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Contents

Drought? Try Capturing the Rain

Anil Agarwal

It is possible to banish drought completely—and in ten years maximum if the government puts its mind to it. The article presents a plan for rain water harvesting.

Anil Agarwal was Member of World Water Commission and is Currently Director, Centre for Science and Environment, New Delhi.

Several parts of the country witnessed a serious drought this year. The result was acute drinking water shortages in Gujarat, Rajasthan, western Madhya Pradesh, Orissa and Andhra Pradesh. According to newspaper reports, several towns in Saurashtra were getting an extremely irregular supply of water (see Table 1). Most of the medium dams and reservoirs in the region dried up. The government tried to deal with the problem by providing water through tankers and by deepening existing borewells. The Central government promised to run water trains. But is all this inevitable? Do we have to do this every time the rainfall is less than normal? This problem can be solved almost permanently unless, of course, there is a series of consecutive droughts for several years. The change will come, if political leaders are prepared to promote a new approach to water management.

Table 1: Drinking Water Availability in Gujarat Towns in April 2000

Place	Availability of drinking water
Rajkot (1)	30 minutes every alternate day
Jamnagar, Jasdan and Amreli (1)	20 minutes once in three days
Jodiya town, Jamnagar district (2)	20 minutes in 12 days
Dhrol town, Jamnagar district (2)	Half the population gets water once in eight days

Sources:

(1) Janyala Sreenivas 2000, Forget the Sensex for a second, look what else is going down, Indian Express, New Delhi, April 19, p. 1.

(2) Janyala Sreenivas 2000, Once a fortnight, they get a few drops and that too for 20 minutes, Indian Express, New Delhi, April 21, p. 1.

During one of the meetings of the World Water Commission, which submitted its report in the Hague in April 2000 to a bevy of water ministers, a member had strongly emphasized the need for educating politicians about the importance of water. However, there is rarely a politician, especially in India, who does not emphasize the importance of water. But hardly any of them know how to solve the water problem. Not surprisingly, few government initiatives have been able to deliver the goods as the current unprecedented drought has shown in such starkness. The portents of this so-called once-in-a-century drought has become clear as far back as September 1999 when national elections were being held and Shri L.K. Advani had to face slogans like *'Pehle Paani Phir Advani'* in Saurashtra. As far back as December, many villagers in north Gujarat had begun to leave home because of water shortage. Once the monsoon season was over, the government could not have done anything to solve the water problem except to provide some succour in terms of drought relief works, emergency water supply through tankers, and digging deeper borewells for some residual water in the bowels of the earth.

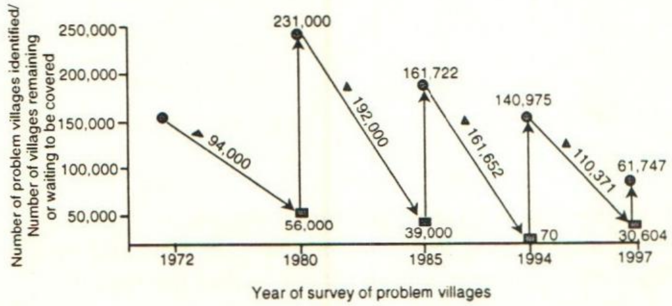
But this is not enough. Many will term what is happening in Gujarat and Rajasthan a 'natural disaster'. This is really far from the truth. It is truly a 'human-made' or rather a 'government-made' disaster. Over the last one hundred years or so, the world and India, too, have seen two major shifts in water management. One is that individuals and communities have steadily given over their role almost completely to the state even though more than 150 years ago no government anywhere in the world provided water. The second is that the simple technology of using rainwater has declined and in its place exploitation of rivers and groundwater through dams and tubewells has become the key source of water. As water in rivers and aquifers is only a small portion of the total rainwater, there is an inevitable and growing and, in many cases, unbearable stress on water from rivers and groundwater.

The world and India have seen two major shifts in water management. The simple technology of using rainwater has declined exploitation of rivers and groundwater through dams and tubewells has become the key source of water.

Dependence on the state has also meant that costs of water supply are high; with cost recovery being poor the financial sustainability of water schemes has run aground; and repairs and maintenance is abysmal. With people having no interest in using water carefully, the sustainability of water resources has itself become a question mark – problems we see across the board today. As a result, there are serious problems with government drinking water supply schemes. Despite all the government efforts, the number of 'problem villages' does not seem to go down. As N.C. Saxena, former rural development secretary puts it, "In our mathematics, 200,000 problem villages minus 200,000 problem villages is still 200,000 problem villages" (see Graph 1).

Graph 1: UNENDING EXERCISE: Record of government rural drinking water supply schemes

The graph shows that even though a large number of villages are covered between two surveys the number of problem villages keeps growing. For instance, in 1980, there should not have been more than 56,000 problem villages, but there were 231,000. Obviously, the money pumped in and the methods used were unsustainable.



- ● Number of Problem villages identified
- ■ Number of villages covered during the specified survey period
- ▲ Number of villages waiting to be covered

Year of Survey	Number of Problem Villages identified	Number of villages covered till the next survey	Number of villages not covered before the next survey
1972	150,000	94,000	56,000
1980	231,000	192,000	39,000
1985	161,722	161,652	70
1994	140,975	110,371	30,604
1997	61,747		

Source: N.C. Saxena, Ministry of Rural Development, Government of India

Given the fact that India is one of the most well-endowed nations in the world in terms of average annual rainfall, there is no reason why it should suffer from drought. This year or any other year. The most important lesson that our decision-makers should learn from the current crisis is how to drought-proof the nation in the years to come – a task that can easily be accomplished in less than a decade if the country puts its mind to it.

The government has indeed invested heavily on water resources development. But these programmes have focussed mainly on:

- Large-scale irrigation development for increasing Green Revolution-style agricultural production and,

* Drinking water supply programmes.

Yet large parts of the country remain drought-prone. This is because no specific effort has been made to drought-proof rainfed areas which suffer from high rainfall variability from year to year and season to season. Moreover, the government has encouraged a massive intervention into the country's hydrological cycle but it has precious little to sustain the integrity of the hydrological system. A fine example of the disintegration of the country's hydrological system is what we are doing to our groundwater. The country has been constantly encouraging exploitation of groundwater but has done little to recharge it. As a result, groundwater tables are falling all over the country. Considering the fact that over 90 per cent of rural Indians depend on groundwater to get their drinking water, the decline poses a serious problem which becomes an emergency in a year when the rains are low as in this year. The poor, who depend on dug wells, which dry off first, as compared to tubewells or borewells, are the first to suffer.

Communities & Rain

Community-based rainwater harvesting—the paradigm of the past—has in it as much strength today as it ever did before. A survey conducted by the Centre for Science and Environment (CSE) of several villages facing drought in Gujarat and western Madhya Pradesh last December—Ghelhar Choti in Jhabua district, Thunthi-Kankasiya in Dahod district, Raj-Samadhiyala and Mandlikpur in Rajkot district, and Gandhigram in Kachchh district—found that all those villages which had undertaken rainwater harvesting and/or watershed development in earlier years had no drinking water problem whatsoever and even had some water to irrigate their crops. On the other hand, neighbouring villages were desperate for water and planning to migrate when the real summer hit them. This survey revealed that rainwater harvesting can meet even the acid test of a bad drought.

In late March, we got further confirmation of our conviction. Going with President K.R. Narayanan in a helicopter to the Arvari watershed to give the *Down to Earth*-Joseph C John Award to village Bhaonta-Kolyala in late March, we could see nothing but barren fields all the way from Delhi to Alwar. This area is suffering from a second consecutive drought-year. But suddenly we came across green and golden fields and realised that we had reached the oasis of the Arvari watershed where several villages have over the last 5-10 years built hundreds of rainwater harvesting structures. The President saw a more or less dead Arvari river, unable to withstand the burden of two years' drought, but wells were still full for water and, therefore, fields were rich and productive and villagers reasonably happy.

Getting Priorities Right: Potential of Rainwater Harvesting

What makes rainwater harvesting such a powerful technology? Just the simple richness of rainwater availability that few of us realise because of the speed with which water, the world's most fluid substance, disappears. Imagine you had a hectare of land in Barmer, one of India's driest places, and you received 100 mm of water in the year, common even for this area. That means that you received as much as one million litres of water—enough to meet drinking and cooking water needs of 182 people at a liberal 15 litres per day. Even if you are not able to capture all that water—this would depend on the nature of rainfall events and type of runoff surface, among other factors—you could still, even with rudimentary technology, capture at least half a million litres a year. It is, in fact, only with this rudimentary technology that people came to inhabit the Thar desert and have made it the most densely populated desert in the world. And assuming you could capture the 2000 mm annual rainfall that is common in eastern India, you would need only 500 square metre of land (a 21 metre by 21 metre plot) to capture one million litres. It is also interesting to note that rural population density follows intensity of annual rainfall. Barmer, for instance, has less rainfall but few people and a lot of land available per person whereas 24-Parganas in West Bengal has much more rain but more people and less land available per person.

Even in the villages suffering from drought this year, it is not as if there was no rain. In many areas like Andhra Pradesh, Orissa and western Madhya Pradesh the rainfall levels, though lower than normal, were still more than 500 mm, which is an enormous amount. The average annual rainfall in Saurashtra and Kachchh, the worst affected, is 578 mm. This year, according to newspaper reports, it was very depressed but still around a couple of hundred millimetres (mm). But the people of Saurashtra and Kachchh let the water go. It does not matter how much rain you get, if you don't capture it you can still be short of water. It is unbelievable but true that Cherrapunji which gets 11,000 mm annual rainfall, still suffers from serious drinking water shortages.

In fact, we have consistently argued that there is no village in India that cannot meet its basic drinking and cooking needs through rainwater harvesting. Figures speak for themselves. India's average annual rainfall is 1170 mm. It varies from 100 mm in the deserts of Western India to 15,000 mm in the high rainfall hills of the North-east. Nearly 12 per cent of the country receives an average rainfall of less than 610 mm per annum while 8 per cent receives more than 2500 mm. But more than 50 per cent of this rain falls in about 15 days and less than 100 hours out of a total of 8760 hours in a year. The total number of rainy days can range from a low of five days in a year in the desert regions of Gujarat and Rajasthan – though on some of these days there can be high-intensity rainstorms – to 150 days in the Northeast. Therefore, it is very important to capture this rainwater which just comes and goes in a few hours.

> **There is no village in India that cannot meet its basic drinking and cooking needs through rainwater harvesting.**

Recognising this fact that almost all the rain comes down in a few hours, our ancestors had learnt to harvest water in a variety of ways:

- They harvested the rain drop directly. From rooftops, they collected water and stored it in tankas built in their courtyards. From open community lands, they collected the rain and stored it in artificial wells called kundis.
- They harvested monsoon runoff by capturing water from swollen streams during the monsoon season and stored it in zings in Ladakh, ahars in Bihar, johads in Rajasthan and eris in Tamil Nadu, to name a few.
- They harvested water from flooded rivers in places like North Bihar and West Bengal.

In 1991, India had 587,226 inhabited villages with a total population of 629 million giving us an average population of 1071 persons per village, up from 942 persons in 1981. Let us, therefore, assume that the average population of an Indian village today is about 1200. India's average annual rainfall is about 1170 mm. If even only half this water can be captured, (though with technology inputs this can be greatly increased), an average Indian village needs 1.12 hectares of land to capture 6.57 million litres of water it will use in a year for cooking and drinking. If there is a drought and rainfall levels dip to half the normal, the land required would rise to a mere 2.24 hectares. The amount of land needed to meet the drinking water needs of an average village will vary from 0.10 hectares in Arunachal Pradesh (average population 236) where villages are small and rainfall high to 8.46 hectares in Delhi where villages are big (average population 4769) and rainfall is low. In Rajasthan, the land required will vary from 1.68-3.64 hectares in different meteorological regions and, in Gujarat, it will vary from 1.72-3.30 hectares. And, of course, any more water the villagers catch can go for irrigation.

Does this sound like an impossible task? Is there any village that does not have this land availability? India's total land area is over 300 million hectares. Let us assume that India's 587,000 villages can harvest the runoff from 200 million hectares of land, excluding inaccessible forest areas, high mountains and other uninhabited terrains, that still gives every village on average access to 340 hectares or a rainfall endowment of 3.75 billion litres of water. These calculations show that the potential of rainwater harvesting is enormous and undeniable. There is just no reason whatsoever for thirst in India.

Therefore, it is possible to drought proof the entire country. Not just drinking water, most of India's agricultural fields should also be able to get some irrigation water to grow less water-intensive crops every year through rainwater harvesting. The strategy for drought proofing would be to ensure that every village captures all the runoff resulting from the rain falling over the entire land and the associated government revenue and forest lands, especially during years when the rain was normal, and store it in tanks or ponds or use it to recharge the depleting groundwater. It would then have enough water in its tanks or in its wells to cultivate substantial lands with water-saving crops like millets and maize.

Even with a national water grid or all the proposed dams like those on the Narmada being built, there just isn't going to be enough river water to provide irrigation to every single village of India. A substantial part of India's agricultural lands will remain rainfed. This is confirmed by official statistics. The National Commission for Integrated Water Resources Development Plan has estimated that the ultimate irrigation potential is as much as 140 million hectares. Some 75.9 million hectares will be irrigated by surface water schemes – of which 58.47 million hectares will be irrigated by major and medium projects and 17.38 million hectares will have to be irrigated by minor irrigation schemes like tanks – while 64.1 million hectares will be irrigated by groundwater. But all this is still a dream. As of 1992-93, 119.3 million hectares were rainfed, of which 78.43 million hectares were under foodgrains (IWRDP, 1999). But there is enough rain which with a good combination of rainwater harvesting and groundwater recharge, can increase the productivity of this rainfed land. These lands today support some of the poorest people in the country. And if we don't do this, people living in rainfed areas will not prosper.

