per cent), it could not offset the negative effect of area and their interaction. These

results are supported by the growth rates for that crop. The production of rapeseed-mustard was increased mainly due to interaction effect (41.148 per cent), followed by area and yield effect.

During pre-green revolution period, there was significant increase in the production of all the oilseed crops except castor. In this period, the area effect was the major force of output growth of all the oilseed crops. During the green revolution period, increase in the production of groundnut, sesamum, castor and safflower was mainly due to productivity growth. The yield effect contributed as high as 256.64 per cent towards rise in sesamum output. The area effect was mainly responsible for the output growth of rapeseed-mustard, soybean, sunflower, linseed and niger accounting from 47.48 to 75.78 per cent to increase in total output growth for these crops. Though production of sunflower during the green revolution period was influenced by the negative growth in productivity with their share at 95.22 per cent, however, area effect had a positive bearing on production. During the third period, except linseed and safflower, other oilseed crops recorded increment in production. The area expansion was comparatively more instrumental in increasing the production of rapeseed-mustard, soybean and sunflower, while yield was the major force in increasing groundnut, sesamum, niger and castor production. Linseed production had declined which is evidenced by negative effect of area (126.51 per cent) and interaction (27.22 per cent), however, the productivity of this crop had increased during this period. The growth rates of these crops supported the results. During the fourth period of study i.e. after 1986-87 TMO period, it is observed that as we have seen in growth rates, the production of linseed and safflower recorded decline due to negative growth of area in both crops. All other crops recorded significant increase in production. The area expansion was mainly responsible for increase in production of rapeseed-mustard and soybean, contributing 95.04 and 55.1 per cent. The productivity growth was instrumental in increasing the production of groundnut, sesamum, sunflower, niger and castor. In case of groundnut, yield effect was so high that it offset the negative effect of area and interaction. Sunflower crop also recorded a significant positive contribution of productivity after negative contribution in second period. It means that TMO succeeded in increasing the productivity of only these two crops.

Table 5: Percentage contribution of area, productivity and their interaction towards increasing production of oilseed crops (per cent)

Crop	Effect	Period I	Period II	Period III	Period IV	Overall Period
Total Oilseed	Area	64.05	36.42	36.12	43.54	36.35
	Prodty.	26.59	56.54	45.13	44.58	27.83
	Inter-action.	09.36	7.05	18.76	11.88	35.82
Ground-nut	Area	73.34	–11.43	1.69	–103.83	39.55
	Prodty.	17.58	114.80	97.87	211.54	30.86
	Inter-action.	9.08	–3.37	0.44	–7.70	20.58
Rapeseed-mustard	Area	85.19	75.48	45.66	95.04	38.16
	Prodty.	10.73	21.13	34.12	3.33	20.70
	Inter-action.	4.09	3.39	20.21	1.64	41.14
Soybean	Area	–	72.56	60.28	55.61	51.60
	Prodty.	–	2.70	3.99	11.55	0.26
	Inter-action.	–	24.74	35.73	32.84	48.14
Sesa-mum	Area	167.78	–131.46	–354.03	–13175.62	–97.75
	Prodty.	–63.55	256.64	635.32	17287.80	265.43
	Inter-action.	–4.23	–25.19	–181.31	–3982.18	–67.68
Sunflower	Area	–	239.16	88.64	34.60	112.15
	Prodty.	–	–95.22	1.84	46.44	–0.80
	Inter-action.	–	–43.95	9.52	18.96	–11.35
Linseed	Area	194.89	49.64	–126.51	–109.82	–149.21
	Prodty.	–66.20	44.05	53.74	14.25	84.43
	Inter-action.	–28.69	6.31	–27.22	–4.43	–35.22
Niger	Area	–	47.48	–31.09	–7988.57	12.89
	Prodty.	–	42.65	137.62	9135.40	70.82
	Inter-action.	–	9.86	–6.53	–1046.83	8.30
Castor	Area	–750.45	1.31	14.83	12.27	3.64
	Prodty.	780.63	97.21	66.77	71.00	77.24
	Inter-action.	–130.18	1.48	18.41	16.73	19.11
Safflower	Area	–	22.79	–61.77	–86.61	8.10
	Prodty.	–	52.33	–50.11	–21.53	77.77
	Inter-action.	–	24.88	11.89	8.13	14.13

Productivity Gap

With the stagnant or declining production on the one hand and increasing consumption on the other, the supply-demand gap is witnessed significantly over the years which were met through imports. As against 97 per cent self sufficiency achieved in 1992-93, only about 54 per cent of consumption requirements are now

(2001) being met from indigenous sources and rest is met by imports. International comparison reveals a wide gap in India's performance between achievement in output and productivity. While India compares favourably in terms of total output, it compares poorly in terms of yield per hectare. India ranks first in output of groundnut but lagged on 65th position in respect of yield (Kalirajan and Shand, 1997). Except castor, we are too much lagged behind in the average productivity of other oilseed crops as compared to world figures (Table 6). The linseed, soybean, sunflower and rapeseed-mustard crop productivity is less to the extent of 40 to 60 per cent and of groundnut and sesamum, it is 15 to 32 per cent of world average productivity. During 2000-2001, the world production of 10 major oilseeds was estimated at 3,069 lakh tonnes. The production of 10 major oilseeds in India was estimated at 207.9 lakh tonnes, of which the production of soybean was estimated at 48 lakh tonnes compared to the world production of 1,711 lakh tonnes. The average yield of 10 major oilseeds during the current year is estimated at 0.63 tonnes per hectare for India while the world average yield is 1.5 tonnes per hectare, with Brazil is topping the chart at 2.54 tonnes per hectare.

Table 6: Productivity of oilseed crops in India as compared to World (kg/ha)

Crop	India	World	Highest producing country
Groundnut	913	1336	6075 (Israel)
Rapeseed-mustard	875	1543	6667 (Algeria)
Soybean	1008	2148	3571 (Ethiopia)
Sunflower	556	1247	2858 (Switzerland)
Sesamum	332	389	1175 (Egypt)
Castor	1261	1014	1221 (India)
Sunflower	606	846	2250 (China)
Linseed	344	858	2136 (Tunisia)

Source: The Hindu Survey of Indian Agriculture 2002

Conclusions and Policy Implications

From the above discussion we may conclude that all oilseed crops recorded growth in area in the country over a period of time, except sesamum and linseed. There was a significant increase in the production and productivity of total oilseeds as well as oilseed crops except linseed and sunflower, respectively. There was mixed trend in growth in area, production and productivity of oilseed crops during the green revolution and post green revolution period. The variability was found to be more in production as compared to area and yield. The growth in the production of castor, niger, safflower and sesamum is mainly on account of growth in productivity whereas, production of groundnut, soybean, rapeseed-mustard and sunflower increased due to the expansion of area. Total oilseed crops production increased due to near about same contribution of all the three factors in which expansion in area was the main one. This clearly indicated that the potential of the viable technology developed for the major oilseeds have not yet made a significant impact in increasing oilseed productivity. Besides other probable reasons may be higher hazards of pests and diseases compared to cereals, poor crop management practices and lower size of land holdings.

The oilseed production profile in India indicated that the country which accounted for one third of the global output, bears testimony to the fact that the Technology Mission on Oilseeds has been able to bear the much desired fruits in terms of increased production with soybean and sunflower crops promising major growth potential (Kataria and Chahal, 2002). Groundnut crop, which accounted for a major share in the oilseed industry, has now been replaced by soybean, because of its comparative stable yield and market prices (Siddayya and Dileep, 2002). Indian oilseeds cultivation has so far grown quantitatively. It now needs to take a qualitative leap forward. Edible oils, which provide vital proteins, are produced from oilseeds. However, the production of oilseeds is next in importance only to cultivation of food grains and cash crops in India and the rest of the world. Thus, oilseeds have to fight with other crops, such as rice and wheat, for land, soil, climate, water and fertiliser. Therefore, in general, there is hardly any scope for bringing additional area under oilseeds.

- Hence research efforts are needed to increase productivity and increase area under oilseed crops through inter-cropping.
- Efforts should be made to transfer existing technology from lab to land.
- Supply of improved seed at reasonable rates to increase seed replacement ratio (srr).
- India must make efforts to increase the productivity of its oilseeds by at least 50 per cent to achieve self-reliance and come on par with the rest of the world. This can be achieved through the use of improved farming techniques, hybrid seeds, fertilizers, organic and inorganic pesticides, mechanization and de-fragmentation of farmlands, besides improving irrigation facilities.
- Efforts are needed to raise productivity through adoption of improved technology with effective extension, education and research efforts to develop disease resistance high yielding varieties suitable to agro-climatic condition of the region.

- For realization of better yield under irrigated conditions as compared to rainfed conditions, measures should be taken to increase the area under irrigation.
- Due to the sensitiveness of oilseed crops to market forces, the supports price policy needs to be continued and strengthened. Provision of good market facilities, modernization of extraction facilities for better oil recovery and strengthening of processing facilities for value addition are critical in achieving the sustained growth of the oilseed sector. There is an urgent need for future trading in oilseed for stabilizing the prices in the long run (Hegde, 2002).

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Anyone can do any amount of work provided it isn't the work he is supposed to be doing at that moment.

– Robert Benchley

Feature

Foodgrain Losses at Farm Level – Wheat in Punjab

Jaskaranjit Singh & M.S. Sidhu

The article estimates the losses in the case of wheat crop in Punjab during harvesting and threshing and also during the marketing stage due to inadequate structures at the farm level. The primary data far the year 1999-2000 were collected through the personal interview method by using a pre-tested schedule. Suggestions for reducing the huge losses are provided in the article.

Jaskaranjit Singh is a post-graduate student and M.S. Sidhu an Economist (Marketing) with the Department of Economics and Sociology, Punjab Agricultural University, Ludhiana.

The government launched various development programmes to increase foodgrain production in the country after independence. Keeping in view the requirements of our increasing population, the major emphasis was laid to develop the farm inputs were supplied to the farmers at concessional rates and price incentives were provided for major foodgrains like wheat, paddy etc. The foodgrains production increased from about 51 million tonnes in 1950-51 to about 74 million tonnes in 1966-67. It further increased to about 199 million tonnes in 2000-2001. India is the second largest producer of wheat and rice in the world. India's share in the case of rice is about 22 per cent of the world rice output. Similarly, India produces about 11 per cent of the global wheat (Tata Services Ltd., 2000). Our buffer stocks of foodgrains were around 58 million tonnes in January 2002 (Government of India, 2002).

On the other hand, the losses to the procured foodgrains at different stages of handling have been recorded. Such losses offset the efforts of the government to increase the availability of foodgrain to the masses. Losses at the farm level lowered the marketed surplus of foodgrains and adversely affected the income of the farmers.

Annual loss of foodgrains in India due to poor post-harvest handling and storage is about 9.33 per cent of production, which amounts to about 20 million tonnes annually. In case of wheat, the losses are estimated at 0.43 per cent in grinding, 2.41 per cent by rodents, in transport 0.16 per cent, in mandis at 0.68 per cent and in storage in the central pool at 4.10 per cent. In the case of rice, the estimated loss during storage varies from 0.87 to 4.07 per cent, in transport at 0.65 per cent, in mandis at 1.84 per cent and in storage in the central pool at 4.99 per cent (Singhal, 1999). The estimates of waste of foodgrains revealed that 1400 million people could have been fed for a month on the 18.95 million tonnes of foodgrain waste in the country during the year 1998-99. A concerted effort may be made by the

government, public agencies, farmers, traders, research institutes, processors, consumers, etc. to reduce these post-harvest losses by at least 50 per cent in the coming years to feed more than one billion people (Rangi and Sidhu, 2000).