Drought-proofing Vs Large-scale Irrigation

But for this to happen, our planners and politicians will have to stop confusing irrigation for drought-proofing with large-scale irrigation for Green Revolution-style agricultural development. Otherwise, the country will get its priorities wrong and tens of millions of poor people will continue to suffer the horrors of drought. Depending on the availability of money and resolution of problems like rehabilitation, both can be attempted but priority must go to drought-proofing measures which require little money is comparison and will bring results within 5-10 years.

Drought-proofing and large-scale irrigation development are not a substitute of each other. What one can do, the other cannot. Firstly, only after all the proposed dams are built to promote large-scale irrigation development and interlinking of rivers takes place, every piece of the country's cultivated land will see the benefit of canal irrigation. These lands will have to depend either on groundwater or local water harvesting. Heavy use of groundwater can only be sustained if there are local efforts to keep recharging the groundwater. Therefore, large-scale irrigation development is no substitute for drought-proofing based on local water harvesting systems and sustainable use of groundwater.

The second argument against large-scale irrigation development follows from the first. Big dams can only help to create pockets of Green Revolution-style agricultural production (with water-intensive crops) but they cannot drought-proof the whole country. As a result they can at best create 'national' food security as they have done uptil now—which means that few districts of the country generate a huge agricultural surplus which is then used to feed the ones which are doing agriculturally poorly, especially during drought years. But they cannot create 'local' food security—which means that all areas of the country have water management strategies to ensure that local food production is as productive as possible and stable even during water-short years. Local food security is as important as national food security. Which Bhil or Oraon *adivasi*, for instance, wants to depend only on grains from Punjab? All of them would like to grow enough grain at least to feed themselves. Water harvesting and groundwater together can definitely drought-proof the country and create local food security which big dams cannot. Then India's poor people and poor lands will not have to suffer the ignominy of the kind they had to this year. The government has to realise that Indians cannot survive on a single-track water management policy.

Water harvesting can drought-proof the country and create local food security.

In addition, India's future food security even from its so-called Green Revolution areas will depend heavily on a nationwide groundwater recharge programme which can only be taken by individual communities through rainwater harvesting. If this is not done, agriculture will suffer even in current irrigated areas because of the increasing overexploitation of groundwater and lowering of groundwater tables across the country. With more than 17 million tubewells and borewells energised by diesel and electricity, groundwater is now used to irrigate more than half of the country's irrigated area. And as areas irrigated by groundwater show higher productivity than those irrigated by canals, the contribution of groundwater to India's total agricultural output from irrigated areas is much more than that of canals. During drought years, when rivers dry up, groundwater becomes the main source of water both for drinking and irrigation (World Bank, 1999). Indian agriculture and rural life is today heavily dependent on groundwater. Further lowering of groundwater tables can seriously threaten India's hard-earned food security at a time when India will need to produce more food to feed its growing population.

Small Means Even More Water

Let us look at the relevance of village-based rainwater harvesting from yet another point of view. The key component of water management is 'storage' especially in a country like India where the monsoon gives us on average about one hundred hours of rain and then nothing for the remaining 8,660 hours in a year.

This water can be captured in:

- large reservoirs with large catchments by building large dams,
- in small tanks and ponds with small catchments, or
- by storing it in a way that it percolates down into the ground and gets stored as groundwater.

In fact, there is strong scientific evidence to show that village-scale rainwater harvesting will yield much more water than big or medium dams. Some very instructive lessons can be learnt from the work of Israeli scientist Michael Evenari who has produced the best corpus of knowledge on this subject from the bone-dry Negev desert where the average annual rainfall is a more 105 mm. Evenari was intrigued by the fact that the ancient Israeli civilisation had built towns right in the middle of the Negev desert with their own agriculture and water supply systems—much like the towns of Jodhpur and Jaisalmer that the enterprising Marwaris developed in the Tar desert. Both the Israelis and the Marwaris used the rain they received with great ingenuity to meet their food and water needs. In his effort to reconstruct the ancient farms of the Negev, Evenari came up with a very surprising finding: Water harvested from small watersheds per hectare of watershed area was much more in quantity than that collected over large watersheds. On hindsight this makes eminent sense because water collected over larger watersheds will have to run over a larger area before it is collected and a large part will get lost in small puddles and depressions, as soil moisture and through evaporation. This loss of water can be stunningly high. While a 1 ha watershed in the Negev yielded as much as 95 cubic metres of water per hectare per year, a 345 ha watershed yielded only 24 cum/ha/year. In other words, as much as 75 per cent of the water that could be collected was lost. The loss was even higher during a drought year. After years of research, Evenari summed his findings as follows: "... during drought years with less than 50 mm of rainfall (normal rainfall in the Negev desert is about 105 mm) watersheds larger than 50 ha will not produce any appreciable water yield while small natural watersheds will yield 20-40 cubic metres per hectare and microcatchments (smaller than 0.1 hactare) as much as 80-100 cubic metres per hectare" (Tables 2 & 3).

Table 2: The Surprising Effect of Size: The effect of the size of catchments on the quantity of water harvested as found in the Negev desert (in case of catchments with a 10 per cent slope and a 105 mm rainfall year). Small catchments give the maximum water. And the difference can be quite high. 3000 microcatchments of 0.1 hectare each will give five times more water together than one catchment of 300 hectares even though the total land area from which the rain is harvested remains the same. In simpler words, in drought-prone areas, 10 dams with a one hectare catchment each will give substantially more water than one large dam with a 10 hactare catchment.

Size of catchment (hectares)	Quantity of water harvested (cubic metres/hectare)	Percentage of annual rainfall collected
Microcatchment (a)	160 cubic metres/hectare	15.21%
20 hectares	100 cubic metres/hectare	9.52%
300 hectares	50 cubic metres/hectare	3.33%

These were critical findings because the amount of rainwater one can collect depends on the amount of land from which the runoff can be harvested. But Evenari was finding that even if you have the same amount of land you will collect more water if you break up the land into many small catchments than if you collect water from it as one catchment. Several studies conducted in India by the Central Soil and Water Conservation Research and Training Institute in Dehra Dun also show a clear relationship between size of catchment and amount of runoff that can be captured. One study shows that just increasing the size of the catchment from 1 ha to about 2 ha reduces the water yield per hectare by as much as 20 per cent (see Graph 2). Several other studies conducted by the Central Soil and Water Conservation Research Institute in Agra, Bellary and Kota and another study conducted in the high rainfall region of Shillong, have all found that smaller watersheds give higher amounts of water per hectare of catchment area (J.S. Samra, 2000). In a drought-prone area where water is scarce, 10 tiny dams with a catchment of 1 ha each will collect much more water than one larger dam with a catchment of 10 ha (see Fig. 1).

Table 3: Even Greater Effect During Drought: The effect of the size of catchments on the quantity of water harvested as found in the Negev desert during drought years with less than 50 millimetres rainfall

Size of catchment (hectares)	Quantity of water harvested (cubic metres/hectare)	Percentage of annual rainfall collected
Microcatchment (a)	80-100 cubic metres/hectare	16-20%
Small natural watersheds	20-40 cubic metres/hectare	4-8%
Larger than 50 hectares	No appreciable water yield	0%

Notes: (a) A microcatchment is a very small catchment of size upto 1000 square metres or 0.1 hectare.

Source: Michael Evenari et al, 1971, The Negev: The Challenge of a Desert, Oxford University Press, UK.

The amount of rainwater one can collect depends on the amount of land from which the runoff can be harvested.

It should not be surprising that the large number of medium-size dams that have been constructed in

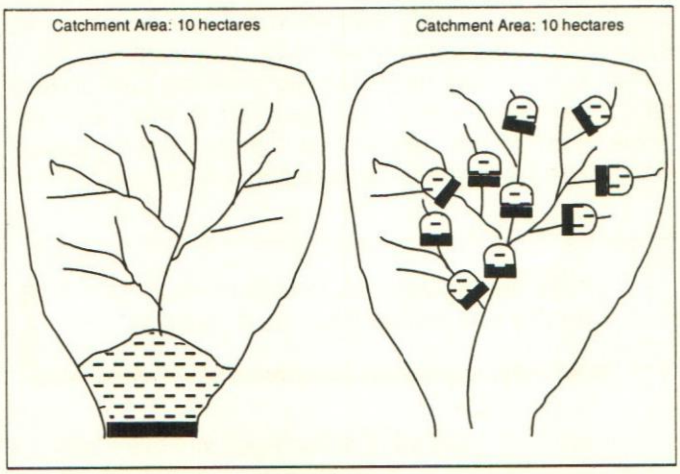
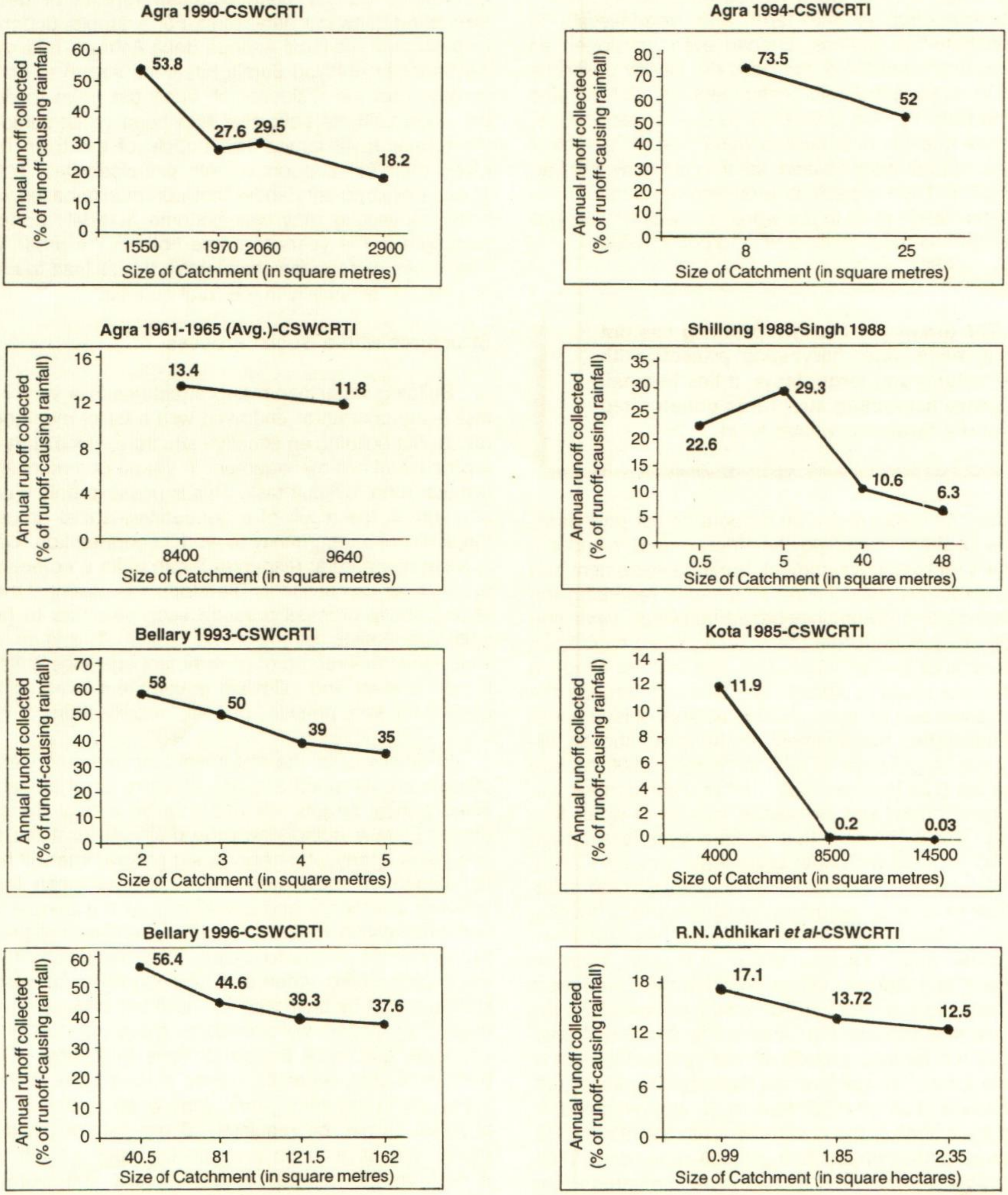


Fig. 1. Smaller Catchments Give Much More Water.

Graph 2: Effect of Size on Quantity of Water Harvested: Studies from India

Several studies carried out in India show the same results that were found in the Negev desert: Larger catchments resulted in a smaller percentage of the annual rainfall falling on the catchment which resulted in runoff being captured.



Source: J.S. Samra, director, Central Soil and Water Conservation Research Training Institute (CSWCRTI), Dehradun, personal communication.

Saurashtra have stored very little water in this drought year and started going dry by December 1999. But then the answer to drought-proofing of the area lies not in mega-water harvesting projects with medium and large dams. It lies in small water harvesting structures which are constructed at the farm and village-level. To demonstrate his findings, Evenari even developed an orchard in the middle of the bone-dry Negev desert by creating a separate microcatchment—a plot of land ranging from 15.6 sq m to 1000 sq m—for each tree to maximise quantity of harvested water. Therefore, look at it any way, community-based, small-scale rainwater harvesting is not just capable of providing more than drinking water needs even in the worst of drought situations but is also the most efficient way to collect water.