The estimates of waste of foodgrains revealed that 1400 million people could have been fed for a month.

Objectives

The present study has been undertaken to estimate the losses at the farm level from production till the produce was marketed in the case of wheat crop in Punjab. The specific objectives of the study were (i) to examine the loss to wheat during harvesting and threshing; (ii) to study various types of storage structures used by the farmers; (iii) to study the storage loss to wheat at the farm level; and (iv) to study the loss to wheat during marketing by the farmers.

Methodology

Wheat crop was studied because it occupied about 43 per cent of the total cropped area of the Punjab State during the year 1999-2000. The total sample consisted of 120 farmers, i.e. 60 farmers from each selected district. The farmers were categorized into three strata, namely, small, medium and large. The secondary data used in the study have been taken from reputed published sources. The primary data collected from the farmers pertained to the year 1999-2000. It was a normal year in Punjab from the agricultural production point of view. The primary data were collected through the personal interview method. The schedule prepared in this regard was pre-tested.

Results and Discussion

Size of operational holdings and cropping pattern

The study brought out that the average size of operational holding of the sample farmers was 10.66 acres during the year 1999-2000 out of which 9.92 acres (93.06 per cent) and 0.74 acre (6.94 per cent) were owned and leased, respectively. The farmers allocated about 73 per cent of the average operational holding to paddy crop in kharif season and about 81 per cent to wheat crop in the rabi season. The remaining area was mainly under vegetables, sugarcane, oilseeds and fodder crops. The average yield of wheat crop was 22.65 qtls. per acre. The farmers of Ludhiana district got higher yield of wheat to the extent of 22.90 qtls. per acre as compared to 22.33 qtls. for Amritsar district.

Harvesting of Wheat

The harvesting of cereal crops is mainly done with sickle about 24 per cent as well as combine-harvester about 76 per cent. It was found that all the large category farmers used the facility of combines. The small and medium category farmers harvested the produce both with sickle and combine. About two decades ago in Punjab, the wheat area harvested with combine was only 2.36 per cent (Gill, et al, 1984). It may be due to easy availability of combines in Ludhiana district at competitive rates. Moreover, Ludhiana is a central district of Punjab as compared to Amritsar which is located along the international border with Pakistan. It has been found that combine was not easily available to the farmers in Amritsar district, therefore, they opted for harvesting of wheat with sickle.

Area harvested with combine worked out to about 76 per cent and with sickle about 24 per cent.

Harvesting Losses of Wheat

The losses during harvesting of wheat are shown in Table I. While harvesting wheat, either ears were scattered or grains fell on the ground due to shattering. On an average, per acre loss while harvesting with sickle was 21.54 kgs for all the selected farmers while comparing the losses per acre with different categories of the farmers, it was the highest for the medium category, i.e. 22.13 kgs per acre followed be small category (20.92 per acre). It was found that none of the large farmers harvested their produce with sickle. The district wise analysis revealed that per acre loss for harvesting with sickle in Ludhiana district was 22.89 kgs as compared to 20.57 kgs for Amritsar district.

The study brought out that loss by combine-harvest was 5.95 kgs per acre as compared to 21.54 kgs with sickle. In Amritsar district, the loss by combine-har-

None of the large farmers harvested their produce with sickle.

Table 1: Harvesting loss to wheat with sickle and harvest-combine with the selected farmers, 1999-2000

(Area in acres, Loss in kgs.)

Farm category	Area harvested with sickle	Per holding loss with sickle			Per acre loss with sickle			Area harvested with combine	Total loss with combine	Per acre loss with combine
		Scattered ears	Shattering of grains	Total loss	Scattered ears	Shattering of grains	Total loss			
Amritsar Distt										
Small	1.88	26.49	10.41	36.90	14.09	5.54	19.63	0.86	5.42	6.30
Medium	4.71	72.05	28.45	100.50	15.30	6.04	21.34	6.76	44.69	6.61
Large	–	–	–	–	–	–	–	28.00	178.25	6.36
Average	2.49	36.75	14.48	51.23	14.76	5.81	20.57	5.25	33.83	6.44
Ludhiana Distt										
Small	1.75	28.82	10.10	38.92	16.47	5.77	22.24	1.08	6.12	5.67
Medium	2.05	35.52	13.37	48.89	17.33	6.52	23.85	10.10	58.24	5.76
Large	–	–	–	–	–	–	–	34.85	192.17	5.51
Average	1.64	27.58	9.96	37.54	16.82	6.07	22.89	7.88	44.33	5.62
Overall										
Small	1.81	27.60	10.26	37.86	15.25	5.67	20.92	0.97	5.76	5.94
Medium	3.31	52.77	20.49	73.26	15.94	6.19	22.13	8.52	51.84	6.08
Large	–	–	–	–	–	–	–	31.69	185.76	5.86
Average	2.06	32.16	12.22	44.38	15.61	5.93	21.54	6.57	39.08	5.95

vester was 6.44 kgs per acre as compared to 5.62 kgs in Ludhiana district.

Threshing Losses of Wheat

The losses during threshing of the produce can occur due to some grains passing into the straw and some grains getting mixed with dust and dirt on the threshing floor. The data given in Table 2 indicates the loss to wheat during threshing. On an average, the wheat threshed by small and medium categories was 37.77 qtls. and 75.17 qtls., respectively. The large farmers threshed their produce with combine-harvest. The loss at the threshing floor for small category was 25 kgs due to scattered grains which could not be collected as these remained mixed with dust and dirt while another 37 kgs were cost as grains passed into the straw during the process of threshing. The corresponding figures for medium category were 44 kgs and 69 kgs, respectively. In percentage terms, the loss was 1.47 as a whole. It was 1.63 and 1.49 per cent for small and medium categories, respectively. This analysis revealed that with the increase in the size of holding, the threshing loss decreased and vice-versa. It may be mainly due to hired threshers used by the small farmers.

The district-wise analysis brought out that grain threshed in Amritsar district was 55.60 qtls. as compared to 37.52 qtls. in Ludhiana district. It was also observed that the total loss of wheat grain during threshing was 85 kgs (1.52 per cent) in Amritsar district as compared to 56 kgs (1.37 per cent) in Ludhiana district. It may be mainly on account of better quality of threshers with the sample farmers of Ludhiana district.

Storage Structures

The losses to foodgrain during storage can occur due to various types of storage structures used by different farmers. A study conducted at Punjab Agricultural University had revealed that in villages, separate godowns were available with only six per cent cultivators. Sixty per cent of the producers stored grains in earthen stores, locally called Bukharies. Thirty per cent kept it in living rooms. The remaining four per cent used other miscellaneous ways of storage. The storage practices in villages were defective and on this account alone, losses varied from two to five per cent (gill and Johl, 1966). Another study conducted at PAU revealed that 54 per cent of the total farmers indulged in loose storage. Bag storage was done by about 34 per cent, metallic bins about 28 per cent, kohl about 10 per cent and bukhari about nine per cent. Other structures accounted for about 3 to 4 per cent with the sample farmers (Gill et al, 1984).

The data given in Table 3 indicate the types of

Table 2: Per holding threshing loss to wheat with the selected farmers, 1999-2000

(Figures in qtls.)

Farm category	Grain threshed	Quantity of the grain			Percentage of the grain		
		Left at the floor	Passed into the straw	Total loss	Left at the floor	Passed into the straw	Total loss
Amritsar Distt							
Small	38.54	0.26	0.38	0.64	0.67	0.98	1.65
Medium	104.46	0.64	0.99	1.63	0.61	0.94	1.55
Large	–	–	–	–	–	–	–
Average	55.60	0.34	0.51	0.85	0.61	0.91	1.52
Ludhiana Distt							
Small	37.22	0.24	0.36	0.60	0.64	0.96	1.60
Medium	47.47	0.27	0.44	0.71	0.56	0.92	1.48
Large	–	–	–	–	–	–	–
Average	37.52	0.22	0.34	0.56	0.54	0.83	1.37
Overall							
Small	37.77	0.25	0.37	0.62	0.66	0.97	1.63
Medium	75.17	0.44	0.69	1.13	0.58	0.91	1.49
Large	–	–	–	–	–	–	–
Average	46.61	0.27	0.42	0.69	0.57	0.90	1.47

storage structures used by various farmers during the year 199-2000. It is seen that foodgrain storage in gunny bags was the most common, followed by storage in metal bin and bharola. A similar trend was found in Ludhiana and Amritsar districts, except that bharola was used by sample farmers of the latter district. It was also found that in Ludhiana district, cent per cent of the farmers were using metal bin storage structures whereas in Amritsar district, 88.33 per cent farmers were using metal bin storage structures. This may be due to better economic condition of farmers of Ludhiana district as compared to the farmers of Amritsar district. Value productivity of Ludhiana district was about Rs 28 thousand per cultivated hectare as compared to about Rs 22 thousand in Amritsar district (Rangi and Sidhu, 1996). Moreover, the awareness of the sample farmers of Ludhiana district was more compared with the sample farmers of Amritsar district, regarding storage of foodgrains. The metal bin is the safest storage structure. It was also seen that 11.67 per cent farmers of Amritsar district stored their produce in bharola. None of the sample farmers were found to store their produce in bharola in Ludhiana district.

The metal bin is the safest storage structure.

Table 3: Storage structures used by the selected farmers, 1999-2000

Farm category	Metal bin	Bharola	Gunny bags	Total number of farmers
Amritsar Distt				
Small	33 (89.18)	4 (10.81)	37 (100.00)	37
Medium	15 (88.23)	2 (11.76)	17 (100.00)	17
Large	5 (83.33)	1 (16.67)	6 (100.00)	6
Total	55 (88.33)	7 (11.67)	60 (100.00)	60
Ludhiana Distt				
Small	34 (100.00)	–	34 (100.00)	34
Medium	19 (100.00)	–	18 (94.73)	19
Large	7 (100.00)	–	7 (100.00)	7
Total	60 (100.00)	–	59 (98.33)	60
Overall				
Small	67 (94.36)	4 (5.63)	71 (100.00)	71
Medium	34 (94.44)	2 (5.55)	35 (97.22)	36
Large	12 (92.30)	1 (7.69)	13 (100.00)	13
Total	113 (94.16)	7 (5.83)	119 (99.16)	120

Note: (i) Figures in parentheses indicate percentage to total number of farmers.

(ii) The total of percentage may be more than 100 because one farmer used more than one storage structure.

Storage Losses of Wheat

A recent estimate made by the Ministry of Food and Civil Supplies, Government of India has revealed that

the foodgrain wasted in post-harvest operations in India are very high. The estimated food losses during the year 1998-99 could have fed up to 117 million people for a year or the entire country for about six weeks (Saran, 1999). Rodents and insects alone polished off the monthly food requirement of 760 million people (Ibid). The total preventable (post harvest) losses of foodgrains are estimated to be about 20 million tonnes a year, equal to the annual production of Australia (Ibid). These losses also included storage losses.

Rodents and insects alone polished off the monthly food requirement of 760 million people.

The data given in Table 4 indicate the storage losses to wheat during the year 1999-2000. The study brought out that average quantity of wheat stored by sample farmers was 18.83 qtls. for family consumption and 4.17 qtls. for seed purpose. A farmer in the small category stored 13.26 qtls. for home consumption and 1.98 qtls. for seed purpose. The corresponding figures for medium category were 23.44 qtls. and 5.86 qtls. while for the large category, these were 36.56 qtls. and 11.45 qtls., respectively. The per holding loss to wheat stored for family consumption was 87 kgs. and for seed purpose about 14 kgs. The loss as percentage to the total quantity stored for family consumption was 4.62 while for seed, the loss was 3.33. The higher loss for family consumption was natural because wheat was stored throughout the year for family consumption, whereas for seed purpose this was utilized by the middle of November in most of the cases. It was reported by sample farmers that rats, insects, dampness, birds, etc. caused loss to wheat during storage.

The district-wise analysis revealed that in Ludhiana district, the per holding loss to wheat stored for family consumption was 92 kgs and for seed purpose about 16 kgs. The per holding loss to wheat stored for home consumption was 82 kgs and for seed purpose 12.5 kgs in Amritsar district. The study indicated that the loss as percentage to the total quality stored for family consumption was 4.63 and for seed, the loss was 3.37 in Ludhiana district. The loss to the total quantity stored for family consumption was 4.60 per cent while for seed, the loss was 3.32 per cent in Amritsar district. The loss to the stored wheat was marginally more in Ludhiana district as compared to Amritsar district.

Table 4: Per holding storage loss to wheat with the selected farmers, 1999-2000

(Figures in qtls.)

Farm category	Quantity stored for		Loss to the produce stored for		Loss as percentage to the gain stored for	
	Family consumption	Seed	Family consumption	Seed	Family consumption	Seed
Amritsar Distt						
Small	12.82	1.97	0.61	0.068	4.75	3.45
Medium	22.27	5.24	1.02	1.175	4.58	3.33
Large	35.76	10.56	1.59	0.34	4.44	3.21
Average	17.79	3.76	0.82	0.125	4.60	3.32
Ludhiana Distt						
Small	13.72	1.99	0.66	0.071	4.81	3.56
Medium	24.48	6.42	1.13	0.216	4.61	3.36
Large	37.25	12.21	1.67	0.40	4.48	3.27
Average	19.87	4.59	0.92	0.155	4.63	3.37
Overall						
Small	13.26	1.98	0.63	0.069	4.75	3.48
Medium	23.44	5.86	1.07	0.196	4.56	3.34
Large	36.56	11.45	1.63	0.37	4.45	3.23
Average	18.83	4.17	0.87	0.139	4.62	3.33

Marketing Losses to Wheat

Large market arrivals in the peak season cause congestion in the market yards and result in admixtures, pilferage and wastage. Handling becomes difficult and daily bidding cannot be completed in some cases (Singh and Mann, 2000). Thus, weighing is postponed to the next day and the farmers have to stay back with their animals, carts and tractors (Ibid). Such problems in the market cause marketing loss to the farm produce.

The data given in Table 5 indicate the losses during marketing to wheat during the year 1999-2000. The study indicated that the small, medium and large categories of farmers sold about 41 qtls. 232 qtls. and 680 qtls. of wheat. The average quantity of wheat sold was about 167 qtls. In the market, during the cleaning operation, some grains passed on along with foreign matter, dust and dirt. It was found that 46 kgs of wheat were lost by each sample farmer. The second factor leading to the loss in the market was when the lots were unloaded on the roadside during the peak marketing season, and the grains got mixed with dust and dirt. The loss on this account worked out to be 63 kgs. per holding. As a result, due to these two factors, the total loss turned to be 1.09 qtls. per holding, i.e. 0.65 per cent of wheat sold by the selected farmers got lost in the market. This loss as percentage to total produce sold, turned out to be the highest on large holdings. This was natural be-

Table 6: Total losses at farm level to wheat in Punjab, 1999-2000

Particulars			Losses (thousand tonnes)
Harvesting loss			
Area harvested with sickle in Punjab on the basis of area of sample farmers	=	809.73 thousand hectares	
Area harvested with combines in Punjab on the basis of area of sample farmers	=	2578.27 thousand hectares	
Per hectare loss with sickle	=	53.22 kg.	
Total harvesting loss in Punjab for area harvested with sickle (809.73 thousand hectares × 53.22 kg./hectare)	=		43.09
Per hectare harvesting and threshing loss with combine	=	14.70 kg.	
Total harvesting and threshing loss for area harvested with combines in Punjab (2578.27 thousand hectares × 14.70 kg./hectare)	=		37.90
Sub-total	=		80.99
Threshing loss			
Production of wheat in Punjab during 1999-2000	=	15910 thousand tonnes	
Grains threshed with threshers by the sample farmers	=	23.90 %	
Total wheat threshed by thresher alone $\frac{(15910 \text{ thousand tonnes} \times 23.90)}{100}$	=	3802.49 thousand tonnes	
Threshing loss of sample farmers	=	1.47 %	
Total threshing loss in Punjab $\frac{(3802.49 \text{ thousand tonnes} \times 1.47)}{100}$	=		55.90
Storage loss			
(a) Family consumption			
Total number of operational holdings in Punjab	=	1116951	
Quantity kept for family consumption with each sample farmer	=	18.83 qtls.	
Total wheat stored by farmers in Punjab (1116951×1.883 tonnes)	=	2103.21 thousand tonnes	
Storage loss with the sample farmers	=	4.62 %	
Total storage loss at farm level in Punjab on the basis of storage loss of sample farmers. $\frac{(21032 \text{ thousand} \times 4.62)}{100}$	=		97.20
(b) Seed			
Total number of operational holdings in Punjab	=	1116951	
Quantity kept for seed per holding with sample farmers	=	4.17 qtls.	
Total seed stored by farmers in Punjab on the basis of sample farmers (1116951 × 4.17 qtls.)	=	466 thousand tonnes	
Seed loss with sample farmers	=	3.33 %	
Total seed loss at farm level in Punjab on the basis of storage loss of sample farmers $\frac{(466 \times 3.33)}{100}$	=		15.52
Total storage loss at farm level in Punjab i.e. family consumption plus seed (97.20 + 15.52)	=		112.72
Marketing loss			
Market arrivals in Punjab (crop year 1999-2000)	=	9750 thousand tonnes	
Marketing loss	=	0.65 %	
Total marketing loss in Punjab on the basis of sample farmers $\frac{(9750 \text{ thousand tonnes} \times 0.65)}{100}$	=		63.38
Total loss in Punjab at various stages (1+2+3+4)	=		312.99
Total loss as percentage to wheat production	=	1.97 %	
Monetary value of loss wheat in Punjab			
Loss	=	303.01 thousand tonnes	
Price of wheat (post-harvest period)	=	Rs. 5800 per tonne	
Loss in rupee terms (312.99 thousand tonnes × Rs. 5800 per ton)	=		Rs. 181.53 crore

cause large lots in the market were to be spread on a wider space and loss turned to be higher.

The district-wise analysis revealed that small, medium and large categories of farmers sold about 42 qtls., 243 qtls. and 746 qtls. of wheat, respectively, in Ludhiana district. These figures for Amritsar district were about 39 qtls., 221 qtls. and 603 qtls., respectively. In Ludhiana district, each sample farmer sold about 188 qtls. of wheat as compared to about 147 qtls. in Amritsar district. It was also found that per holding marketing loss was 1.28 qtls. in Ludhiana district which was 0.68 per cent of the quantity sold. This figure was 92 kgs (0.62 per cent) for Amritsar district. This may be on account of heavy market arrival of farm produce in the peak marketing season in Ludhiana district.

Table 5: Per holding loss to wheat suffered by the selected farmers during sale in the market, 1999-2000

(Figures in qtls.)

Farm category	Marketed surplus of wheat	Quantity lost during cleaning	Quantity wasted	Total loss	Percentage of marketed surplus lost
Amritsar Distt					
Small	39.06	0.055	0.13	0.185	0.47
Medium	220.92	0.61	0.80	1.41	0.63
Large	602.90	1.84	2.28	4.12	0.68
Average	146.97	0.39	0.53	0.92	0.62
Ludhiana Distt					
Small	42.22	0.058	0.16	0.218	0.51
Medium	242.79	0.79	0.99	1.78	0.73
Large	746.44	2.31	2.85	5.16	0.69
Average	187.90	0.55	0.73	1.28	0.68
Overall					
Small	40.58	0.056	0.14	0.196	0.48
Medium	232.46	0.70	0.90	1.60	0.68
Large	680.19	2.09	2.58	4.67	0.68
Average	167.44	0.46	0.63	1.09	0.68

Total loss to Wheat in Punjab

Based on the losses to wheat suffered by the sample farmers during the year 1999-2000, the harvesting, threshing, storage and marketing losses have been worked out for the state as a whole. The information in this regard is given in Table 6. The harvesting loss to wheat was about 81 thousand tonnes, threshing loss about 56 thousand tonnes, storage loss about 113 thousand tonnes and loss to wheat in Punjab was about 313 thousand tonnes, which was 1.97 per cent of the wheat production. In monetary terms, the loss was to the extent of about Rs 182 crores during the year 1999-2000.

Conclusions and Suggestions

Wheat is the principal crop in Punjab. It occupied about 43 per cent of the total cropped area of the State during the year 1999-2000. The study brought out that harvesting loss to wheat was 21.54 kgs per acre with sickle and 5.95 kgs per acre with combine harvest. The area harvested with combine and sickle was about 76 per cent and 24 per cent, respectively. The threshing loss was 1.47 per cent of the produce threshed. The foodgrain storage in the gunny bags was the most common followed by storage in metal bin and bharola. The average storage loss for family consumption and seed was 4.62 per cent and 3.33 per cent, respectively. The rats, insects, dampness, birds, etc. caused loss to wheat during storage. The average quantity of wheat sold was about 167 qtls. The marketing loss was 0.65 per cent of the produce sold. The total loss at the farm level to wheat in Punjab on the basis of sample farmers was about 313 thousand tonnes which was 1.97 per cent of wheat production. In monetary terms, the loss was to the extent of about Rs 182 crore during the year 1999-2000.

There is no doubt that loss to wheat at farm level cannot be brought to zero level under any circumstances. However, the following suggestions will help in reducing the quantity of loss at farm level.

- The extension agencies may advise the farmers in the State to harvest the wheat crop at the appropriate time. The delay in harvesting results in high harvesting loss.
- At present, the threshers used by the farmers are not of ISI standards in most of the cases. It is suggested that threshers of high quality may be used by the farmers for threshing of wheat.
- The farmers may be advised to use metal bins for storage of wheat because it is the safest method of storage. Proper chemical treatment may also be provided to the grains during storage. Grains may be dried in the sun for 3-4 days before storage.
- The auction platform for farm produce may be made pucca with cement flooring in all the principal yards, sub-yards and purchase centres in the State. Cover sheds may also be built in all these markets.

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The vision must be followed by the venture. It is not enough to stare up the steps – we must step up the stairs.

– Vance Havner

Feature

Dynamics of Farm-Size & Productivity in Punjab

D.K. Grover, Kamal Vatta & Sanjay Kumar

The paper highlights the change in nature of relationship between farm size productivity from negative and significant to sizes—neutral or positive and significant, over the last decade. It may be attributed to widespread diffusion of technology among all classes of farmers, irrespective of their farm size. The positive and significant relationship shows the scope for increasing the productivity of crops by increasing the size of the farm. The nature of the emerging relationship in Punjab signifies the need for economically viable farms and the increase in the operational farm size, which in fact has been happening to some extent. In other words, it requires the need of flooring limit to be encouraged through appropriate policy initiatives on the size of operational holdings in the state and also to re-consider the law related to land-ceilings.

D.K. Grover, Kamal Vatta and Sanjay Kumar are with the Agro-Economic Research Centre, Deptt. of Economics & Sociology, Punjab Agricultural University, Ludhiana.