The answer to drought-proofing lies not in mega-water harvesting projects with medium and large dams. It lies in small water harvesting structures constructed at the farm and village-level.

After the media storm on drought hit our politicians, several of them, including the Prime minister and the ministers for rural development, urban development and water resources, have made statements regarding the importance of a community-based rainwater harvesting strategy to drought-proof the country. There have been developments in the states, too. The Andhra Pradesh government plans to spend Rs. 400 crore through the new mission and bring 10 million hectares of land under good watershed management. In the areas chosen, villagers will be given Rs. 20 lakh to develop a 500-hectare watershed (The Pioneer, 2000). In the urban context, the Delhi government has expressed interest in water harvesting. Given the fact that groundwater levels have declined for 4-10 metres in several parts of the Capital over the last decade, the Delhi government is contemplating a law to make it mandatory for all new group housing societies to harvest that rain falling within their complexes (H.T., 2000; Indian Express, 2000). In Gujarat, irrigation minister Nitin Patel said in late April that the government is planning to construct 10,000 check dams across the state under its Sardar Patel Sahbhagi Jal Sanchay Yojaya. Villagers will have to provide 40 per cent of the cost of the check dam. The government has received over 16,000 applications of which 8,563 have been approved and, to begin the exercise, the government has sanctioned Rs. 100 crore for the construction of 2,000 check dams (TOI, 2000). This is a remarkable change as compared to the past. Between 1991 and 1999-2000, various departments of the Gujarat government only built a total of 1,341 check dams (Desai, 2000).

If all the commitments made by the Central Minister and the State government of Gujarat and Andhra Pradesh, come true, a sum of Rs. 1500-2000 crore has been committed for rainwater harvesting. This is indeed heartening. Equally heartening are reports of people promoting rainwater harvesting. For example, under the inspiration of the local Ananda Baba Ashram, a Lakhota Jal Sanchay Abhiyan Samiti has been set up to collect money from the residents of Jamnagar town to desilt the huge Lakhota Lake that had been constructed by the former royal family. The people of the town have given their full support to this exercise (Das, 2000). These developments show that community-based rainwater harvesting may well become a widely adopted paradigm in the years to come both in the urban and rural areas. But the question is: Will this all lead to effective results, especially in the rural context?

Structures with a Social Process

Building water harvesting structures is a very easy task—any contractor endowed with a bit of money can do so. But building an effective structure which starts off a process of self-management in village communities is a much more difficult task. This is possible only if each structure is the result of a cooperative social process-the ability of a community to work in cooperation. Water is a strange natural resource: It can unite a community as easily as can divide it. Therefore, it is essential that a strong social process precede each structure to build what economists call the 'social capital'. This is an area where the track-record of government agencies is literally non-existent and inflexible government rules militate against the very principle of social mobilisation.

In other words, the statements by state and Central officials are as much a cause of worry as of applause. Fixed annual targets will prove to be a total disaster: money literally going down the drain. At least the first two years of any water harvesting programme will have to be spent on social mobilisation. This will mean, firstly, creating awareness and confidence in the people that water harvesting works. Once this is achieved, it means sitting with the people to create village institutions which will decide where, when and how the water harvesting structures will be built, who will build the structures, how much the villagers will provide to share the cost of the structure, and once the structure is built, how will its benefits, that is, water, be shared amongst the villagers, especially in the early years when water is scarce, and how will its use be regulated. Every part of the community will have to be involved by making each section—from the landed to the landless and women's groups—appreciate the benefits it will derive from the exercise. And by making efforts to ensure that benefits do indeed flow to each section of the community.

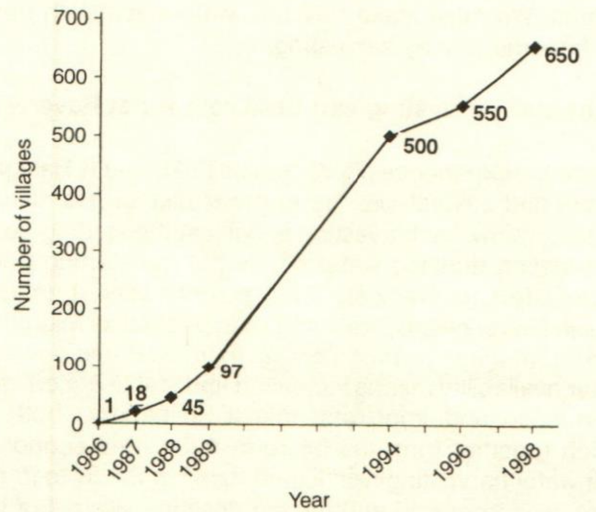
It is for this reason that water harvesting works best when combined with watershed development. It is in the nature of structures to benefit mainly those who have land leaving the landless without any benefits and therefore alienated from the exercise. But development of watersheds to conserve both water and soil not only increases soil and water conservation and leaf and grass production on what are usually common lands, which can greatly benefit landless households, but also increases the life and effectiveness of the structures that benefit the landed by reducing siltation. Contractors must be totally kept out and all wage benefits should go to the landless.

Nothing works better than when villagers see all this in actual practice. For this purpose, it is important to have funds to take interested villagers to see villages where such principles are being observed and how water harvesting has changed their lives. Under the Madhya Pradesh Rajiv Gandhi Watershed Development Mission (RGWDM), busloads of tribals from Jhabua were taken to see Ralegan Siddhi. Tarun Bharat Sangh (TBS) also regularly organises Paani Yatras in neighbouring areas to that villagers who have done it can talk face to face with those who have not. All this means that the progress in the first few years will be slow. This was the case both with RGWDM and TBS. But the experience of both also shows that replication comes very rapidly once 'the idea' catches on. As R Gopalakrishnan, who oversees RGWDM in Madhya Pradesh, puts it, "In the first two years of the programme, the results were so slow that we kept wondering whether we are getting it right." In other words, governments must be prepared to accept that their first year's effort will bring nothing, second and third year maybe something, and fourth and fifth years hopefully a lot. It is a gradual exercise. The number of villages participating in the water harvesting programme of TBS also grew slowly at first and then very rapidly in the later years as the villagers became more and more confident of the value of what they were doing (see Graph 3).

Social mobilisation is essential for the success of water harvesting for several other reasons. Firstly, the community must be closely involved in the construction of the water harvesting structures to ensure that they are built with technical competence; that is, the site is chosen properly, the technical parameters are correct, etc. Badly built structures will not deliver water and can get easily washed away. Secondly, even in properly built structures which deliver water, once the water starts getting available either as increasing levels of groundwater or as surface water in a tank, the community will have to start managing the available water which in the earlier years may not be enough to irrigate lands of all the farmers. In those years, the farmers will have to share the water and use it on crops that don't use too much

Graph 3: Promoting environmental self-reliance

In the first three years, few villages got involved in the water harvesting programme of Tarun Bharat Sangh. With passage of time, the numbers, however, grew rapidly as villagers gained confidence in the programme and were able to see a positive outcome of their efforts.



Source: Tarun Bharat Sangh, Alwar.

water. This will happen if there is already a community process associated with the water harvesting structure. Otherwise a few people will grab the water leading the rest of the community alienated.

Social mobilisation is essential for the success of water harvesting.

The government will also have to review and revise old British-time laws like the Indian Easement Act which prevent public participation in water management. Management experts point out, 'God is in the details'. The culture of rigid and inflexible government rules must be changed to fit the task of social mobilisation. And as government officials are not social workers, all this will happen only if they hand over work to NGOs with a track record, howsoever few they might be, and wait patiently for results to come. But if they want a government programme, it can still be done, but then they themselves will have to oversee the implementation of the programme to keep their warring and errant officials in place. Inter-departmental coordination – between the departments of revenue, soil conservation, irrigation, forests and agriculture – is essential for water harvesting- watershed development programmes to succeed. The direct supervision of the Madhya Pradesh Chief Minister of the RGWDM was a key element of the programme's success. It is not surprising that despite the drought this year, newspaper reports from western Madhya Pradesh were few. Otherwise the result will be a lot of wasted mud, bricks and mortar and alienated people, with water harvesting getting a bad name. Already, newspaper reports are showing that there has been considerable corruption in the check dams sponsored by the government of Gujarat. We must make sure that water harvesting does not become money harvesting.

Rainwater Harvesting can Eradicate Rural Poverty

As the experience of villages like Sukhomajri, Ralegan Siddhi and several villages in Alwar district has clearly shown, rainwater harvesting is not just the starting point for meeting drinking water needs but the starting point of an effort to eradicate rural poverty itself, generate massive rural employment and reduce distress migration from rural areas to urban areas. Increased and assured water availability means increased and stable agricultural production and improved animal husbandry—both of which together form the fulcrum of the rural economy. Rainwater harvesting has helped Ralegan Siddhi to transform itself from one of the most destitute villages of the country in the 1970s to one of the richest villages today. In all villages which have regenerated their local economy with the help of good management of their natural resources, distress rural-urban migration has been greatly reduced or has been totally eliminated.

Another interesting dimension of community-based rainwater harvesting is that it helps generate a community spirit within the village—something that is getting lost across the country—and build up what economists call the 'social capital'. In fact, we can argue that if we want *Panchayati Raj* to work, then the first thing the *panchayats* should be asked to take up is water harvesting—*har gaon ka apna talaab* (a tank in every village).

If it all makes so much sense then why is this paradigm not accepted by the government and spread across the country? President K.R. Narayanan even called for a national movement for water harvesting in his last Republic Day address to the nation. The problem is really mind-sets. Rainwater harvesting demands a new approach to governance itself—a participatory form of governance rather than a top-down bureaucratic one. Unfortunately, our political leaders have created a culture of dependence on the government and love to make promises, howsoever hollow they may be, that they will provide everything to the people through government largesse. Given this political mind-set, the water bureaucracy, too, has developed a culture of providing services, howsoever poor they may be, rather than one of empowering people to develop their own water supplies. And it is still locked into the big dam, pumps, pipes and borewell paradigm. We are not here going into the merits of the small versus large dam debate—in certain situations large dams could be needed—but there can be no doubt that the small has an extremely important role to play and this is being totally neglected. A balance between the big and the small is essential.

> **Rainwater harvesting demands a new approach—a participatory form of governance rather than a top-down bureaucratic one.**

But, nonetheless, there has been a remarkable change in the public discourse on the relevance of the country's rainwater harvesting traditions in the last few years, especially since Centre for Science and Environment (CSE) published *Dying Wisdom: The rise, fall and potential of India's traditional water harvesting systems* in 1997, a compelling account of how these traditions still work in many parts of the country even in the face of all odds. The recent statements by the Central and state ministers are encouraging but the government needs to go beyond them. It should heed the President's advice and prepare a concrete plan of action to develop a mass movement for water harvesting.

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Recycling to Meet the World's Water Needs

John Anderson

In this article, John Anderson, Chair of the International Water Association's Water Reuse Group, discusses how water can be recycled to reduce the demand on high quality freshwater sources. Successful water recycling projects have been implemented in many countries. This experience has demonstrated the feasibility of water reuse on a large scale and its role in the sustainable management of the world's water. Various examples are presented. Key issues and future directions in water recycling are also discussed.

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The world's supply of fresh water is finite and is threatened by pollution. Rising demands for water to supply agriculture, industry and cities are leading to competition over the allocation of limited fresh water resources. To avoid a water crisis, countries must conserve water, manage supply and demand, pollute less and reduce the environmental impacts of growing population.

Water Cycle

In nature, water (like energy) is neither created nor destroyed but is converted from one form to another. In the natural water cycle, rain falling on the land is mostly transpired by the vegetation. but some percolates to groundwater and some runs off to the rivers and flows to the oceans to evaporate and return as rain. The small amount used by wildlife for drinking is repurified by natural processes. Almost all of the world's water (97%) occurs as salt water. Of the remaining 3 per cent, two-thirds occurs as snow and ice in the polar and alpine regions. So only about 1 per cent of global water occurs as liquid freshwater. More than 98 per cent of the freshwater occurs as groundwater, while less than 2 per cent is available in streams and lakes. So the liquid freshwater is a finite and limited resource. (Bouwer, 2000)

Mankind has significantly altered the natural water cycle by overlaying new water cycle elements including:

- Extractions from rivers and groundwater for urban and agricultural use
- Return of treated or untreated wastewaters to streams
- Water reclamation from wastewater and recycling for beneficial uses
- Desalination of saline waters in areas where fresh water is in short supply.

Mankind has significantly altered the natural water cycle by extractions from rivers and groundwater for urban and agricultural use and return of treated or untreated wastewaters to streams.

In many areas of the world, groundwater is the main water resource and often rates of extraction greatly exceed the rates of recharge, so groundwater levels are declining. An extreme example of the impacts of surface water diversion for irrigation has been the decline of the Aral Sea in Central Asia. Once the home of thriving fisheries, the Aral Sea has shrunk to a fraction of its former size. Onetime foreshore towns are now many kilometres from the sea. The economic, social and environmental impacts are severe. Urban development also has had a significant impact on the water cycle. Water drawn for urban water supply reduces streamflows in rivers. At the same time, stormwater runoff and wastewater discharges often carry high levels of pollution which cause a decline in the water quality of rivers. Serious degradation has been observed in some rivers, which have high levels of urban development in their catchments.