The structure of land holdings is one of the basic and most important factors influencing the pace as well as pattern of agricultural development of a region. The distribution of land holdings in India continues to be uneven in character portraying institutional constraint for the small/marginal holdings and thus much of the rural poverty is attributed to unequal distribution of land resources among the operating size-classes. Researchers have gathered evidence of growing inequality in the distribution of land holdings (Sirohi et al, 1976; Dutta, 1988; Ali, 1996) and some others have focused on its improvement in certain parts of the country (Singh and Kahlon, 1976; Jain, 1984).

Growing inequality in distribution of land holdings was attributed to the growth of population, leading to sub-division of family and holding size, based on inheritance law of property on one hand, and the land reform measures in the form of redistribution of surplus agricultural land (over and above the ceiling limits) in favour of marginal land-owners and sale of land by big owners also affected the distributional pattern of land holdings in India.

Thus, it has been a subject of great concern for policy makers to understand the relationship between farm size and productivity. At a static level of development and low level of adoption of agricultural technology, it can be argued that there exists an inverse relationship between the farm size and productivity. As the adoption of technology improves, the resource-rich (large) farmers adopt these on a better scale and the scenario may change to one of no relationship between farm size and productivity. Further progress may even change the relationship to a positive one. It can also be argued that the inverse relationship holds good over certain range of farm size and not over all the ranges of size.

The inverse relation between farm size and productivity was reported by Kahlon and Johl (1962), Sankhyan (1978) and Singh et al (1979). Higher use of farm family

labour by small farms was observed to be the reason for this relationship (Kahlon and Johl, 1962; Singh et al, 1979; and Rani, 1971) as small farmers make intensive use of inputs, put more area under irrigation and provide better management so that their productivity is higher. The family labour input of small farms, with zero opportunity cost, is certainly more intensively used even beyond the point where the total marginal value productivity of labour is still positive; it is a simple economic rationale.

Rao (1967), Rani (1971) and Bhardwaj (1974) in their studies in different parts of India could not observe any significant or systematic relationship between farm size and productivity and concluded that holding size had no effect on productivity.

In another series of contrary results, Singh and Patel (1973) rejected the hypothesis of inverse relationship and observed increase in output per hectare with an increase in farm size. They opined that due to technological breakthrough, large farmers used modern inputs and used the land more intensively to get higher output. Sankhayan and Sidhu (1974) and Singh and Mohammad (1994) also established a positive relationship between farm size and productivity. They attributed this to greater access of capital to large farmers, which allowed them to use manures and machinery more intensively and purchase the technologies that ultimately increased the productivity.

The objectives of socio-economic equality and food security of a region are directly affected by the distribution of operational holdings. The relationship between farm size and productivity can directly influence the state policy aimed at the distribution of land holdings. As negative relationship calls for a shift towards larger holdings and hence, more concentration of land. Keeping all the above in mind, the present paper intends to study the following:

1. The nature and extent of temporal variations in the distribution of operational holdings in Punjab.
2. The relationship between farm size and productivity of paddy and wheat in the state.

Database and Methodology

The data pertaining to number and area of operational holdings were obtained from the Statistical Abstracts of Punjab and the Directorate of Agriculture, Punjab. The analysis is restricted to 12 districts existing during 1990-91 and the five new districts, which emerged later in the State, were merged to the parent districts according to the proportion of operational area drawn from the parent district. The new districts were thus merged using the following coefficients:

New district (1)	Original district (2)	% of operational holdings of 1 merged with 2
Nawanshahar	Jalandhar	Hoshiarpur
Muktsar	Fridkot	1.00
Moga	Faridkot	1.00
Mansa	Bathinda	1.00
Fatehgarh Sahib	Patiala	0.77
	Ludhiana	0.20
	Sangrur	0.03

To study the inequality in the distribution of land holdings, Gini coefficients were calculated as follows:

$$\text{Gini coefficient} = 1 - \sum \frac{\left(X_i \left(Y_j + Y_{j-1}\right)\right)}{10000}$$

Where

X_i = Percentage of number of operational holdings in the i-th size-class.

Y_i = Cumulative percentage of area of operational holdings in the i-th size class.

The operational holdings were divided into five size-categories following the national classification viz., marginal (below 1 ha), small (1 to 2 ha), semi-medium (2 to 4 ha), medium (4 to 10 ha) and large (above 10 ha). The data collected by the Department of Agriculture, Punjab, under the scheme 'Crop-cutting experiments' were used to find the relationship between farm size and productivity. The data pertained to one district from each of the three agro-climatic zones in Punjab. The three districts were Hoshiarpur (Submontaneous zone), Ludhiana (Central plains) and Bathinda (South-western zone). The analysis was carried out for the years 1988-89 and 1998-99.

The details of the experiments are given below:

District	No. of Experiments		
	Paddy	Wheat	Total
Hoshiarpur			
1988-89	28	58	86
1998-99	42	80	122
Ludhiana			
1988-89	184	230	414
1998-99	200	200	400
Bathinda			
1988-89	47	149	196
1998-99	40	131	171
Total			
1988-89	259	437	696
1998-99	282	427	709

The log-linear regression model (log Y = log a + b log X, where Y is crop yield and X is a farm-size) was used to find the relationship farm size and productivity.

Results and Discussion

Distribution of land holdings

Due to large increase in the number of operational holdings from 1980-81 to 1990-91, the average size of holding declined from 3.82 to 3.61 hectare. The average size again increased to 3.98 hectare during 1995-96, due to decline in total number of holdings in the state (Table 1). Thus, the economic scenario in Punjab agriculture is one of maintaining the average farm size in operational terms.

Table 1: Total number, area and average size of operational holdings, Punjab

Year	Total Number of Operational Holdings	Total Operational Area (ha)	Average Size of Holding (ha)
1980-81	1,019,992	3,892,462	3.82
1985-86	1,078,430	4,103,892	3.81
1990-91	1,116,951	4,032,685	3.61
1995-96	1,037,908	4,129,296	3.98

Table 2 shows that the proportion of marginal holdings (of upto 1 ha) in total number of operational holdings in the state declined abruptly to 13.83 per cent during 1995-96, after a continuous increase from 1980-81 (19.42%) to 1990-91 (26.47%). It may be due to the uneconomic size of these holdings. In fact, most of the research studies in Punjab have shown that due to more intensive use, most of the natural resources (like irrigation and increase in cropping intensity, etc.) have almost been used to potential by 1990-91, thereby leaving little reserve potential for increasing the income levels on a given size of operational farm. This will be more telling for the uneconomic marginal holdings, hence the decline in their number and proportion. Opposite trend was observed in case of the proportion of semi-medium and medium operational holdings was very sharp. Thus, the phenomenon of reverse tenancy seems to have got momentum during the 1990s. The decline in the proportion of marginal holdings during the nineties may be due to the marginal farmers leasing out their land to other farm size groups as crop raising is becoming less remunerative, causing an increase in the proportion of middle range of more economical semi-medium and medium farms.

Table 2: Percent distribution of number and area of operational holdings in Punjab

Size of holding	1980-81	1985-86	1990-91	1995-96
Marginal (0-1 ha)	19.42 (3.04)	23.76 (3.38)	26.47 (4.07)	13.83 (2.05)
Small (1-2 ha)	19.55 (7.22)	19.25 (7.58)	18.25 (8.14)	18.53 (6.29)
Semi-medium (2-4 ha)	28.18 (20.32)	26.97 (20.46)	25.86 (20.87)	31.09 (20.89)
Medium (4-10 ha)	25.61 (40.22)	23.20 (38.72)	23.41 (40.22)	29.02 (42.52)
Large (10 ha)	7.24 (29.20)	6.82 (29.86)	6.01 (26.70)	7.53 (28.25)

Source: Statistical Abstracts of Punjab

Note: Figures in parentheses represent the per cent of total operational area in the state

In a similar way, the proportion of operational area under small and marginal holdings first increased from 1980-81 to 1990-91 and then declined. An opposite trend was observed for medium and large holdings. The area under small and marginal holdings increased from about 10 per cent during 1980-81 to about 11 per cent in 1985-86 and to more than 12 per cent in 1990-91 but declined to about 8 per cent during 1995-96. Around 63 per cent of the area was covered by the farm size groups of 2 to 10 ha in 1995-96, which was 4 per cent more than it was a decade earlier. About 28 per cent operational area was covered by large farms during 1995-96.

Marginalisation of holdings in Punjab

The problem of relatively less profitability of agriculture gets further accentuated with a decrease in farm size. The economic condition of marginal farmers is the worst owing to economically no-viable size of these holdings. The analysis of proportion of marginal holdings helps to find out whether the number of these holdings has come down owing to the above reason or there has been an increase in density of marginal holdings due to the failure of other sectors of the economy in absorbing these farmers due to the lack of opportunities and better income.

Three patterns of change in the proportion of district-wise marginal holdings were observed (Table 3). In 10 out of 12 districts, there was an increased marginalisation of land holdings from 1980-81 to 1990-91. Slightly different results were obtained in Amritsar and Patiala districts during the same period. However, during the period 1990-91 to 1995-96, the proportion of marginal holdings declined in all the districts. There could be two reasons for this scenario. One, the real farm incomes of the marginal holdings being too small

might have forced them to become wage earners. Two, better opportunities in other sectors might have increased faster during the nineties. Both the reasons have been operating simultaneously in Punjab. The scope for increasing income from agriculture through more intensive use of natural resources like land (cropping intensity) and water (irrigation intensity) have almost been used to potential by 1990-91 thereby leaving little reserve potential for increasing the farm incomes on a given farm size. (The cropping intensity in Punjab increased from about 140% in 1970-71 to about 160% in 1980-81 and further to about 180% in 1990-91; further increase was marginal to only about 185% in 1998-99). Similarly, with respect to irrigation water resource there is an over exploitation as vindicated by the declining water table in Punjab. This is particularly more telling for the uneconomical marginal holdings of below 1 ha. An instance of relative increase in employment in other sectors is hard to be evidenced but even in the farm sector, farm level investments in machinery have continued to increase till date, which requires an increase in the services sector as well as in the maintenance and repair of these machines.

Table 3: District-wise proportion of marginal holdings in Punjab

District	Number			
	1980-81	1985-86	1990-91	1995-96
Gurdaspur	30.31	33.48	36.60	31.12
Amritsar	20.51	18.67	22.21	7.46
Kapurthala	12.08	18.21	21.68	18.63
Jalandhar	20.54	23.78	29.94	16.08
Hoshiarpur	27.72	30.05	31.96	23.29
Ropar	30.79	34.69	41.42	27.23
Ludhiana	14.38	22.75	28.91	13.98
Ferozepur	15.03	21.41	25.07	5.63
Faridkot	16.87	26.63	29.67	1.04
Bathinda	12.45	13.17	14.55	13.17
Sangrur	13.03	16.26	18.66	8.34
Patiala	18.85	25.49	21.86	7.97

Source: Statistical Abstracts of Punjab

Large Holdings in Punjab

Six patterns of change in the proportion of large holdings were identified across different districts in the state (Table 4). However, in most of the districts (8 out of 12) the proportion of large holdings has gone up from 1990-91 to 1995-96 except in Gurdaspur ,Amritsar, Kapurthala and Ropar districts. Significant increase in proportion has been found in Ferozepur and Faridkot districts from about 8 to 12 per cent and 10 to 16 per cent, respectively. These are the districts (particularly Faridkot) where the water table has been rising and a distinct change in cropping system from cotton-wheat to rice-wheat took place in the nineties. The fact that marginal holdings have been declining and leasing out their land which might have been leased in relatively more by larger holdings to utilise their surplus (machine) capital investment might also be another explanation for this phenomenon.

Table 4: District-wise proportion of large holdings in Punjab

(per cent)

District	Number			
	1980-81	1985-86	1990-91	1995-96
Gurdaspur	3.03	2.58	2.08	1.85
Amritsar	5.17	4.60	4.82	4.50
Kapurthala	5.93	4.50	6.50	6.37
Jalandhar	5.38	5.47	5.08	6.08
Hoshiarpur	2.99	2.45	2.69	2.94
Ropar	2.37	2.65	2.18	1.92
Ludhiana	5.84	5.82	6.69	8.81
Ferozepur	9.19	10.10	7.92	12.49
Faridkot	11.95	10.97	9.96	16.29
Bathinda	13.23	10.93	10.12	12.02
Sangrur	9.11	9.42	6.05	7.85
Patiala	9.31	7.65	6.75	8.55

Source: Statistical Abstracts of Punjab

Inequality in Land Distribution (Gini Ratios)

Table 5 highlights the gini concentration ratio for the distribution of land holdings in Punjab from 1980-81 to 1995-96, which shows that after an increase till 1985-86, the inequality in distribution of operational holdings in Punjab has narrowed down during 1990-91 and 1995-96.

Table 5: Gini ratios for land holdings in Punjab

	1981-81	1985-86	1990-91	1995-96
Gini ratio	0.4697	0.4984	0.4893	0.4387

Most of the correlation coefficients between gini ratio and productivity for different periods were negative and non-significant (Table 6). The negative relationship indicates a decline in productivity with increase in inequality of land distribution, as the coefficients were not significant, this relationship is only indicative and not an affirmative one.

Table 6: Correlation between gini ratio and productivity of paddy and wheat in Punjab

Crop	Year			
	1980-81	1985-86	1990-91	1995-96
Paddy	–0.4643	0.1743	–0.3018	–0.4062
Wheat	–0.3343	0.2618	–0.0621	–0.3586

Farm size and productivity

The nature and extent of the relationship between farm size and productivity was studied for paddy and wheat. This is based on the crop cutting experiments data for 534 plots in 1988-89 and 86 plots in 1998-99 for paddy and wheat crops.

Paddy

There was no significant relationship between farm size and productivity of paddy except for zone I for the year 1988-89 (table 7).

Table 7: Relationship between farm size and productivity of paddy in Punjab

Region	Constant (Log a)	Coefficient (b)	R^2
A.	Zone I		
	1988-89	3.427* (0.254)	–0.281** (0.116)
	1998-99	2.896* (0.132)	–0.018 (0.066)
B.	Zone II		
	1988-89	3.118* (0.086)	0.039 (0.033)
	1998-99	3.131* (0.051)	–0.011 (0.019)
C.	Zone III		
	1988-89	3.044*(0.132)	0.042 (0.048)
	1998-99	3.220*(0.065)	0.000 (0.024)
State			
	1988-89	3.060*(0.076)	0.041 (0.029)
	1998-99	3.025*(0.045)	0.024 (0.017)

Note: Figures in parentheses represent the standard errors. *, ** significant at 1, 5% levels.

During 19888-89, the relationship was negative an significant in zone-I. The farm size elasticity of productivity for paddy indicates a decline in productivity of paddy by 0.28 per cent with one per cent increase in farm size during 1998-99. It may be due to technological advancements in the zone, making the productivity size-neutral over time.

It may be concluded that the productivity of paddy crop was almost size-neutral during 1988-89. However, the negative relationship between farm size and productivity, if any, became non-significant during 1998-99 due to technological advances.

Wheat

The productivity of wheat was observed to be size-neutral in the state an din each of the three zones during 1988-89 (Table 8). During 1998-99, the relationship turned out to be positive and significant in zone I. There was no change in the relationship, which remained size neutral in other zones during 1998-99.

Table 8: Relationship between farm size and productivity of wheat in Punjab

Region	Constant (Log a)	Coefficient (b)	R^2
A.	Zone I		
	1988-89	2.537*(0.161)	–0.107 (0.084)
	1998-99	2.408*(0.071)	0.109*(0.040)
B.	Zone II		
	1988-89	2.715*(0.056)	0.011 (0.023)
	1998-99	2.859*(0.043)	0.017 (0.012)
C.	Zone III		
	1988-89	2.463*(0.066)	0.025 (0.025)
	1998-99	2.632*(0.031)	0.075*(0.012)
State			
	1988-89	2.548*(0.050)	0.029 (0.020)
	1998-99	2.632*(0.031)	0.075*(0.012)

Note: Figures in parentheses represent the standard errors. *, ** significant at 1% level.

Conclusions and Policy Implications

It may be concluded that in Punjab state, which is one of the agriculturally-most-developed states of the country, there is a negative relationship between farm size and productivity. The analysis highlights the existence of size-neutrality of the productivity or the positive and significant relationship. It may be attributed to widespread diffusion of technology among all the classes of farmers, irrespective of their farm size. The non-significant relationship between the farm size and productivity implies no adverse effect on yields with increase or decrease in the farm size. However, the positive and significant relationship shows the scope for increasing the productivity of crops by increasing the farm size. Thus, the nature of the emerging relationship in Punjab signifies the need for economically viable

farms and the increase in the operational farm size, which in fact has been happening to some extent. In other words, it requires the need of flooring limit to be encouraged through appropriate policy initiatives on the size of operational holdings in the state and also to re-consider the law related to land-ceilings.

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A failure is not always a mistake; it may simply be the best one can do under the circumstances. The real mistake is to stop trying.

– B.F. Skinner

Feature

Factors Influencing Irrigation Tank Maintenance in Tamil Nadu

P. Paramasivam

Water is becoming an increasingly scarce resource with its demand growing in sectors. The need for water conservation is forcing the stakeholders to go in for large scale rainwater harvesting, wastewater recycling etc. In this connection it is disheartening to note that the time-tested tanks as an effective source of rainwater harvesting, groundwater recharge and surface irrigation, are gradually loosing their relevance due to various factors and lack of maintenance. This paper analyses the factors contributing to the probability of maintenance through a Linear Probability Model. It is found that while trends like increase in the number of wells, growing off and non-farm employment opportunities have a dampening effect on collective tank maintenance, education may improve the probability of maintenance.

P. Paramasivam is Associate Professor at the Water Technology Center, Tamil Nadu Agricultural University, Coimbatore.

Tanks have been an important community resource providing multiple services to village communities in the southern states of India. Especially in Tamil Nadu there are about 39,000 tanks. Irrigation has been the prime service though additionally they provide water for domestic needs, livestock needs, and occasionally fisheries. Of late, the land associated with tank bed has been used for social forestry plantations.

In recent decades there have been perceptible changes in the nature and usefulness of tanks; with increasing number of them becoming gradually defunct due to various reasons. The share of tank irrigation in the total irrigated area of the state has come down from a peak of about fifty percent in the early fifties to about twenty five percent in late nineties. Studies by Palanisami et. al (1997), Vaidyanathan and Janakarajan (1989), Janakarajan (1993), Umasankari (1991), Mukundan (1988), Oppen and Rao (1980), and Palanisami and Flinn (1988, 1989), have focused on various management issues and problems in tank irrigation systems.

Declining Role of Tanks

More precisely, the factors affecting tank irrigation range from above to below outlet. The above outlet factors include heavy siltation in the tank bed, encroachment of tank beds, poor functioning of the sluices, and surplus weirs of the upper tanks, severe encroachment and siltation in the supply channels, deforestation, encroachment and erosion in catchments, conflicts over inter-tank water distribution among the farmers of different tanks/villages etc. Mainly siltation has reduced the tank water storage capacity upto 20 percent although in some cases heavy siltation is said to have completely eliminated storage capacity. (Palanisami et al., 1997)

The below-outlet problems include disintegration of traditional irrigation institutions such as Kudimaramath (an informal type of Water User's Association), poor

tank structures, rapid increase in the number of private wells, and the consequent emergence of active water market in the tank commands, poor water control due to field to field flood irrigation, conflicts over sharing water in scarcity times etc. The disintegration of traditional irrigation institutions is both a cause and effect of poor tank performance. Many tanks have gone completely defunct due to the interplay of above reasons and some tanks are reported to be functioning only in normal/excess rainfall years and not in poor/low rainfall years.

The impression that one could gather by studying the literature on the functioning of tanks over decades in that, though effective once, their performance has been weaning consistently and definitely. And it is not a case of a more developed resource replacing or substituting an inferior one. In fact, in the state the extent of area that has been taken out of tank irrigation has been put under ground water irrigation. Tanks are all the more relevant in such a situation since they are the proven means for recharging the ground water itself. Thus substitution of ground water for tanks and their neglect poses a grave risk of eating into the capital in the long run. From being a common property resource with multi uses, irrigation tanks are increasingly looked upon as percolation ponds meant for groundwater recharge. Though technically an open access resource, ground water turns out to be a private resource since it could be accessed only through wells on owned land. Community wells could help to preserve common property attributes of ground water, if established in adequate numbers. However, available studies indicate that community wells are not present in adequate strength.

Tanks are the proven means for recharging the ground water.

Growing number of wells in the tank ayacut is generally cited as a reason for the declining interest of tank irrigation beneficiaries towards common tank maintenance. Thought to be helpful to supplement tank water conjunctive irrigation once, wells have gained in stature, turning out to be sole sources of irrigation for many farmers in tank ayacut. By privatisation the water, wells afford greater flexibility in individual decision-making in terms of withdrawal rate, timing, crop combinations etc. and thus provide greater incentives for private investment on wells than on common investments on tank maintenance.

Role of wells apart, the changing nature of the village economy and occupations also seem to have contributed to the decline of traditional tank management institutions at local levels. Agricultural sector still remains at subsistence level atleast in areas where it predominantly depends on rains. Tanks have their role to play contingent upon copious rains. Risks associated with rainfed agriculture reinforce low levels of capital formation and farmers tend to seek alternative avenues. Their interest in agriculture declines in general and more so in investing their limited resources on common property resource maintenance, a venture where their private returns are uncertain. This is coupled with the rising costs of agricultural inputs especially labour, chemicals and organic fertilizers. Thus, several factors affect common property maintenance interests of the local user community.

Role of formal governmental agencies in reviving the functionality of tanks either through direct efforts or inducing local stakeholders have not been helpful either. Technically all tank lands are owned by the state and maintenance of tanks with ayacut area of 40 hectares or more is vested with the Public Works Department (PWD) while the rest are managed by local panchayats. Often the functioning of the agencies is dictated by funds allocation and directions from the top rather than being guided by local realities or needs. Besides being irrelevant to the field needs such actions alienate the local stakeholders from active involvement in tank maintenance.

Non-governmental agencies, external lending agencies and academicians have proposed several models to activate local partnership in common property resources management. Under the modernisation programme funded by EEC, local participation has been insisted upon. All these go to indicate that there are institutional issues to be resolved before making participatory management of common property resources by local stakeholders viable and beneficial to the user community.

Issues of Tank Maintenance

Theoretical issues governing management of common property resources have been extensively discussed in the literature. Especially, institutional arrangements, rights assignments and rules for common efforts needed have been analysed under game theory framework. Earlier literature revolved around "tragedy of commons", an outcome of the "prisoner's dilemma" game espousing an inferior equilibrium. These types of arguments have led early analysts to conclude that such a strategy is a dominant strategy and would lead everyone using the common property to be a free rider. Ultimately, the resource is predicted to be degraded and this has been advanced as an argu-

ment for private property rights in early works (Hardin 1968, North and Thomas 1977, Demestz 1967, Cheung 1970). These types of arguments have been contested (for example Runge 1986) on grounds that, free rider behaviour assuming individual decision making independent of other's choices, does not dominate all the situations. Common property resources do have situations involving non-dominant strategies that involve individual choice contingent on other's behaviour. Collective actions do provide beneficial pay offs equal to that of free rider benefits, if not more, when it is internalised after initial enforcement.