In the Nile Valley below Aswan, current water demands exceed the yield of the Aswan High Dam by a considerable margin. The shortfall is being made up by reuse of wastewater and irrigation drainage water discharges (Croce 1998). Indications are that lack of sufficient water supplies will become the single most important factor limiting South Africa's socio-economic growth in the twenty-first century. Current projections indicate that water demand will exceed available supplies soon after the year 2020 (Odendaal et al, 1998).

Water Recycling

Recycled water is a valuable resource. Instead of being thrown away, appropriately treated water can be recycled—used a second time—to reduce the demand on high quality freshwater sources. Water recycling increases the available supply of water and enables greater human benefit to be achieved with less freshwater. Therefore, water recycling can make a substantial contribution to meeting the world's water needs and to lessening mankind's impact on the world's water environment. A move from the old "use once and throw away" approach, to a new sustainable "conserve, use wisely and recycle" water economy will benefit the whole world. Felicia Marcus, the US Environmental Protection Agency's Regional Administrator for the dry western region of the USA, says: "Water recycling is a critical element for managing our water resources. Through water development and a viable economy."

A move from the old "use once and throw away" approach, to a new sustainable "conserve, use wisely and recycle" water economy will benefit the whole world.

Development of Sustainable Water Management Policies

An example of the new approach to sustainable water management is the water reform process in Australia. Concern over declining river water quality has led to new public policy measures to achieve sustainable management of Australia's water resources. Federal measures include funding of capital works to reduce nutrient discharges, a cap on new irrigation diversions in the Murray-Darling river basin and a requirement for the states to introduce environmental flows. The state governments have also introduced water reform measures. The most far reaching is the water reform package introduced by the New South Wales state government. This package includes:

- Establishment of a Healthy Rivers Commission to set water quality and river flow objectives in each catchment.
- Development of a Water Management Plan for each catchment incorporating water quality objectives and river flow objectives which share water between users and the environment.
- Development of integrated water planning for urban areas incorporating water conservation and recycling measures.
- Consolidation of existing water legislation into a new NSW Water Management Act 2000. The primary objective of the Act is to "provide for the protection, conservation and ecologically sustainable development of the water resources of New South Wales". The Act
  - sets aside water allocations for the environment
  - classifies rivers and aquifers according to levels of stress and conservation values and nominates of water source protection zones
  - clearly defines licensed water access rights under volumetric allocations, which may be reduced in dry times

- Introduction of load based licence fees for discharges with rebates for water recycling
- The possible inclusion of recycled water in water trading arrangements.

Water Recycling in Action

The mission of water suppliers is to provide reliable high quality services that meet customer needs and protect the environment. In recent years they have implemented successful water recycling projects in many countries. This experience has demonstrated the feasibility of water reuse on a large scale and its role in the sustainable management of the world's water. The following examples are a small sample of the projects, which have been implemented.

Reuse for Agriculture: In California, the Monterey Regional Water Pollution Control Agency has constructed a scheme to use up to 20 billion litres per year of recycled water from the Monterey and adjoining towns to irrigate 5000 hectares of vegetable crops in the Lower Salinas Valley. Previously, excessive use of local groundwater for irrigation had led to seawater intrusion into the aquifers. In Mexico, 90 per cent of the wastewater from Mexico City is used for irrigation in the Valley of Mexico and the adjoining Mezquital Valley, an area with low rainfall and poor soils. The use of wastewater for irrigation has greatly increased crop yields. A second benefit of this irrigation has been an increase in groundwater recharge including the creation of a new shallow aquifer and an increase in the base flow of local streams. In South Australia, a major scheme has been constructed to supply up to 30 billion litres per year of recycled water, from the Bolivar sewage treatment plant in Adelaide, to the Virginia area north of Adelaide for irrigation of horticultural crops. The scheme includes a 120 million litres per day water reclamation plant that incorporates dissolved air flotation and filtration processes (Marks 1998).

Urban Reuse: In California's Silicon Valley, the San Jose and Santa Clara Country authorities were directed to limit fresh water discharges to the south end of San Francisco Bay to not more than 450 ML/d to reduce damage to an environmentally sensitive salt marsh environment. Rather than construct an ocean outfall, they have built the 140 ML/d South Bay Water Recycling Scheme to deliver recycled water for urban, industrial and agricultural users. In Australia, water will be recycled for residential uses at Rouse Hill, a new housing development area in the north-western sector of Sydney. The area is ultimately planned to have 300,000 people with the first stage of the development catering for 30,000 people. A second reticulation system has been installed to supply recycled water for toilet flushing and garden watering. The scheme is expected to commence operation in 2001. A water recycling scheme has been installed at Homebush Bay in Sydney, Australia where the Sydney Olympic Games were staged. Up to 7 million litres per day of recycled water from stormwater and treated wastewater sources will be recycled for toilet flushing and irrigation of open space areas. Microfiltration and reverse osmosis treatment processes are used to achieve the required water quality. The scheme will reduce demands on Sydney's freshwater supplies by about 850 million litres per year.

Industrial Reuse: In Australia, recycled water from the Dora Creek sewage treatment works is pumped to the Eraring Power Station at Lake Macquarie, about 100 km north of Sydney. There it is treated by microfiltration and reverse osmosis to produce water of potable grade which is further treated in the existing demineralisation plant to produce purified water which is used as boiler feed to provide steam for power station turbines. This recycled water replaces a billion litres per year of potable water previously supplied from the town water supply system (Cole & Deans 1994).

Recycling to Supplement Water Resources: Incidental or unplanned supplementation of water resources is widespread where treated wastewater is discharged to rivers, lakes and groundwaters, which are subsequently used for drinking water supplies. Commonly quoted cases include the Thames and Rhine Rivers where multiple uses occur between source and the ocean. In the USA, a 1980 study by the US EPA reviewed 1246 water supply systems serving 80 million people in towns over 25000 population and found that 26 million people were served from sources which contain between 5 per cent and 100% treated wastewater during low flow periods.

In South Africa, water reuse has played a major role in matching demands and available raw water supplies. The 1956 Water Act required treated wastewater flows to be returned to stream of origin unless applied to beneficial reuse, a requirement that encouraged the introduction of high standards of treatment. As a result, recycled water constitutes a substantial proportion of the base flow in many rivers. For example, recycled water is now about 50 per cent of the inflow into Hartbeespoort Dam which supplies water to Pretoria and Johannesburg (Odendaal 1998).

Since 1962, the Los Angeles County Sanitation District has been using recycled water to recharge a groundwater potable water supply through surface spreading basins at Whittier Narrows. The recycled water was initially disinfected secondary effluent and was upgraded by addition of tertiary filtration in 1978. The amount of recycled water recharged annually averages 16 per cent of the total inflow to the groundwater basin. Depending on location and aquifer characteristics, the proportion of recycled water in potable water wells ranges from 0 to 23 per cent. After extensive data acquisition and analysis, an independent scientific panel to the State of California concluded that the Whittier Narrows groundwater recharge was as safe as commonly used surface water supplies. Since 1976, Orange County in California has operated Water Factory 21, a 57 ML/d water reclamation plant producing recycled water of drinking water standard which is injected under pressure into a heavily used potable aquifer to prevent salt water intrusion. After more than 15 years of intensive groundwater monitoring, Orange Country has observed no change in groundwater quality that would cause a public health concern. The plant is currently being expanded. In Virginia, recycled water from the Upper Occaquan water reclamation plant is discharged to the 42000 ML Upper Occaquan reservoir, which supplies drinking water to about 1 million people in North Virginia. Typically recycled water represents 10 per cent to 15 per cent of the reservoir inflows and the average detention time in the reservoir is 26 days. The water reclamation plant was initially 55 ML/d capacity and has been enlarged to 100 ML/d. Further enlargement to 200 ML/d is planned.

Since 1985, El Paso in Texas has used recycled water from the 38 ML/d Fred Harvey water reclamation plant to recharge the Hueco Bolson drinking water aquifer. Detention time is approximately 2 years before water is drawn for supply from the El Paso potable water wells. No negative effects on health related water quality parameters have been observed but there has been some increase in total dissolved solids content in the aquifer. Windhoek, the capital city of Namibia, is situated in the central highlands of Namibia between the Kalahari Desert to the east and the Namib Desert to the west. The nearest perennial river is the Kavango, 750 km away. As a result of severe water shortages during drought, the world's first potable water reclamation plant of 4.8 ML/D (million litres/day) capacity was constructed in 1968. The plant has consistently produced water of acceptable potable quality for 30 years. It has been upgraded on several occasions and is currently being enlarged to 21 ML/d using advanced membrane technologies. Overall since 1968, recycled water has contributed 4 per cent of the total water supply in Windhoek but has been up to 31 per cent of the total supply during severe drought periods. The recycled water is blended with treated water from the Goreangab water treatment plant before distribution, with the maximum blend being 1:1 during drought periods. The average blend since 1968 has been 1:3.5. The blend from Goreangab is mixed with water from other sources in the service reservoirs so that normally there is a maximum proportion of 25 per cent recycled water in any zone in any period (Van der Merwe 1996).

Health Considerations

The American Waterworks Association (AWWA) has published the following Reuse Policy Statement. First and foremost, AWWA believes that sources of water with best available quality should be used for potable purposes. The use of reclaimed water can significantly reduce the demands placed on limited conventional supplies of potable water. Accordingly, AWWA encourages responsible use of reclaimed water in lieu of potable water for non-potable uses. Furthermore, when raw water supply sources to an area are limited and reclaimed water is generally of equal or superior quality to other raw water supplies, AWWA does not oppose indirect use of reclaimed water whereby reclaimed water is a supplement to existing raw water sources receiving appropriate subsequent treatment. These sources must be acceptable to health authorities and water users.

Drinking water supply sources are subject to close monitoring to ensure that the supply is safe. As an overall goal, water recycling projects should provide at least the same degree of public health protection as conventional water supplies. Water quality issues for potable reuse projects are the same as with any potable water supply project. Parameters to be addressed include pathogens, organics and inorganics. Due to the wastewater origin of recycled water, treatment technologies must address the potential higher levels of microbiological and chemical contamination. In the absence of specific standards covering potable reuse applications, the industry has developed a "multiple barriers" approach to ensure the appropriate levels of safety and reliability. In this concept, multiple unit processes or other mechanisms are provided to remove or inactivate each quality parameter of concern, particularly the microbiological parameters.

Water recycling projects should provide at least the same degree of public health protection as conventional water supplies.

An epidemiological study was conducted in Windhoek from 1976 to 1983. No abnormal occurrence of cancer or other disease was observed. Rates of diarrhoeal illness were no higher in the reticulation zones that receive recycled water than in reticulation zones which do not receive recycled water. The results of supplementary carcinogenicity tests using mice, mutagenicity assays of the recycled water and biological surveillance of fish were all negative. The authors concluded that within the limits of the epidemiological studies done, no adverse effects on health attributable to the consumption of recycled water could be established (Isaacson et al, 1987).

The US City of Denver conducted a 10-year potable water reuse trial using a 3.8 ML/d demonstration water reclamation facility. The trial included comprehensive water testing and health studies. The advanced treatment processes reliably produced a product, which satisfied all current and proposed US drinking water standards. The recycled water was also of better quality than the existing Denver water supply. A complete two-year chronic toxicity and carcinogenicity study was conducted on the recycled water and the existing drinking water supply. No adverse health effects were detected from lifetime exposure to any of the samples. Reproductive studies on the recycled water and the existing drinking water supply detected no adverse health effects from either supply during a two-generation reproduction study. No organism (bacteria or virus), nor any compound (organic or inorganic) was found in any sample which even approached regulatory limits (Lauer 1996). The US City of San Diego recently conducted a Health Effects Study (HES) to assess the risks associated with using recycled water to supplement potable water supplies. The HES compared recycled water from the Aqua II advanced water reclamation plant (0.2 ML/d) at Mission Valley with raw water entering the City's Miramar drinking water treatment plant and was later extended to cover recycled water from the Aqua III advanced water reclamation plant at San Pasquel. The Health Advisory Committee concluded that: The health risk associated with the use of the Aqua II AWT water as a raw water supply is less than or equal to that of the existing City raw water as represented by the water entering the Miramar water treatment plant (Oliveri & Eisenburg 1998).

Looking Ahead

Despite the success of water recycling projects, there are a number of unresolved issues. There are differences in water quality standards for similar reuse purposes, and continuing debate over whether recycled water can be used safely to supplement drinking water supplies. Uncertainty on such key issues inhibits projects, increases costs and reduces environmental benefits.

The International Water Association's Water Reuse Group is an international network, working together worldwide to achieve more sustainable water management through water recycling. As part of the Group's commitment, it is holding an International Water Reuse Workshop in Los Angeles, California, on 1-2 February 2001. The aim is to identify the key water recycling issues that need to be addressed, and the actions needed to remove impediments to water recycling. Key questions include:

- Recycled water and sustainable water management: how can we build sustainability into project decision making?
- What water quality is appropriate for various reuse applications?
- How can we resolve the paradoxes between planned and unplanned recycling into fresh-water sources?
- Can operators guarantee water quality and process reliability?
- Can we develop international guidelines for water recycling?
- What steps can we take to improve public understanding of water recycling?
- How can we best harness the knowledge of professionals and communities worldwide about water recycling to achieve sustainable water management?

International Guidelines

Water recycling requires effective measures to protect public health and the environment. For solutions to be physically implemented they must be technically feasible and economically affordable. Different nations have developed different approaches to managing risk through water recycling regulations and guidelines. The approaches vary between high technology/high cost/low risk approach (eg California's Title 22 regulations), and low technology/low cost/considered risk (eg the WHO guidelines) depending on the local balance between affordability and risk. These inconsistencies in approach, and the absence of a unified scientific approach, increase public concerns about risks, and sometimes give rise to unnecessarily conservative responses to water recycling projects.An international panel has recently put forward a proposal for a single international framework of water recycling guidelines (Anderson et al, 2000). The hazards, which arise from the particular use of a given quality of recycled water, are similar no matter where we live. So it is possible to create a single international framework (thinking globally) with a series of quality steps progressing from low quality/high risk to high quality/low risk. The resulting risks depend on exposure, dose and response, which are a function of the application, the method of application and local conditions. And tolerable risk levels are conditioned by local circumstances and cost structures. Therefore, choosing a step on the quality/risk ladder should be based on national or provincial circumstances (acting locally). It follows that international guidelines must not only specify which recycled water quality gives low risk for a particular application, but must also provide guidance on how to assess and manage risk to achieve acceptable risk matching local circumstances.

International guidelines must not only specify which recycled water quality gives low risk for a particular application, but must also provide guidance on how to assess and manage risk.

While minimum treatment systems may have high health and environmental costs, a low risk approach may be expensive. A controlled approach, which balances risks and costs and keeps water recycling affordable, may be a better choice in some cases. An advantage of establishing flexible international guidelines with a series of steps is that an individual country can climb a ladder of progressive investment to upgrade recycled water quality as progress in the national economy makes lower risk levels more affordable. At any point in time, an individual country can maximise the benefits obtained from water recycling and its investment of scarce capital funds. Developing a single framework for international water recycling guidelines will confer a number of benefits:

- National and local authorities will be able to change their focus from standard setting to risk management.
- With a single framework, international research and development efforts can be better targeted.
- A common international framework will improve public understanding of, and confidence in, water recycling.

In Anderson et al, (2000), the authors recognise that the international guideline concept that is presented in this paper requires further development to create a working document and invite discussion and suggestions for further development of the concept.

Decentralised Treatment & Recycling

Of all the public health initiatives introduced in the last 150 years, the move from individual to community wide water and sewerage systems has been the most beneficial. In Australia, introduction of safe reticulated water supplies between 1880 and 1920 cut the death rate in half and reduced incidence of infectious diseases and infant mortality by a factor of ten. In some countries there is now a movement, supported by environmental groups, for a return to individual household systems in the interests of conservation. Individual household systems have the advantage of low pipework costs. Individual systems are often an appropriate solution for large rural residential allotments with adequate area for irrigation. Considerable technological improvement in needed in current individual household systems to achieve acceptable public health and environmental outcomes in urban areas. Locating water reclamation plants closer to the point of reuse would also reduce pipework costs for community systems. Community systems are likely to be better than individual systems in terms of performance, reliability and treatment costs. The halfway house of neighbourhood treatment and recycling systems may be the right balance in the long term. The Australian research organisation CSIRO has embarked on an ambitious project to re-examine the basic design assumptions of reticulated water, sewerage and drainage services. The initial results of this work indicate considerable potential to reduce service costs through redesign of systems and the placement of some system components at neighbourhood level (Speers 2000).

There are obvious gaps in community knowledge of human interaction with the water cycle. These gaps include an almost total lack of awareness of how water supply and wastewater systems work. This is compounded by community inhibitions relating to bodily functions and growing community concerns about health risks. Much of the available information on water issues is too technical for the average person. Community consultation processes on water and wastewater projects are often delayed and sometimes frustrated because of this lack of knowledge. Informed and rational debate about proposals is possible only if the community is knowledgeable and well informed on water issues before the commencement of any community consultation process. A pilot two year water education project is now underway in Queensland to improve community understanding on water issues (Bovill & Simpson 1998).

A necessary ingredient of community education is the use of understandable terminology. There is currently an active debate worldwide on appropriate terminology for grades of recycled water based on quality. An alternative proposal is to describe recycled water products in terms of their end use. It may be possible to combine these two ideas to produce a workable and understandable system. Developing simple and easily understood terminology will also assist in community education and increase public confidence in water recycling.

Economics & Sustainability

In most coastal locations in Australia, the costs of developing new fresh water supplies often exceeds US$0.40/m^3, and in drier inland areas the cost is often much higher. In Namibia, the cost of the recycled water after the latest expansion of the Windhoek water reclamation plant will be about 30 per cent of the estimated cost of delivering water from the Kavango River (Van der Merwe 1996). A considerable amount of work is being done to evaluate water recycling projects in terms of their economics and sustainability. A recent example is the Sydney Water Corporation's December 1999 Water Recycling Strategy which evaluates potential water recycling projects in terms of levelised annual costs in $/m^3 and Greenhouse gas impacts expressed in equivalent kWh/m^3 energy use. The levelised annual cost approach has been described by White & Howe (1998). The results of these analyses suggest:

- Selected large industrial reuse projects and urban landscaping projects which are located close to the treatment plant are more economic than dual reticulation residential schemes
- Indirect potable reuse would be more cost effective than many non-potable reuse but would have higher Greenhouse gas impacts.
- Decentralised treatment and recycling systems may warrant further examination
- There is still scope to implement low cost water conservation measures which provide a 10 to 20 year window of opportunity in which to make informed decisions about implementing advanced water recycling applications and to further improve the technology.

In recent years, development of thin-film-composite reverse osmosis membranes has greatly reduced energy requirements and costs of desalting seawater and brackish waters. Advances in energy recovery systems have reduced energy requirements for desalination of seawater to less than 5 kWh/m^3. These membranes have also opened up new opportunities to treat recycled water to drinking water standards and better. In some cases, water from desalination and advanced treatment systems will be less costly than water from developing new conventional sources of water supply.

Energy requirements are still an impediment to advanced treatment, recycling and desalination systems in many parts of the world. Major research and development efforts are in progress in many countries to develop alternatives to fossil fuel energy sources to drive advanced treatment, recycling and desalination systems. These include: recovery of waste heat to drive thermal desalination processes; use of energy from solar dishes to drive thermal, vacuum distillation or reverse osmosis desalination processes; of use of energy from photovoltaic cells. Of equal interest is the hydrogen fuel cell technology now being developed for the motor industry.

This has potential for much wider application and potential to use solar energy as the prime source of energy for fuel conversion. Just as we have seen giant strides in technology in the last 20 years, it is possible to see even greater advances in the technology for sustainable development and sustainable water management in the next 20 years.

Energy requirements are still an impediment to advanced treatment, recycling and desalination systems. Research and development efforts are in progress to develop alternatives to fossil fuel energy sources.

Conclusion

There is still much to do to improve water recycling technologies, develop international guidelines, improve public understanding of water recycling, and improve the evaluation of project economics and sustainability. While water problems may often seem difficult, or sometimes insurmountable, we have seen enormous progress in water conservation and recycling in the last 20 years to overcome water shortages. There is the promise of further advances in the necessary technology in the decades to come. There is cause for optimism that, with focussed effort, mankind can reverse the degradation of the planet's water environment and meet the world's water needs.

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"The willingness to hear hard truth is vital not only for CEOs of big corporations but also for anyone who loves the truth. Sometimes the truth sounds like bad news, but it is just what we need".

– Bill Gates

Combating Drought in Rajasthan

Abhijit Ghose

Drought is a recurring feature of the arid state of Rajasthan. Drinking water remains the major problem during the drought period. Construction of big dams as a replacement of small water harvesting structures as a drought proofing measure has proved counter productive. Each village should ensure that it is self-sustained in its water use. Creation of more water harvesting structures should be the strategy for employment generation in drought relief works.

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Plants play an important role in maintaining the hydrological cycle in nature. Water enters into our ecosystem in form of precipitation like rains and snows. Before they reach the ground, vegetations around intercept them and help in reducing their impact on soil, which otherwise contribute to soil erosion. After water touches the ground, a part of it gets infiltrated into the soil enriching soil moisture whereas a portion of it goes down deep into the ground to recharge ground- water aquifers. Leaf litters on the ground surface help in slow percolation of water into the soils without which the water on touching the ground moves as surface flow along with soil particles. Plants through their root systems bind the soil and prevent soil erosion. Secondly, the roots of plants help to recharge the ground water level. Surface flows culminate into a stream, streams into river and rivers into large water bodies like lake, sea or ocean. Due to solar radiation water gets heated up and evaporates into atmosphere as water vapor and ultimately constitutes clouds or snows. Plants also consume water along with soil nutrients and minerals which they convert into their food material in green leaves in presence of sun light (photosynthesis) and the excess water is thrown out into the atmosphere as water vapors through the stomatal openings of leaves (transpiration). Evaporation is a physical phenomenon and evapotranspiration completes the hydrological cycle in nature; an uninterrupted hydrological cycle alone can guarantee continuation of life of plants and animals.

Rainwater Harvesting

Though rainfall over the land mass is not uniform, even on arid tract considerable amount of water is received. 10 milli-meter of rain equals 10,000 liters of water per hectare. Harvesting this rainwater can provide water for regions where alternative sources of getting more water are remote as well as cost prohibitive. Rainwater harvesting is particularly suited to supplying water for small villages, schools, households, small gardens, livestock and wildlife. In 1929, a 2400 sq.mt. catchment in arid part of Australia (300 mm average annual rainfall) provided adequate water for "6 persons, 10 horses, 2 cows, 150 sheep" even during the years of lowest rainfall. Rainwater harvesting is possible in areas with as little as 50-80 mm average annual rainfall. This seems to be the lowest limit, but during a year with only 24 mm of rain, a water harvesting catchment in Israel still yielded usable runoff.

> **Harvesting rainwater can provide water for regions where alternative sources of getting more water are remote as well as cost prohibitive.**

Managing Water

India enjoys a monsoon climate and receives most of the precipitation during southeast monsoon between May-June to September-October barring a portion of peninsular India, which receives winter rains. Himalayas, the northern mountain range only receive snows due to elevation in winter months between December to March and rivers originated from this mountain range carry snow melted water into their fertile basins in summer months. If the world's rainfall were averaged over its landmass, it is seen that India receives more than one-and-a-half times the rain that other parts of the world get. It is estimated that in India, the total precipitation in a year of average rainfall is nearly 400 million hectare meter (Mham), out of which 150 Mham percolates into soil; 180 Mham joins the surface flow and 70 Mham is lost in evapo-transpiration in the system. Out of 150 Mham, which enters the soil about 110 Mham constitutes soil moisture and 40 Mham percolates deep into ground water table. Of the 180 Mham run-off, major, medium and minor irrigation projects spread over the entire country have so far succeeded in trapping only 17 Mham in various reservoirs and another 4 to 5 Mham are stored in tanks and other devices, which amount only to 16 per cent utilization of precious water resource. Unless we trap more water of the surface flow and increase net-addition to water table, we are bound of face a serious water crisis in near future. Another alarming feature of this surface flow is the amount of silt load it carries. It is estimated that in India every year 6 billion MT of top soil is being washed out making our

> **Unless we trap more water of the surface flow and increase net-addition to water table, we are bound to face a serious water crisis.**

land impoverished and at the same time raising flood plains of our river systems and other water bodies. The calculated lives of all man made reservoirs have also become ineffective due to heavy silt load and constantly pose threats to their economic viability. Thus managing water so that it is available at the right place in the right time is a major issue.

Rajasthan – Home of Perennial Drought

In India the rainfall shows a skewed pattern from year to year, time to time and place to place. The western part of the country gets very low rainfall and therefore is categorized as arid. Besides, a large area of the country receiving low rains due to being located in rain shadows, is categorized as semi-arid. Rajasthan, the country's largest state after partition of Madhya Pradesh, is considered as synonym of "registhan", which means desert. Aravali mountain system, which runs in north-east direction almost from border of New-Delhi in south-west direction up to Gujrat border, divides the state into two unequal halves. About three-fifth area lying west of Aravallies is completely arid and constitutes nearly two-third of the Great Indian Desert or Thar Desert. Two-fifth area of the state lying in the eastern flank of Aravallies is semi-arid. Due to low and erratic rains, agricultural production of the state is an uncertainty. As insurance, live stock rearing is generally practiced as second profession by almost all cultivators. Analysis of rainfall data of the state over last one century reveals that every fourth year rains fail making it a drought year. Recurring droughts have completely paralyzed the state's economy. During good rains, farmers yield good harvest, which they store for scarcity days. Drinking water for men and animals and fodder for animals become in short supply during drought. Due to complete failure of agriculture, crop residues they burn for cooking also becomes in short supply and the limited forest resources of the state face constant threat from illicit extraction of fuel wood and fodder. Besides, in drought years, unemployment becomes rampant contributing to large scale migration of rural population to cities of the state as well as to neighbouring states. Cattle migration in greener areas of the state and to other adjoining states also poses serious law and order problems.

Government spends huge amounts for drought relief operations in scarcity years. Fodder depots are opened at places by transporting fodder from affluent regions of the country and to create employment opportunities, various developmental works are undertaken in drought-hit areas. However, the supply of drinking water is crucial. In the absence of any perennial stream, recharge of the limited ground water resources of the state is impossible. Over the years, the consumption of ground water has increased manifold with the increase of human and cattle population of the state. Due to increasing dependence of farmers on energized wells, there is unrestricted ground water mining almost everywhere. Hence, the potential threat of water crisis has assumed serious proportion.

Traditional Methods

Traditionally, people of the arid state were well aware of the value of water since the beginning of human settlement. They had quickly learnt about the economic use of scarce water resource from their surrounding environment of plants and animals. They used to conserve and store limited rain water by constructing underground tanks, locally known as "tanka". Each was of 10,000 to 20,000 Litres capacity and these were filled up in spite of very little rains in a year.