The theoretical discussions and dilemmas could not perhaps be resolved on logical grounds alone, ignoring premises. Premises themselves need to be empirically validated before theoretical solutions are attempted. This is the crux of arguments of free rider strategy critics.

Management of tanks is on the decline is a fact in Tamil Nadu. Most of the tanks as a common property resource are being degraded for various reasons discussed earlier of which non-participation of beneficiaries in management is also one. Perhaps one would be tempted to argue that it is due to the free rider strategy being adopted by the stakeholders. The important difference though is that while the free rider strategy suggests an element of overuse and non-cooperation under the assumption of individual benefit maximisation atleast in the short run, no such behaviour could be expected in a tank irrigation situation. There arises a possibility when one takes into account groundwater use under private property premise along with tank water use, but here again groundwater use at whatever level per se cannot directly degrade or overuse tank water except through seepage over which an individual well owner has no direct control.

Management of tanks is on the decline.

Thus, given fields conditions, management of tank resources does not seem to follow game theoretical considerations under a collective action framework. Several factors appear to have worked in general to weaken the binding forces and incentives for collective action for maintaining irrigation tanks. Given that agriculture operates under near perfect market conditions, pay offs to an individual farmer for most of his production strategies and decisions are independent of the others' choices. Given the uncertainity of tank water for irrigation purposes, substituting wells not only frees them from uncertain outcomes of collective action, but also affords them further flexibility in production, decision making, independent of others' choices.

Role of government agencies has only helped to further weaken the incentives for collective action by bringing in more uncertainities through unscientific tank system management. The input and output price regimes faced by the farmers have also been providing more incentives for seeking sources of income other than agriculture. It is in this context that one may have to look at the management of irrigation tanks as a common property resource by local participation and the effectiveness of their maintenance.

An Empirical Sample Study

Attempt is made in this paper to bring out the present environment under which tanks are functioning, their temporal effectiveness and changes, the factors contributing to their maintenance performance.

The results are based on an intensive study of a sample set of villages served by tanks in the state. For the purpose of the study, 100 villages were selected randomly at the rate of 25 villages in four tank intensive Southern districts of Tamil Nadu. They included Madurai, Ramnad, Virudunagar and Sivaganga districts. These villages were post stratified depending on the nature of tanks existing in the village; villages with tanks commanding less than 40 hectare managed by panchayats Unions (PU tanks) and villages with larger tanks covering more than 40 hectares managed by PWD (PWD tanks). This is the sample villages; there were 38 villages covered by PU tanks and 52 villages covered by PWD tanks. There was also a category of villages, ten in number, which were not served by tanks and they were retained as a separate category for comparison purposes. The Southern districts included in the study were more or less following similar agricultural activities and experience, homogenous climatic conditions, as they all fall under the southern agro-climatic- zone. Earlier detailed studies under National Agricultural Technology Projects (NATP) have brought out the homogeneity of the region. Hence the analysis of data was done grouping data according to tank types; PU managed and PWD managed. Data for the study were collected from the study villages using a structural questionnaire. The Village Administrative Officers (VAOs) who are the village level official functionaries provided documented data, besides recall information gathered from knowledge, elderly persons of the villages surveyed.

Socio-economic Backgrounds of Tank Served Areas

Some pertinent data relating to the study villages are presented in this section. The common property

resource, namely, irrigation tanks, is shared by the people of the villages. The growth in population exerts an upward pressure on the sharing of the resources. In an uncertain environment the growing population represented by the growing number of household units further reduces the dependability of tank water for different uses. Subdivision of agricultural units leads to an increase in the number of irrigation stakeholders claiming right on the use of the tank resources. The population details of the village along with households are presented in Table 1. The temporal growth in population households data were based on the recall estimates of the senior citizens of the locality and may be subject to some margin of error. Similar is the case with the number of households uniformly across villages benefited by both PU and PWD tanks and villages that have no tanks in their boundary. Except in the case of PU tank villages to a marginal extent, in all other cases there has been significant net out migration of households signifying a tendency among people to seek income avenues away from the village economy. However, it cannot be ascertained whether this out migration is across villages or to urban localities.

Table 1: Population, households and migration trends in study villages

Particulars	PU	PWD	Non tank	Average
Present population of the village	2872	2399	3479	2687
10 years ago	2557	2006	2887	2304
20 years ago	1933	1700	2363	1855
Present households number	272.13	184.42	212.70	220.58
10 years ago	243.08	162.29	180.70	194.83
20 years ago	211.68	139.81	155.10	168.65
No. of households out migrated in 10 years	8.84	10.90	15.80	10.61
No. of households in migrated 10 years	10.18	3.17	10.90	0.61

PU tanks : 38 NT : 10 PWD tanks : 52

Table 2: Literacy of the villages

Literacy (%)

Literacy category	PU	PWD	Non tank	Average
Adult male literacy	43.79	41.56	44.10	42.66
Female literacy	26.45	28.15	30.90	27.78
General years of schooling; Boys	10.32	8.98	7.40	9.33
Girls	7.97	7.19	6.80	7.45
School attendance rate; Boys	54.39	51.02	57.70	52.97
Girls	41.74	40.77	47.20	41.78

Considering the social background, in terms of literacy (Table 2), there appears to not much variation across villages classified on tank present and type. Yet literacy level is below 50 percent for the adult male population and in the case of adult females around 25 percent. On an average the village population completes only school education, the total schooling year varying from seven to ten years. Here again the girls are in a disadvantageous position.

The standard of living as evident from the consumer goods possession (Table 3) indicates that some development is seen in the village scenario. However, significant differences are seen among the percentage of people owning durable consumer goods like TV, bicycle, motorcycles etc. between villages with and without tanks (both PU and PWD). It is interesting to note that more people of villages that are not served by tanks are able to afford durables. It may have something to do with necessities for diversification and consequent income levels. Between PU tank villages and PWD tank villages, people of PU tank villages appear to be better off relatively. This might be due to the fact that PWD tanks are becoming more difficult for management and thus offer lesser scope for improving the income levels of the people.

Table 3: Indicators of standard of living in the study villages

Particulars	PU	PWD	Non tank	Average
Percent of household owning				
i) Television sets	33.82	18.73	54.30	28.02
ii) Bicycle	86.08	66.29	95.70	76.75
iii) Motor cycle	13.29	6.00	19.00	10.07
iv) Automobile	0.58	0.44	4.60	0.91

Table 4: Local and non-local non-agricultural activities

Categories	% of households employed			
	PU	PWD	Non tank	Average
Households with non-agri local jobs	29.97	11.10	13.00	18.46
Local self employment	3.74	3.40	6.00	3.79
Government employment	4.26	3.31	3.70	3.72
Households with non-agri non-local jobs	19.66	22.02	29.30	21.85
Non-local self employment	3.26	2.00	11.50	3.43
Non-local private employment	7.87	8.42	6.30	8.00
Non-local agricultural labourer	6.21	13.00	6.13	4.21
Non-local government employment	5.21	7.20	4.97	4.05

The possibilities and engagement of people in non-agricultural activities in terms of the percentage of households gives an indication about the employment options of the village (Table 4). In general, non-agricultural activities could be further segregated into non-agricultural employment outside the village as migrant labour. In general, tank served villages appear to offer more non-agricultural employment than non-tank villages. This might be due to the multi use possibilities of tank-based activities, which do not exist in non-tank villages. Among PU and PWD tank villages, PU tank villages seem to offer more possibilities for local non-agricultural employment activities, consistent with the standard of living discussion earlier.

Considering non-local, non agricultural activities, as expected, non tank villages had more participation in all categories, similarly, among PU and PWD tank villages, PWD tank village people depended marginally more on such activities. The non tank village people thus appeared to concentrate comparatively more on non-agricultural activities and were more prepared to work as migrant labour compared to their counterparts in the tank served villages, both PU and PWD types. These opportunities have an indirect effect on the agricultural activities and to an extent reflected in the tank resource maintenance efforts.

Siltation is responsible for the declining performance of the tank.

One of the major factors responsible for the declining performance of the tanks is the siltation that reduces the storage capacity of the tanks, which is relevant atleast in normal and above normal rainfall years, though with lesser frequencies. Studies indicate that some of the tanks have been completely silted and could no more serve their intended purpose. But desiltation is a costly process, with no guarantee that it would provide continuous and consistent benefits. In early days local farmers removed the silt to be used in their fields for soil quality improvement. This process was assisted by the ownership of bullocks and carts by the farmers themselves. Farmers used their own carts for transporting silt from tanks during off and non-cropping seasons. Thus desiltation used to be a continuous process, free of cost. With the introduction of green revolution based high yielding varieties and new technology, emphasis seems to have shifted to organic fertilizers. Besides, fodder crops were replaced by short duration food crops (which again were a boon for minimizing rainfall related water availability uncertainities) and animal maintenance has been done away with tractors that replaced bullock labour for ploughing operations (Table 5). Nearly 75 percent of the farmers were found to be using tractor for ploughing irrespective of whether the villages have tanks or not. Only about sixteen percent of the farmers owned animals, not all of them usable for ploughing. Interestingly, though, only about 1.5 percent of the farmers owned tractors, implying that others depend on hired tractors for ploughing. Thus with changing values of agriculture on account of technology and living standards and with the gradual loss of the private transportation means, the free and slow but continuous desiltation of the tank was lost.

Table 5: Animal labour and machine usage and labour charges

Labour details	PU	PWD	Non tank	Average
Percentage of farmers using bullock labour	29.34	24.06	26.20	26.28
Percentage of farmers owning animals	16.26	13.40	16.40	22.39
Rent for ploughing animals (Rs/day)	107.37	94.42	119.00	101.80
Percentage using tractor for ploughing	70.66	75.94	73.80	73.72
Percentage of farmers owning tractors	1.50	1.48	1.90	1.53
Rent for tractors (Rs/hr)	222.50	232.88	243.50	230.00
Male wage within village (Rs/day)	59.87	55.19	55.00	56.95
Female wage within village (Rs/day)	63.29	63.94	59.00	63.20
Female wage outside village (Rs/day)	32.50	34.23	30.00	33.15

Table 6: Rainfall, frequency of droughts and damages

Particulars	PU	PWD	Non tank	Average
Average yearly (mm) (based on last 25 years)	835	828	906	838
Standard deviation	259	252	232	253
Coefficient of variation	31.02	30.43	25.61	30.19
Number of drought in past 10 years	3.45	3.38	3.50	3.42
Percentage of severe damage	70	78	80	75

The performance of tanks, given other conditions, depends on the rainfall distribution of the region (Table 6). But again, almost uniform distribution of rainfall, observed differences in tank maintenance and performance, could be attributed to factors local to the studied villages, with or without tanks. The rainfall distribution, its standard deviation and co-efficient of variation have all been more or less the same across the

study villages, irrespective of whether they have tanks or not. The frequency of occurrence of droughts and their damage were also perceived similarly by the respondents to the survey across the villages.

Table 7: Sources of extent of irrigation in the study villages

Type of land / Source of irrigation	Area irrigated (acres)			
	PU	PWD	Non tank	Average
Wet land under irrigation	150.21	355.32	72.53	249.10
Total wet land	188.28	436.52	72.55	305.79
Dry land under irrigation	[illegible]	[illegible]	[illegible]	126.77
Total dry land	1170	1010	1400	1110
Area irrigated by:				
Private tube well Tank season	0.08	0	0	0.03
Dry season	0.08	1.02	0	0.56
Private dug well: Tank season	6.43	14.76	144.59	24.58
Dry season	8.92	22.56	25.21	17.64
Community well: Tank season	0	4.96	0	2.58
Dry season	0	0.06	0	0.03
Tanks : Tank season	147.15	354.57	0	240.29
Dry season	50.28	8.95	0	23.76
Canals: Tank season	1.79	1.29	72.54	8.60
Dry season	1.78	0.46	25.61	3.48

Tanks had been the predominant source of irrigation in villages (Table 7), whereas private dug wells and whatever possibilities existed, canals were the dominant sources. An interesting feature is that while almost hundred percent of lands classified were irrigated during the period under survey. Thus, out of 188 acres of wetlands in PU tank villages only 150 acres were actually irrigated, while out of 436 acres in PWD tanks only 355 acres were irrigated, In non-tank villages, on the other hand, 72 acres classified as wetlands were all irrigated. Even lands classified as dry lands or garden lands, non-tank villages, were able to provide irrigation to proportionately higher area compared to the tank served villages, both with PU or PWD tanks. This gives the impression that wells and canals provide more secure irrigation than tanks. Also, PWD tank villages had marginally higher average number by the order of ten, indicating that no-tank villages exclusively depend on wells, where canal or other sources of irrigation are absent. The reliability of tank as a source of irrigation, which falls short of other possible sources, namely wells and canals, has implications for the community efforts to maintain them.

The tank water distribution at the local level still vests with informal arrangements among the users. Almost all the tanks surveyed had some sort of informal grouping or organisations, which may be loosely termed Water Users Associations. Only in a single PWD village there was an effort to form a formal Water Users Association, which did not progress well (table 8). These informal associations were mostly concerned with management through restrictions imposed on the crop acreage and consequent water use. Additionally they also tried to negotiate with the government or other villages.

Table 8: Activities and distribution water user groups to manage drought.

Activities	PU tank villages	PWD tank villages
Restrictions on area/ water use	24	29
Negotiation with government/other villages	2	1
No efforts	9	19

Table 9: Tank modernisation

Particulars	PU	PWD
Tanks modernised recently	21	30
Invested by: Government	14	29
Panchayats	4	–
Users	3	1
No. of Tank works subsidized	18	25
By Government	1	1
Panchayats	17	–
PWD works	–	28
In how many works villagers participated	17	15
Participants paid cases	17	13

Other than the limited purpose of regulating, the available water supply to the member users, these informal water users associations had not engaged themselves in tank maintenance activities in any significant way. Their resource base to undertake such activities were practically non-existent. The number of users in an y given tank environment being limited, the scope for self resource mobilisation by these groups were limited as well. Whatever modernisation or maintenance efforts were undertaken in the tanks surveyed were all practically sponsored and implemented by the government through its agencies (Table 9). Only about fifty percent of the tanks in each category were taken up for maintenance works in the recent past.

Factors relevant and tank maintenance probabilities – an LPM model

In the earlier sections some of the factors that have an impact on tank maintenance were discussed with empirical data drawn from a sample set of tanks. Not all tanks are regularly maintained. Thus tank maintenance is a binary variable for a given tank which assumes a value either zero or one. Different tanks when compared may assume either value at random, which might be related to the underlying tank environment factors. The conditional probability P_i that a given tank with certain ayacut area (T_i) will be subjected to maintenance (M_i = 1) can be expressed as a Linear Probability Model (LPM),

$$P_i = E\,(M_i = 1 \mid T_i) = Z \qquad (1)$$

One can postulate a functional relationship,

$$Z = f\,(X_i); \qquad i = 1 \ldots n \qquad (2)$$

To avoid certain economic problems of LPM, normally a probability density function is used to surrogate LPM. Either logistic function or normal distribution function is used. Assuming logistic in particular, the resulting logit model becomes,

$$P_i = E\,(M_i = 1 / T_i = 1/1 + e^{-z} \qquad (3)$$

Noting that probability of non-maintenance is given by $1-P_i$, the odds ratio is obtained as,

$$P_i /(1- P_i) = e^{zi} \qquad (4)$$

Which on taking log on both sides and assuming a linear form for the functional relationship postulated in (2) becomes,

$$ln\,[P_i / (1- P_i] = b0\,] \qquad (5)$$

Since P_i assumes either one or zero, for a given tank ayacut area, one may use time series data on maintenance to arrive at an estimate of P_i under the assumption that the tank system structure is fixed, and thus ln $[P_i / (1-P_i)]$, where P_i can be replaced by estimated P_i as above. But U_i in (5) heteroscedastic and is distributed as,

$$U_i \sim N\,[0,\, 1/N_i P_i\,(1-P_i)] \qquad (6)$$

The resulting equation can be estimated through weighted least squares (WLS) which is equivalent to applying OLS to the transformed equation obtained by weighing variables.

$$\sqrt{w_i}\,L_i = \beta_1 \sqrt{w_i} + \beta_2 \sqrt{w_i}\,X_2 + \ldots + \beta_n \sqrt{w_i}\,X_i + \sqrt{w_i}\,U_i \qquad (7)$$

where $w_i = N_i P_i\,(1-P_i) = L_i = \ln\,[P_i / (1-P_i)]$. N_i is the number of years over which maintenance frequency is computed and needs to be reasonably large. The usual R^2 as a measure of goodness of fit may not be so in logit models. (The model is estimated as passing through origin (without the intercept) since the first term gives the estimate of intercept as it reduces to (5) when all weights are equal to one). In the present case the above model is applied to the tank maintenance data over different period of years as obtained from the survey. The specific model tried was, I_n

$$ln\,P_i/(1-P_i) = \beta_1 + \beta_2\,Non\ ag.hh/thh + \beta_3\,Dro\ freq + \beta_4\,Vill.wage + \beta_5\,wells + \beta_6\,AdMaLit + \beta_7\,PU/PWD\ \beta_8\,Trac\ Use\% \qquad (8)$$

Table 10: Estimation results of Logit model

Variable	Coefficient	Standard error	t-statistics	p-value
Intercept (u_{ti})	–0.0204	0.3667	–0.0557	0.9557
Nonag.hh/thh	–2.3841	0.8725	–2.7325	0.0077
Dro. Freq	–0.0821	0.0166	–4.9298	0.0000
Village	–0.0075	0.0045	–1.6861	0.0956
Wells	–0.0013	0.0017	–0.7602	0.4493
Ad Mal Lit	0.0052	0.0028	1.8525	0.0676
PU/PWD	–0.2067	0.1035	–1.9971	0.0491
Trac Use %	0.0201	0.0221	0.9216	0.2493

The variables included in the above model and their computations are briefly as follows:

P_i: represents the *probability of tank maintenance* works undertaken in the tank system. The frequency of major maintenance works namely repair of the sluices, desilting, supply channel cleaning undertaken in the past 15 years as collected from locally informed persons were used to construct the variable. Though each of these works could be done in isolation or in combination, for computation of frequency of maintenance, each of them were treated individually as each of them were treated as a major item of work in many cases and implemented separately. Wherever they were done jointly, they were counted as a single maintenance occurrence.

Non ag.hh/thh: represents the *ratio between non-agricultural households in the village to the total households* of the village during the survey year. Higher the ratio lesser the frequency of maintenance works expected.

Dro.freq: represents *drought frequency* of the tanks measured in terms of more than 75 percent failure of expected inflow of drought frequency on maintenance works. Apriori, infrequent droughts may encourage proper maintenance of tanks in the hope of harnessing water to mitigate late season scarcity. On the contrary, if the frequency is more and persistent, it may lead to a perception that whatever maintenance is done is a waste and thus contribute negatively to the maintenance efforts. Earlier studies and literature quote uncertainity in rainfall and water receipts as one of the reasons of neglecting maintenance works. Hence the effect of drought frequency is an empirical issue.

Vill. wage: *wage rates in the locality* were found to be more or less homogenous and adult male wage rates in the locality remained more or less constant the analysis is not gender biased for the purpose on hand. Higher wage rates, by escalating the production cost, in the absence of commensurate increase in the output prices (a view expressed by the majority of the interviewed persons) depresses the incentives for additional investments on tank maintenance works. Additionally, it may encourage cultivators to turn into labourers.

Wells: the number *of private wells in the ayacut area* and their effect is expected to be negative on maintenance efforts as discussed in the earlier sections.

AdMalLit: represents *adult male literacy* and is included as a proxy for the ability of the local tank stakeholders to perceive the problems in their perspectives. Though not necessary, collective action comes out of informed judgment brought about by awareness created through literacy. The percentage of adult literacy in the village was included in the analysis. It is expected to contribute positively for maintenance efforts.

PU/PWD: is a *dummy variable* to account for the management structure of the tanks. PU tanks were assigned the value zero and PWD tanks the value of one. PWD management, being removed from local realities through bureaucratic management, is expected to contribute negatively to the maintenance.

Trac Use%: represents the *percentage of cultivators using tractors for ploughing* operations in their cultivated lands. Higher reliance on tractors is associated with factors like timeliness of the operations with available moisture, non availability and higher costs of bullock and human labour. These factors imply that the opportunity cost of labour is high when put to maintenance of the tanks. Overall one is inclined to expect a negative relationship between tractor use and tank maintenance efforts.

Results

Above logit model was estimated using the data relating to ninety villages, pooling both PU and PWD tank villages, by introducing the management dummy variable. As noted already, weighted least squares method was used to estimate the model parameters. Results of the analysis are presented in Table 10 and were found to be broadly in agreement with expected signs. R square of the estimated model was 0.5129 with adjusted R square out to 0.4592.

Among the variables, proportion of non agricultural households, and drought frequency were found to be associated with high negative impact on tank maintenance efforts as implied by the coefficients, significant at one percent probability level. PU/PWD management affected maintenance negatively at five percent level, and wage levels again had a negative effect on maintenance efforts, though at a lesser ten percent significance level. Only adult male literacy and tractor use percentage had a positive effect on tank maintenance and among them only the former was significant. The effect of tractor use is not clear, the co- efficient being non-significant.

Among the variables ratio, non-agricultural households among total households was observed to have the highest absolute impact on the probability of tank maintenance efforts. When the ratio increased by one percent tank maintenance activities decline by 2.38 percent. Considering the fact that maintenance was quantified in terms of number activities and not in value terms, the decline in probability is significant. Increase in non agricultural households result not only out of demographic changes but also due to poor and marginal farmers turning to avenues other than agriculture. Next variable to have considerable impact was the type of tanks. Considerable difference existed in the maintenance efforts between PU and PWD tanks and the probability of difference was about 0.2 percent. Similarly an one percent increase in drought frequency dampens maintenance efforts by about 0.8 percent. Frequency of droughts, wage levels and presence of wells did not appreciably influence tank maintenance in terms of absolute probability levels, irrespective of their levels of significance.

Conclusion

The general nature of the above sample analysis and logit results indicates that the prevailing environment and attributes of user stakeholders are not very conducive for effective and frequent maintenance of tanks. This is evident from the fact that most of the variables of the logit model estimated were negative. A

positive indication of the results is that improving literacy could contribute for better maintenance frequency of the tanks. Yet, among the odds, its ultimate viability and limits is somewhat open to question. While primary literacy may help to create an awareness of the benefits of common management efforts, enhanced literacy levels might also lead to out migration of individuals and households from the localities as well as agricultural operations which may in turn adversely affect maintenance by increasing the ratio of non agricultural households among the total households.