Due to conservative use of water, the stored water used to suffice a medium size family through out the year. Often big tankas were constructed for community use in village centers by diverting water from rooftops of each dwelling unit of the village. Since sandy soil of desert region is of porous nature, artificial catchment area is prepared around each tanka by compacting soils with stones and grit, sometimes plastered with lime. Such man made catchment is locally called "python". Tankas are covered to reduce loss by evaporation. Besides constructing tankas on private as well as community lands, people divert rainwater into natural or man made depressions known as "talab". They even used to plant shady trees around such water bodies to minimize evaporation losses by creating conducive micro-climate. Big wells called "baori" were very common. Small rivulets and streams were diverted to recharge these baoris. These traditional water harvesting devices did sustain the small population to meet their daily requirement of drinking water and other essential water needs.

Rainwater harvesting was also the main feature of dry land farming techniques used by farmers of desert region in which every drop of rain is retained as soil moisture. Further, they used to keep the land weed free by repeated tillage and level the land after each rain with wooden plank to break soil capillaries to reduce evaporation losses. Subsequent sowings of pulses and other rabi crops used to yield sufficient production for farmers. In desert region, earthern embankment known as "khadin" were constructed in low-lying lands to accumulate water during rains. Animals used the water for drinking purposes after rainy season and with the receding water, people raised crops on beds of Khadins. Gradually such traditional practices have been abandoned and instead of minimizing needs, for more production people now use energized bore-wells and grow crops which are more water demanding. Increasing needs and unending greed have resulted in unsustainable farming practices alien to desert region.

Increasing needs and unending greed have resulted in unsustainable farming practices alien to desert region.

Alternative Solution

In post independence era, emphasis has been on agriculture sector and to have self sufficiency in food production, attempt is being made to bring more land under irrigated agriculture by construction of large size multi-purpose dams by taming of rivers replacing traditional water harvesting techniques. Although such dams constructed as drought proofing measure with huge economic costs have given certain relief to farmers facing vagaries of uncertain monsoons, at places they have brought in more woes than benefits. Environmental considerations show such large irrigation projects as counter productive.

IGNP-Permanent Solution of Drought

The ambitious project of IGNP (Indira Gandhi Nahar Pariyojna) has been constructed in western Rajasthan as a permanent solution for drought proofing. The excess water of Ravi-Beas system from Harika barrage in Punjab is diverted to Rajasthan by constructing a 209 km. long feeder canal up to Masitawali head of Hanumangarh district. The main canal runs from Hanumangarh up to Mohangarh of Jaisalmer district and is of 469 km. length but the total canal system including all branches, distributaries, minors and sub-minors is nearly 9000 km. length. Six lift canals have been constructed from main canal basically to provide drinking water in major cities of west Rajasthan, namely: Bikaner, Jodhpur, Jaisalmer, Phalaudi, Taranagar etc. This canal system has brought a big relief for water-starved areas. Apart from solving the perennial problem of drinking water, huge agricultural production could be possible in the irrigated command areas of IGNP. Besides, extensive afforestation and pasture development along IGNP have resulted in production of timber, firewood and fodder in this region. After construction of IGNP, in vast areas of western Rajasthan the intensity of drought has been reduced to a considerable extent. But for entire Rajasthan state, things are yet to be done as drought proofing measures.

In Search of Solution

In eastern Rajasthan also drought condition is a recurring feature. Perpetual solution from drought lies in local water harvesting in order to make each village unit self sustained so far as water resource is concerned.

> **By constructing number of anicuts at suitable sites, the entire surface flow of village can be arrested.**

Leaving aside the desert region where areas cannot be delineated on watershed basis, rest of the state is divided into macro and micro watersheds. While treating the area on watershed basis, each drainage line is to be treated from the top by construction of a series of check dams. Where more than one drainage lines meet, silt detention dam is required to be constructed at the foothills, to retain soil while water flows down. Water also percolates down to recharge ground water. Big size anicuts with earthern check-dam or check dams prepared with cement concrete, are quite useful water-harvesting devices. This type of structure also helps in recharging of wells in the downstreamside. By constructing number or anicuts at suitable sites, the entire surface flow of village can be arrested and the need of water of the village can be met with. After meeting need of drinking water, if sufficient water is available, it can be made use of for irrigated agriculture. These small structures are not only cost effective but also environmentally viable. Several such anicuts have been constructed by Soil Conservation and Watershed Department in many villages in Rajasthan. Forest Department of Rajasthan is also constructing anicuts within and out of forest areas for the benefit of local people. Within the boundaries of National Parks and Sanctuaries, such anicuts have served as main water sources for the wild animals particularly in summer months. Anicuts constructed at fringe areas of forest, have become useful for both wild and domesticated animals. By undertaking work of these anicuts, participation of the local people has been ensured in forestry development works.

Intensive soil and moisture conservation strategies have been adopted in wasteland development works. 15 to 25% of expenditure in each site is made in these works. In hilly terrain, on steep slopes contour dykes are made with dry ruble stones or even by thick vegetative barrier. Such structures not only arrest the washed out soils but also break the velocity of water while flowing down the slope. In middle slopes staggered as well as continuous contour trenches are dug for retaining soil and moisture. Excavated soils are heaped downhill side on which planting is done by seed sowing. In the gentle slopes of foothill, V-ditches are constructed along contours. In between contour ditches, planting is done in pits or grass seeds are sown after ploughing. In addition, check dams of dry rouble stones or vegetative materials can treat all drains originating from top of hills. In plains, earthen check dams are constructed. Silt detention dam (SDD) or small anicuts are constructed where all the drains meet. Thus entire water and soil-loss from the area is arrested in situ. Unless entire area is treated intensively by in-situ soil and moisture conservation devices, there is every likelihood of anicuts constructed in downhill being silted up. Besides, the anicuts are likely to be washed away by rapid flow of water. Conservation of soil moisture at the site enhances productivity of the area by increased production of grass and other plant materials.

Since construction of more water harvesting devices alone can be used as an effective tool for drought proofing, Government should give top priority to such works. These works will not only create employment generation but also lead to a lasting solution for combating recurring droughts in the state. □

> *Without competitors there would be no need for strategy.*
>
> **– Kenichi Ohmae**

Economics of Water Management: Towards a Policy Option

C.S. Sundaresan

Drought in India is essentially a manifestation of improper management of available water resources in scarce regions and seasons. Identification of sustainable mode of water management, therefore, is the means to mitigate Indian drought. Economics of water resources management suggests that markets could be one rational option for effective utilisation of water. A rational policy decision supported by sound macro-economic environment is likely to sustain competitive water markets in water scarce regions.

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Drought in India is no longer a phenomenon, but a recurring event at regular frequency. Governments, however, treat drought as a natural calamity and initiate for relief spending. Non-government agencies (NGOs) meanwhile logically identify lacunae in government policies and programmes to counter this menace and hence, conclude it is a man made misery. Side by side, economists refuse to term the phenomenon of water shortage a drought with the backing of statistics on average rainfall. Fact of the matter, however, is that a common agreement on drought as a concept is yet to be evolved. In other words, there have been serious definitional constraints to approach drought. The severe water shortage witnessed recently in parts of Gujarat and Rajasthan or its milder manifestations in other parts of the country brought about impressions on the origin and evolution of Indian drought in its chronology. These views, however, indirectly and directly highlight the ineffective management of scarce water resources—to evolve a basic conceptual framework towards probable sources of mitigating drought or water shortage. Water resource management, therefore, becomes the theme issue here.

Governments treat drought as a natural calamity. NGOs conclude, it is a man made misery.

Proponents of different water management strategies have their respective logistics and thereby, the means to solve the water crisis. The first and foremost option among them is for the government to improve its water management programmes. This is from the viewpoint of water being a public good. However, the possibility of such an intervention from government side with desired efficiency, is highly discouraging from the historical experience of governments in public utility services. An alternative, therefore, is community water management – a collective (cooperative) initiative in small scales with geographical limits and characteristics. In the given economic ambience, the scope of a collective initiative in the conventional welfare framework however, is unclear. A logical third option, therefore, is to establish suitable water markets. This paper attempts to conceptualise and analyse the rationality of establishing competitive water markets with its probable economics as a source of improved water management to drive the drought out.

Water Management Options: Concept & Issues

Elaborate statistics are available on the number of districts, villages and even people affected by drought every year. Estimates are also available on rainfall and water availability. On an average, India (as a whole) gets an average hundred hours of rainfall a year. Indian villages get around 1170 mm of rainfall. It is estimated that if around 100 mm of rainwater is harvested from one hectre of land, it is equal to one million litres of water. If this is extrapolated with the total land available, the water scarcity situation becomes a misnomer. Estimates are available on how much area of land has to be brought under water harvesting to make Indian states/villages water sufficient (all through) and hence, prosperous. Water harvesting thereby becomes the key word in mitigating drought in a scientific perspective either collectively or through government programmes. This concept when taken further, identifies the fact that smaller watersheds give more efficiency in rain harvesting. For e.g., ten check dams of one hectre catchment area each would be more efficient than one dam with ten hectres of catchment area.

Community water management has therefore, been one of the most important and effective means, logically proposed to mitigate regional or seasonal water shortage. This however, does not recommend the abandonment of prevailing government water management systems, rather proposes to act as a supplementary to public water management establishments. One major highlight in this supplementary proposal is that government investments for water management be channeled through these new institutions (of community groups) than the conventional means. Conceptually, though this arrangement does not seem to make much difference from the institutional (controls) and administrative point of view, the positive aspects of decentralization and collective ownership is well taken for better results. However, in an economic environment where, the relevance and feasibility of government participation in public utilities is doubted (in the long run), what structural orientation would these community based management initiative have?. Let us forget for a moment that government sponsored water management schemes are present and assume that collective (community) water management schemes are to take the place. Would they be able to arbitrate a demand-supply equilibrium and manage water supplies on a large scale, ensuring equity and transparency?

Two major issues associated with community water management in this context are availability of land (as the basic input), capital and the economics of making such programmes viable and the means to establish equity in water supplies to the beneficiaries all through. Though numerically it is worked out for the number of villages and the area (catchment) to be brought under rain harvesting to make a geographical area drought proof, the practical implications are yet to be conceptualised. For instance, how will the community water management programmes take care of landless and small landholders in their contribution as well as water distribution in the collective initiative? Already there has been information asymmetry in areas like what is the minimum viable land unit to introduce a rain harvest, what would be the investment requirements for water extraction as well as further distribution to members/beneficiaries. In a situation of unequal land holding, if the landed farmers establish rain water harvesting techniques by making use of own capital and land, how can distribution equity of water be ensured? Does this not lead to discrimination and distorted management and hence, a managed calamity as against its perceived benefits? Though rain harvesting is even proposed in urban areas (through rooftop and society rain harvesting) many still have inhibitions about its economics and effectiveness.

Two major issues associated with community water management are availability of land, capital and the means to establish equity in water supplies.

Purpose of the above queries by no means is to rule out the feasibility of effectiveness of a collective water management initiative. On the other hand, it attempts to bring in more clarity to the means of achieving the desired outcome. In the given socio-economic environment, what the above discussion conveys is that effective water management, of any other natural resource, requires an equilibrium management and coordination mechanism, particularly in a scarcity situation. Hence, in a community water management system, criteria for water distribution, source of capital and its mode of

...distribution systems, realisation from the water etc. are vital to evolve a sustainable water management strategy. Distribution and equilibrium management must ensure water availability to the needy, irrespective of their social standing, educational levels or land holdings. This is important due to the possibility that feudal elements can exploit the landless labourers to work in their fields free for a day's water. One option to achieve distributional equity under community water management may be that the beneficiaries invest and establish the infrastructure and the water is sold to them at a subsidised price. Another option is that beneficiaries share the total investments required and water is distributed equally or proportionally among them. In either of the above options, the organisational viability becomes a constraint. Therefore, some sort of pricing becomes necessary for the new organisations to sustain. Once price or any other mode of payment comes into picture, the normal forces of market start working automatically in the distribution/sale. Experiences of cooperatives of various types in India are examples in this regard. Considering the inevitable role of markets in establishing and maintaining desirable water management systems can't the community water management establishments be tuned to operate in a competitive environment as formal or informal marketing agencies? If yes, then it becomes important for the new market agency to conceptualise the scope and prospects of market forces to establish and maintain the desired equilibrium and evolve suitable market strategies accordingly.

Effective water management requires an equilibrium management and coordination mechanism.

Water Markets: Dynamics & Scope

Can water markets be an efficient means to optimise the use and allocation pattern of scarce water resources, hence mitigating the crisis situation? In situations of growing demand with low supplies, market is considered as the best source to balance supply and demand. Countries like Mexico have gone in for water trading as part of their new water management strategy. Others like Peru and Pakistan are considering to follow such market driven systems to avert water crisis in their respective areas (World Bank, 1999). If we look at the dynamics and scope of water markets on a theoretical perspective, there are two schools of thought that determine the relevance of water markets. First, the neoclassical thought and second the pragmatic liberal thought. The neoclassical thought on water markets posits on *the institutional setting in a given system with a legal framework at the centre of enforcing water contracts. The pragmatic liberal thought on the other hand proposes informal water markets under which, reputa*tion and morality of the individuals are the key (as against the legal structure in the neo classical thought). There are practical examples, as well, that the informal water markets work fairly well as long as recharge facility is adequate and there are good number of sellers and buyers in the market (Shah, 1993; Saleth, 1998). The inherent flexibility enables sellers, in case of unsatisfactory service. Therefore, if a country wishes to establish a formal water market within the neoclassical framework, the law must be such that allocation of water rights is equitable and ensure the abeyance of the law by users. On the other hand, informal water markets can be established on mutual trust and cooperation depending on feasibility.