While the logit analysis helps to clearly bring out the nature and direction of quantitative inter relationships among tank maintenance and possible contributory factors, to address practical management implementation in a more effective way one may need further recourse to field observations and analysis of institutional arrangements, both formal and informal.

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You only live once. But if you work it right, once is enough.

– Fred Allen

News & Notes

Labour Productivity

Labour Productivity Growth Rate (%) is an index used as a base in measuring the efficiency of labor input where "real GDP" index is regarded as the output and "labor working hours" index is regarded as the input.

Table 1: Labour Productivity Growth Rate (%)

	Bangla-desh	Republic of China	India	Japan	Republic of Korea	Malaysia	Pakistan	Singapore
1991	2.82	5.38	**-0.82**	2.87	6.21	4.90	6.11	1.90
1992	2.42	5.50	**4.17**	1.93	4.53	4.40	4.51	3.22
1993	1.69	5.96	**4.95**	1.86	4.09	4.00	0.66	9.17
1994	2.85	4.68	**6.29**	1.37	4.98	6.10	1.90	6.61
1995	2.59	5.70	**6.38**	1.05	5.50	6.60	4.26	2.90
1996	3.38	5.82	**6.87**	3.72	5.22	5.70	4.19	1.36
1997	2.98	6.50	**3.82**	2.18	5.22	5.60	-4.74	2.30
1998	1.10	4.69	**5.61**	0.07	1.52	-1.80	-2.72	-2.80
1999	3.09	4.48	**5.09**	1.49	3.82	3.90	1.86	7.41
2000	4.36	4.98	**3.02**	1.58	5.29	6.10	1.64	5.95

Table 2: Labour Productivity Growth Rate: Industry Sector (%)

	Bangla-desh	Republic of China	India	Japan	Republic of Korea	Malaysia	Pakistan	Singapore
1991	6.88	7.08	**-2.62**	3.08	3.85	1.10	n.a.	3.10
1992	7.80	4.58	**-0.04**	-3.56	8.90	-2.50	n.a.	4.40
1993	8.22	4.87	**1.10**	-1.07	7.63	3.90	n.a.	6.59
1994	9.86	2.67	**5.81**	2.45	8.63	2.00	n.a.	8.75
1995	6.98	5.76	**7.14**	4.36	6.29	3.50	n.a.	3.46
1996	5.80	6.84	**2.70**	3.20	9.87	5.00	n.a.	-0.60
1997	8.32	2.70	**-0.05**	4.83	11.27	-0.40	n.a.	0.83
1998	4.92	3.99	**-0.93**	-4.06	8.13	-5.80	n.a.	-1.39
1999	5.55	5.52	**0.75**	2.99	11.28	7.80	n.a.	12.40
2000	2.45	4.26	**1.71**	6.17	9.00	17.10	n.a.	9.23

Table 3: Labour Productivity Growth Rate: Agriculture Sector (%)

	Bangla-desh	Republic of China	India	Japan	Republic of Korea	Malaysia	Pakistan	Singapore
1991	2.46	0.76	**-3.59**	0.80	17.94	3.45	17.53	n.a.
1992	2.53	1.76	**6.01**	7.16	13.88	12.54	3.99	n.a.
1993	0.85	12.48	**4.33**	-1.41	-5.43	6.35	-6.51	n.a.
1994	-0.30	0.88	**5.22**	12.65	8.40	4.75	-2.41	n.a.
1995	3.10	4.47	**-0.67**	-3.17	15.70	-0.03	13.51	n.a.
1996	6.00	4.28	**9.83**	1.04	14.65	5.88	9.08	n.a.
1997	3.19	4.60	**-2.23**	3.55	12.32	1.35	-0.07	n.a.
1998	4.77	1.63	**7.28**	-2.82	-10.88	-2.53	-7.10	n.a.
1999	6.43	7.77	**0.70**	5.58	8.74	2.50	-0.31	n.a.
2000	5.64	6.49	**-0.02**	4.80	2.74	0.50	3.84	n.a.

Table 4: Labour Productivity Growth Rate: Service Sector (%)

	Bangla-desh	Republic of China	India	Japan	Republic of Korea	Malaysia	Pakistan	Singapore
1991	4.40	3.87	**2.53**	3.50	3.54	8.18	-5.03	3.10
1992	3.89	5.66	**3.53**	-1.12	-1.65	-0.22	-0.77	2.02
1993	4.28	4.74	**5.78**	1.13	1.79	8.01	-6.72	10.35
1994	4.87	5.46	**5.18**	1.02	2.99	6.82	4.33	6.04
1995	3.96	5.73	**8.46**	0.91	3.37	7.62	2.86	2.96
1996	4.51	4.17	**5.23**	1.50	1.83	4.30	4.18	2.82
1997	4.96	8.80	**7.71**	1.67	2.60	6.00	-8.65	3.67
1998	5.16	4.87	**6.15**	-1.07	2.33	-3.47	-7.49	-3.76
1999	5.26	2.63	**7.58**	1.86	2.62	0.74	4.00	3.81
2000	5.34	4.70	**2.79**	2.12	1.69	2.79	16.26	3.20

Unleashing Creativity for Generating Ideas

How do creative people come up with ideas? W. Young, author of A Technique for Producing Ideas, insists that the production of ideas follows a process as concrete as that for producing cars. According to Young, a "new" idea is a combination of old elements and being able to devise new combinations depends on the ability to discern relationships between seemingly disparate items. Advertising copywriters, poets, scientists, engineers, and a host of other professionals have used the technique successfully since the first publication of Young's book in 1965 His five simple steps are:

1. Gather material. Be endlessly curious and collect specific and general information from as many sources as possible. Store your data in whatever form you wish: on a computer or electronic organizer, on file cards, in a series of notebooks. Putting accumulated information in your own words helps you remember, clarify thought processes, and disclose gaps. This step should become a lifelong quest.
2. When facing a specific problem digest all your information. Turn the facts over in your mind, bringing different ones together to see how they relate – or don't.
3. Stop thinking about the problem. Let your subconscious take over for a while, analogous to an incubation period.
4. While you are still not thinking about the specific issue, an idea will occur. It may come while you are in the shower, repairing a bicycle, or walking along the street.
5. Examine the idea in the harsh light of reality. Submit it others for criticism and modification for practical use. You'll be surprised at how often one good idea breeds another, either your own or someone else's.

Source: APO News, 2003.

Welfare versus Productivity

The level of welfare of the current member states of the European Union (EU) is unequalled – the vast bulk of their citizens are looked after from the cradle to the grave. This has been enabled by continuous productivity growth and the equitable sharing of its fruits.

Today, however, productivity rarely figures in national debates on the maintenance of the welfare state. Furthermore, the EU's lofty 2000 targets of making it "the world's most competitive information economy" by the year 2010 (essentially by reducing national barriers to further productivity growth) are all but forgotten. Rather, Europe's concerns are with maintaining current levels of welfare in a situation of economic stagnation: employment, unemployment benefits, health systems, old-age pensions, and security. Indeed, governments, both national and European, are apparently working against productivity enhancement despite (implicitly) realizing that it remains the key to economic growth and hence the ultimate source of welfare. Consider the following typical situations:

To help extract the current "sick man of Europe" from its no-growth hole, the German government – two-thirds of whose parliamentary members are trade unionists – has presented reforms aimed at encouraging productivity and entrepreneurship by reducing taxation (which penalizes productive activity and job creation) and making labour markets more flexible. The latter means easing restrictions on dismissals in smaller companies (to encourage more hirings) and trimming unemployment benefits, the current levels and durability of which hardly "make working pay." Other measures include additional incentives for part-time work, removing obstacles to the use of temporary workers, and more efficient labour agencies. However, there is vociferous opposition to such increased flexibility, especially from the trade union movement, and this is despite the government's background.

In France, as well as in Austria and Italy, it is the government's old-age pension reform that is the subject of considerable opposition. Currently some 75 per cent of the working population retires before reaching age 60. Yet life expectancy continues to rise. Thus, a declining workforce – like it or not – has to be ever more productive to pay for the growing army of pensioners (productivity per hour of a French worker equals that of an American). And the dire financial straits of the government are compounded by its actions to smoothen structural change in the economy by payrolling the exit from the working population of older (50 years), especially unskilled, workers. The French, like the Austrians, Italians, and others, realize that sacrifices have to be made, but... not at the expense of "my" welfare. Thus, a congregation of vested interests stymies change. And no one advocates striving for productivity – *quelle horreur* – which remains strongly

associated in the public mind with both working harder and inevitable job losses. So let's not reduce welfare, even though the current level could not be sustained, and certainly make no admonishments to work more or even smarter.

Ireland's productivity-cum-welfare concern is different; its remarkable productivity growth since 1989 has been paralleled by a 50 per cent rise in alcohol consumption. This increase has in turn been responsible for a loss of productivity and growing public expenditure on the consequences of alcohol abuse—equivalent to almost 2 per cent of national output. To counter this phenomenon, the government, rather than legislate, is urging the drinks industry to discourage youth from drinking.

And then, even more important, there is the EU level. In 2002, the European Commission produced a white paper on "Productivity: The Key to Competitiveness of European Economies and Enterprises." It sounds good. However, in 2003, it has made proposals to reduce health hazards, especially allergies. Industries must submit risk assessments for virtually all chemicals circulating within the EU, some 30,000 of them. This is likely to cost Euro 7 billion in the coming decade. On the other hand, as France has demostrated, productivity improvement often results from enterprises turning threats into challenges. In this case, the health benefits for society as a whole from reduced chemical hazards could far exceed the expenditure to achieve this, and enhanced occupational health and safety is a significant contributory factor to productivity development.

These instances indicate some of the ways in which governments are groping for sticks and carrots to ensure—as in Scandinavia—that welfare can better be harnessed for productivity growth and that enhanced productivity can enable welfare to be sustained.

First, governments have to decide on action albeit after broad consultations, and then act decisively. At the EU level in particular, there remain many domains in which action is needed to ensure a more "level productivity playing field." New laws are currently being drafted to enhance the four freedoms of movement (of labour, capital, goods, and services), European public tendering, and mutual recognition of training and taxation systems, among others. But between the drafting and passing of legislation, there are many vested interests to be tamed.

Second, there is the role of the enterprise itself, the generator of national income. Obviously, the benefits of striving to become ever more productive and innovative have to be rewarding for all stakeholders. Law plays a significant role here, but enterprises also need to be aware of their "corporate social responsibility"—their policies and actions must enhance their employees' and community's quality of life. This requires a notably improved understanding of how profits and growth can be balanced with sustainability and environmental improvement, a subject of growing interest.

Third, a new force for sustainable productivity promotion is emerging: the insurance and reinsurance industry. Three decades ago, the tobacco industry rejected claims that it could be held responsible for an individual's long cancer. This is no longer possible. Today insurance companies are increasingly concerned, for example, that carbon dioxide-producing industries could be the subject of vast future claims for causing global warming, with repurcussions on insurers. They are therefore taking a proactive stance toward companies that have not themselves already detected early signs of possible claims. Thus, in the future, private enterprise could well play a significant role in policing companies' sustainable productivity growth.

Anthony C. Hubert
President of EuroJobs

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Compiled by
Arundhati Chattopadhyay
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Articles

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"Agricultural Statistics in India", P.C.Bansil (ed), CBS publishers and Distributors, New Delhi, 2002, page 786, price : Rs.395.00. *(Reviewer: Rajesh Sund) Vol. 43(1):168*

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