A proper conceptualisation of water markets, therefore, involves a rational economic analysis from demand and supply sides. One of the most important pre-requisites for establishing water markets of either sort, however, has been the establishment of tradable water rights. There can be constraints with such tradable water rights. Rights given to public organisations can lead to a situation where they dictate supply conditions and further lead to side payments for supplies (assuming corrupt institutions). Moreover, there can be jurisdictional constraints as well, with such water rights. It seems, therefore, that formal water markets are less likely to develop if they are constrained by high cost of institutional developments and in the absence of proper management systems and infrastructure needed for implementation of a trade environment. The cost of institutions and other infrastructure has been identified as constraints for countries like India and others in the south Asian region in general (Easter et al, 1998). It is also true for this region that there is a general aversion to water markets, because of the belief that markets would disadvantage the landless and low-income segments resulting from the treatment of water as a public good. However, water market in water scarce regions is of great relevance for its effective use patterns and demand-supply management.

Proper conceptualisation of water markets involves a rational economic analysis from demand and supply sides.

From the demand side, water is important for agricultural production (irrigation) as well as for drinking (non-irrigation) in water scarce regions becomes necessary therefore to work out the potential gains to the water user groups from a market. Experiences of water markets to maximise the welfare of these two vital user segments suggest the following. A formal water market specifies the volume and share of water to be sold either for a set period of time or permanently. An informal market on the contrary usually sells an unmeasured flow of surface water from a canal for a specified time or water pumped from a well for given hours. Farmers compare their comparative cost-benefit to utilise the sources of water to be accessed for irrigation. Informal water markets enable better economic returns both in terms of yield and income (Meinzen-Dick, 1998). However, while considering water as a public good or an open access resource, problem arises in areas with high demand and limited supplies. In such situations, even with formal market operations, market aberrations are likely. More precisely, the farmers or trade in this situation would have the incentive to buffer-stock water and pump it until their cost of pumping equals the unit sale price (most profitable output level). This will lead to overdraft (in excess of recharge). None, in this situation, however, would have the incentive to invest in water recharging methods. Continuous depletion of ground water levels accelerates the extraction (pumping) costs and hence the market prices shoot upwards so that irrigation becomes a disincentive for farmers, leading to decline in demand.

Issuing water rights or property rights on ground water further has the potential of monopolizing water markets in the absence of strict monitoring and control mechanisms. Shah (1993) argues that legal, quasi-legal and organisational instruments of public policy, on their own will not succeed in securing compliance of farmers or water right holders, unless they are accompanied by measures aimed at effecting private returns to irrigation... or unless the structure of property rights on water resource itself is drastically reformed. It is doubtful, yet, whether the governments have the institutional capacity to regulate and control sales among the numerous pump operators or the result such an intervention could bring in. The most important economic incentive for overdraft and lack of control in water extraction in underdeveloped countries has been subsidised electricity supply to rural farmers or water suppliers for irrigation. In a formal water market scenario, it become more important to provide certainty necessary for permanent water transfers between different water use segments and administrative jurisdictions. In cases where the water demand for non-agricultural uses is more, it is likely that surface water laws evolve first and ground water management strategies follow.

To establish a water market from supply side, it is operational type of water markets and distribution introduced depending on the use pattern in different water scarce regions. In an informal market environment, the water supplier would ensure supplies to users up to a level at which the cost of extraction equals the price. Another possibility is that the supplier will raise the price of water which buyers cannot afford to pay resulting in reduction of demand. Therefore it is essential to work out the benefits to both the suppliers and users of water in different user segments as well as market scenarios. In the case of formal water markets, through institutional arrangements and specific water rights distribution, economic gains can be accelerated either for the operator or the users. Research in this area reveals that if water trading in a formal market environment is done within individual water districts or communities (geographical jurisdiction), gains from trading would be modest (as there is no spot market). However, if inter-district or community water trade is permitted, subject to different supply constraints and drought conditions, there is scope for substantial economic gains to trades (Garrido, 1998). Both intra-regional and inter-regional water trade however, are sensitive to transaction costs. Estimates are that if these costs exceed 10 to 12 per cent of the market price, then trading and grains from markets would be too insignificant to justify the establishment of formal water markets. However, in active water markets with a substantial demand for non-agricultural use (drinking) of water, the transaction cost is likely to be low. One probability for this has been the assumption that the customers may not be utilising the full volume. In the opposite case, trade prospects are limited and hence, the economic gains gloomy. It would then become rational to suggest that for effective water markets to be established in the formal sector, appropriate institutional and organisational arrangements are to be identified with proper infrastructure and management systems.

It is essential to work out the benefits to both the suppliers and users of water in different user segments.

Once a market for water is established, it is likely that there would be no contingent market, rather only spot markets. The contingent markets can ensure supplies of a given volume at a set price because of the water rights. In spot markets, the buyers may find it cheap to buy water than investing in water rights. The major constraint therefore, of adjusting with established water markets has been that of identifying demand patterns of different user segments and properly pricing the water to justify equity aspects, particularly in areas where water is treated as a public good or a free natural gift.

> **The major constraint has been that of identifying demand patterns and properly pricing the water to justify equity aspects.**

The probability to overcome the constraints for an enabling environment to establish competitive water markets in the Asian region, however, is brighter now because of the recurring droughts and the government's failure to mitigate it despite concerted efforts over the last two decades. For example, recognizing the harm water scarcity can cause to the general public and the farm sector, the UN declared 1980s as the decade of international water supply and sanitation. This cause was re- affirmed by the New Delhi Global Conference on Safe Water and Sanitation. The New Delhi initiative to eradicate water crisis adopted a 'first standard' paradigm. This paradigm prescribed for governments to subsidize water supplies (particularly rural) because many households are too poor to pay for improved/alternate water sources. However, it emphasised that while aiming to achieve distributional efficiency, government funds must be spread thinly, as the resources are limited. The welfare state dictum of 'some for all rather than more for some' was not, however, convincing to many that market has been proposed as a sustainable alternative. One contended view in this argument was that users could be willing to pay a portion of their income for improved water sources. This has been placed as the 'second standard paradigm'. To look into the prospects of these two paradigms World Bank has done extensive research in early 90s. The findings are favourable for a paradigm shift towards the latter for competitive water markets in the region.

The major explanations on why consumers prefer to pay for improved water supply sources are first of all, the non-availability of water all through. Secondly, their option for an improved or quality water source. As per the first standard paradigm, consumers would pay nothing for the existing or for an improved source. In the second standard paradigm, some may come forward and be willing to pay a small percentage of their income. These rude assumptions, however, would not suffice for the estimation of demand and hence, the market potential of water towards an organised marketing. It is however, the income elasticity of demand for improved water sources and the socio-economic characteristics that influence the selection of improved water sources in individual markets. As people would be willing to pay for new water sources in water scarce regions, rationally and theoretically the cost in time and money is the most important determinant in their willingness to pay. Other probable determinants of the consumer's willingness to pay for an improved water source has been water quality, reliability, level of services etc (World Bank Research Team, 1993). Hence, understanding the economics of competitive water markets is desirable in conceptualizing its scope and identifying its potential in practical spheres towards evolving a suitable notional water policy.

Economics of Water Extraction & Marketing: Theory & Practice

Though economics of water extraction and marketing, resembles similar activities of any other natural resources (oil or minerals), it has two major exceptions. Firstly, water is a replenishable resource and secondly the availability levels in different regions vary across seasons. Therefore supply-demand gap over the seasons would be so wide that arriving at an equilibrium condition would be difficult. However, once replenishment is not effected, the extraction and market economics of water resemble other exhaustible natural resources. It is therefore, assumed for this conceptualisation that water replenishment is not taking place at the moment and extraction and marketing follow the general paradigm of demand and supply as in the case of any other natural resource. Since, water is not traded international, the dynamics of markets is determined by endogenous variables rather than exogenous ones. In some countries, government enterprises preserve, extract and sell or distribute water to different users, while in others, the same resource is managed by private agencies, subject to government regulations. However, in either of the cases (if the government enterprise does not wish to socialise the activity at the cost of economics), the theory of firm and the reasoning remain the same for its feasibility and market orientation.

The extraction and sale of water in a particular market is purely a function of supply and demand. However, this operation at a discounted maximum profit depends on the share of a marketing agency at the given price and time. Discounted profits relate to over extraction to make an equivalent value of all unexpected future profits today. If demand exists, the firm can extract water to a level at which the marginal cost equals the price ($MC = P$). It is evident, therefore, that the market size (demand) and the willingness of consumers to pay determine extraction levels. On the other hand, in a subsidised extraction and distribution by public firms, demand would always be higher (being free) and hence, level of extraction would be more. Further with depleting water levels (assuming no replenishment), it becomes costly to extract water and sell at the given price. As an upward price revision is likely to reduce the demand and thereby profitability, private firms can resort to water replenishment means (which government firms seldom resort to, as there is no incentive). Therefore, privately managed water markets can be one alternative to mitigate water scarcity by regulating the demand by proper price mechanisms and reliable water replenishment means. It is therefore, attempted to conceptualise this from a theoretical angle for practical relevance in water scarce regions. Probable impact of general economic and credit policies of the government is also looked into here towards evolving a suitable policy framework in the market environment.

Privately managed water markets can be one alternative to mitigate water scarcity by regulating the demand by proper price mechanisms and reliable water replenishment means.

L.C. Gray (1914) introduced the formal theory of natural resource economics, examining the supply behaviour of individual extractors (firms), who would expect a series of market prices and try to maximise their discounted profits in a small country assumption. H. Hotelling (1931) elaborated Gray's theory by incorporating real market prices into a dynamic model. Theoretically, a firm with no initial investments and being a price taker, tries to adjust the production so that the marginal cost is equal to the market price (MC=P). In other words, if the cost of extracting an additional unit of water is greater than the market price, then the firm would lose. On the other hand, if the marginal cost is less than the prevailing market price, the firm can raise profits by increasing supplies (assuming that demand prevails). It becomes true here that a litre of water extracted and sold today is a litre of water not available for sale on a future date (exhaustible resource assumption). Therefore, the opportunity cost (benefit) of forgoing *present extraction for an anticipated future gain* becomes relevant in water firms. This prevents the indiscriminate extraction of water at present through balancing supply and demand by means of prices. The opposite would be the outcome, if an anticipated future price gain is negative.

Say, after determining a sequence of extraction and sales that used all ground water reserves in the most profitable way, the extractor finds an additional quantity of water. Further assume that extracting and selling this quantity of water at the most propitious time would increase the net discounted profit by an amount (x). If the extractor has this extra quantity of water in the initial reserve, then x would have been the loss in the net discounted profit. In other words, the extractor loses, if he is forced to cut back the extraction of this quantity in one period to offset that quantity of additional extractions in another period. Hence, x is the opportunity cost of extracting the additional quantity. If the value of x is known, then it would be possible to determine the extraction path by computing the extractor's augmented Marginal Cost. This helps in adjusting the extraction levels so that the Augmented Marginal Cost equals Price. This opportunity cost cannot be so small that it encourages aggregate extraction that exceeds the water reserves. Nor can the induced extraction be so large that reserves are left in the ground indefinitely, since the opportunity cost of additional extraction would be zero rather than x. Therefore the opportunity cost must be such that planned cumulative extraction matches the reserves (Salant, 1995). With this situation, the logical extraction is at a level where the MC=P become insensitive, because the extraction at this level does not account for the profits forgone when additional volumes are extracted. In short, if the opportunity cost is sufficiently high, no extraction would take place today, even if the current P>MC of extracting the first unit.

The macro economic variables are expected to exert a significant impact on water markets to establish and maintain such a supply- demand equilibrium condition. Major economic variable that can have a direct bearing on the water market operation is the credit markets and interest rates (towards determining the market price). The likely impact of a credit rationing (or tight or strict credit policy) on water markets is that, the extraction levels would become rapid in the short run to maximise wealth. If the real interest rate is on the increase, the level of extraction would be more in the initial period and decline rapidly in the later state because the opportunity cost (x) would be declining as the future profits are less worth today. Each extractor, in such a situation, would try to sell the entire supplies at a time when the present value of net prices is at the height. To maintain water stocks and thereby market equilibrium, the prices must grow at a level equal to *more than the real interest rate. For example*, if the interest rate is 10 per cent and the price of a barrel of water is Rs. 20, then the price of water next year is expected to be Rs. 22. If that happens, the extractors forgo a portion of their supplies to be preserved for the next year rather than selling the current year itself. However, if that does not happen, the extractors sell the maximum quantity in the current year itself. If it is expected to grow more than Rs. 22, then the supplies in the current year will be sacrificed for the future profits, anticipating a higher present value of the future prices.

It is true, here that if water price does not increase equal to more than the rate of interest, extractors would have no incentive to forgo their current extraction for future. However, more extraction causes extractors to raise their MC because of diminishing returns. Therefore, it is likely that private extractors resort to replenish ground water levels through appropriate rainwater storage or harvesting techniques to reduce extraction costs. Hence, a competitive water market can accelerate harvesting by extraction firms themselves as a means to improve their market competitiveness and profitability. With a number of players in the market, the comparative advantage of individual firms can be determined through their nature and mode of operations. Community (cooperative) water market players can be one source of competition and inspiration to private firms in this field, as anticipatory behaviours are quite likely to influence the equilibrium extraction and price in this type of a market.

A competitive water market can accelerate harvesting by extraction firms themselves as a means to improve their market competitiveness and profitability.

Conclusion

Establishing suitable market mechanism is one of the options open to mitigate drought or seasonal water shortages. However, it is essential first of all to estimate the demand and secondly to identify the characteristics of the water use categories and their willingness to pay so that desirable market structures can be evolved in different regions. Proper policy and legal framework is essential for any water management strategy to sustain in the long run. Conducive macro economic and credit policies would be supplementary to make the market mechanism work. Once competition prevails in the market, the invisible hand would activate the trade towards fairness and consumer welfare.

Acknowledgement

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Merit Goods: The Case of Rural Drinking Water in Kerala

K. Pushpangadan

Capacity utilisation, the ratio of actual water supplied to potential supply from designed capacity, is only 49.5 per cent in Kerala. This would mean that percentage of people with actual public water supply in rural areas is only half of the potential coverage given by the government sources. The study provides capacity utilisation in rural schemes as an explanation for the wide variation in the coverage of drinking water supply existing between the estimates of norm-based consumption and actual consumption. It also develops an engineering methodology for the calculation of actual water supplied from the pumping hours using a stratified random sample of 199 rural schemes in Kerala.

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Provision of rural drinking water has become the responsibility of the state in the developing world since market forces would not provide this life sustaining resource adequately and equitably. As a result, rural drinking water is treated as merit goods. The financial resources made available to various state governments in India for giving potable water to millions of rural poor are very impressive and the coverage, if valid, is commendable. But, the coverage figures are based on the potential/design capacity of the system but not the actual supply reaching the users. In other words, estimates on rural coverage given by various state governments may be biased upwards. This is best illustrated from Kerala. The norm-based estimate, 250 person for every tap, of Kerala Water Authority (KWA) shows that about 32 per cent percentage of rural population is covered in 1994. But the corresponding estimate based on actual consumption of drinking water from public source from the validation survey[1] in 1994 is only 19 per cent. Similarly, the coverage from Census (1991) based on actual users of public water supply is only 12.2 per cent whereas KWA puts it as 4 per cent. This sharp difference also exists in the figures for 1998 released by the National Sample Survey Organisation. Reconciliation of the estimates is possible only if actual water supplied were known. No reliable attempt exists so far in this direction. This paper provides such an attempt by estimating capacity utilisation (CU) of rural water supply schemes in Kerala.

Potable water coverage figures are based on the design capacity of the system but not the actual supply reaching the users.

1. See Pushpangadan, Murugan and Navaneetham (1995), Table 3.

Capacity utilisation is usually defined as the ratio of actual output to potential output. While the actual output is clearly defined, no consensus exists on the measure of potential output[2]. There are two approaches for obtaining the potential output. The first is the engineering approach, which takes the maximum output that the existing capacity can produce as the potential output. This may be interpreted as the maximum output that the short-run capital stock could produce. In other words, it is the short-run measure of potential output. The second is the economic approach based on the firm's average cost curves. In this context, two versions are available in literature; one proposed by Klein (1960) and Friedman (1963), and the other by Cassel (1937) and Hickman (1964). Klein-Friedman definition of potential output is the output at the tangency point of long-run and short-run average cost curve of the firm. The second version, Cassel-Hickman, relates it to the output corresponding to the minimum of the short-run average cost curve. Our case, the choice d of method depends on the availability of data on rural water supply. One readily available information for any water supply system is its design capacity. This is taken as the potential output. Since the design capacity is not based on the cost curves but on the engineering design of the system, our method of estimating CU belongs to the engineering approach. The issues in the selection of sample, data collection and the estimation of CU are as follows.

The design capacity is available from the secondary source, i.e., from the original project report. But the actual water supplied by each scheme is not available. As a result, we were left with only primary survey for getting the actual water supplied. The sample for the survey was selected from the list of all the schemes in the directory on 'Piped Water Supply Schemes in Operation as on 01-04-93' published by the Kerala Water Authority after excluding the following types of schemes: Urban water supply schemes, schemes with missing design capacity; and schemes which are only extensions of urban systems. The remaining schemes were 1173 in number. For sample selection, the schemes were stratified by design capacity and by region. A 25 per cent sample was drawn from each size class using circular systematic sampling method with an initial selection using the random number table. The distribution of the sample is given in Table 1. The spatial distribution of sample by district is given in Table 2. About 43.5 per cent percent of the sample belongs to the southern districts and remaining 56.5 per cent to the northern districts. Maximum observations are from Idukki from the southern districts and Trichur from northern regions.

2. See Nelson (1989) for the survey of literature.

Table 1: Sample Size by Region and Capacity

Design Capacity	Number of Schemes					
	Northern Region		Southern Region		Total	
(mld)	Population	Sample	Population	Sample	Population	Sample
<0.1	389	97	206	52	595	149
0.1-0.2	124	31	65	16	189	47
0.2-0.5	98	25	94	24	192	49
0.5-1.0	21	5	52	13	73	18
1.0-2.0	10	3	50	12	60	15
0.2	12	3	52	13	64	16
Total	654	164	519	130	1173	294

Source: KWA, (1993)

Note: mld: million litres per day

Table 2: Sample Size by Districts

District	Number of Schemes
Southern Districts	
Thiruvanthapuram	22
Kollam	14
Pathanamithitta	13
Alappuzha	11
Kottayam	23
Idukki	32
Ernakulam	13
Northern Districts	
Trichur	38
Palakkad	26
Malappuram	24
Kozhikode	28
Waynad	10
Kannur	25
Kasargod	11
Total	294

Source: Same as in Table 1

The questionnaire for the survey had two major parts. The first part was mainly concerned with cost of production of water supply and other socio-economic factors affecting supply. The second part was on the information needed for estimating water supply using engineering method. The questionnaire was pre-tested in a few schemes in Trivandrum District by two investigators with degrees in engineering. The schedule was finalised after incorporating the findings of pilot survey and with technical advice from College of Engineering, Trivandrum. Fieldwork was started in September 1996 and the same was completed in August 1998. Only 212 of the 294 schemes were finally included for the data collection. The reasons for the exclusion of the 82 schemes are given in Table 3. It may be noted that about 14 per cent of the schemes in the sample were defunct.

Table 3: Reasons for the Exclusion of Schemes by Region

Reasons for exclusion	Number of Schemes	
	North	South
Surveyable	141	89
Defunct	16	25
Natural	3	10
Unsurveyable	4	6
Total	164	130

Source: Primary Survey.

Among the 230 surveyable schemes, 18 of them were employing direct mode of pumping to the distribution lines and hence actual water supplied cannot be measured using our methodology. This reduced the sample size to 212 schemes. After data entry, it was found that another 13 schemes had incomplete data, reducing the sample to 199 schemes for the final analysis. The most important variable needed for the estimation of CU is the actual water daily supplied, the measurement of which is as follows.

Measurement of Output & Capacity Utilisation

During data collection, it was found that the actual water supplied from the scheme was not available instead, only pumping hours were recorded. If pumping hours were not unavailable, it was calculated from the electricity consumption data[3]. The daily water supply was estimated from pumping hours using the engineering method. The equation for the calculation of actual water supplied by the scheme is:

Actual quantity of water supplied per day = t * Q,

Where t is the pumping hours per day, and Q, the discharge of water in m^3/hour. The discharge of each scheme was measured by Dip Stick Method[4]. It was

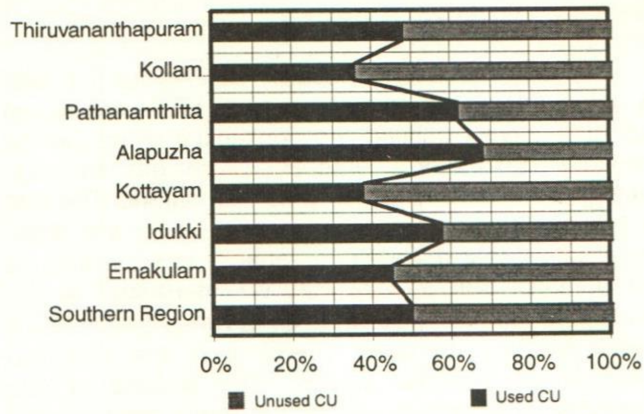

Fig. 1 (a). Average Capacity Utilisation in Southern Districts

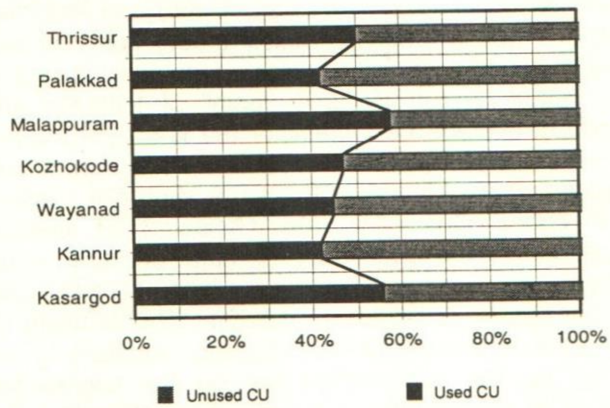

Fig. 1 (b). Average Capacity Utilisation in Northern Districts

calculated from the time taken to fill a given quantity of water in the tank using stopwatch and measuring tape. The capacity utilisation was then obtained for each scheme using the formula:

CU = actual supply of water per day/potential (designed) supply of water per day.

Empirical Results

The spatial distribution of CU is given in Fig. 1. The average capacity utilisation of rural schemes in Kerala is only 49.5 per cent of the designed capacity. In other words, about 50 per cent of the difference in the two coverage estimates by Government of Kerala and by Census and NSSO can be explained by the difference in the capacity utilisation. Figure 1 also indicates that there is a marginal increase, about 3 per cent in the CU of schemes in the southern districts compared with that of the northern districts. The lower CU in the northern districts can be attributed to the widely known voltage problem in the region, which reduces the pumping hours and, thereby, the capacity utilisation. There are also variations in CU within the regions. For example,

3. See Heathfield (1972) for measuring capital usage using electricity consumption data for U.K.

4. See for details Khurmi (1992)

CU is the highest for Allepey followed by Pathanamthitta in the southern districts; lowest being in Kollam followed by Kottayam. In the case of northern districts, Malappuram has the highest CU followed by Kasargodu and the lowest in Kannur followed by Palakkad. Now let us examine the plausible factors affecting the CU of water supply schemes. More specifically, we examine the relationship of CU with the following factors: age of the scheme, source of water supply, type of pumps in the system, input use efficiency and power factor.

CU & Age of System

At the time of the project of any scheme, the design capacity usually includes the likely excess demand arising from population growth. This means that CU and age of the scheme should be positively related. This hypothesis is examined in Fig. 2. Figure 2 does not support the hypothesis of a positive relationship between CU and age of the system. In fact, CU is almost independent of the age of the schemes. The finding remains more or less the same for the schemes in both northern and southern region.

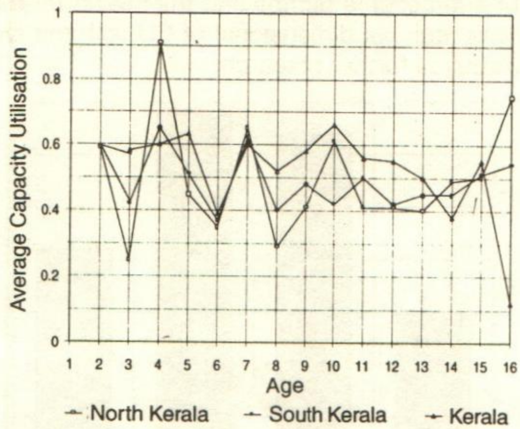

Fig. 2. Capacity Utilisation by Age and by Region

CU and supply source

The behaviour of CU by source of supply is examined in Table 4. About 92 per cent schemes belong to the four sources of supply; open well, river, bore well and tube well. Among them, 56 per cent have open well, 17.3 per cent river and 1.41 per cent bore well as their sources of supply. Among the four sources, CU is highest for bore well based schemes. There appears to be a better CU for open well in the north and river in the south. However, the advantage disappears at the state level; dam, lake and open well-cum-tube well based systems have shown the maximum CU. This cannot be generalised since the number of such schemes is very small.

CU and Type of Pump

Four types of pumps are in use in water supply—centrifugal, jet, vertical turbine, and submersible. The CU by type of pumps and by region is given in Fig. 3. It shows that capacity utilisation is the highest for vertical turbine and lowest for centrifugal pumps in the northern part of Kerala. However, in the southern region highest

Table 4: Average Capacity Utilisation and Supply Source of Schemes

Source	North Kerala		South Kerala		Kerala	
	Number of schemes	ACU	Number of schemes	ACU	Number of schemes	ACU
Open Well	65	0.4871	49	0.4715	114	0.4804
Bore Well	25	0.4970	4	0.5825	29	0.5088
Tube Well			8	0.5697	8	0.5697
River	15	0.4540	20	0.5053	35	0.4837
Open Well & Bore Well	2	0.0910	3	0.5319	5	0.3535
Open Well & Tube Well			1	0.9689	1	0.9689
Pond	2	0.4783	3	0.5681	5	0.5322
Dam	2	0.6977			2	0.6977
Spring			2	0.3656	2	0.3656
Lake			1	0.6667	1	0.6667

Source: Primary Survey

Note: ACU: Average capacity utilisation

CU is for submersible pumps and the lowest for the jet. This strong regional dimensional of CU with the type of pumps requires further research.

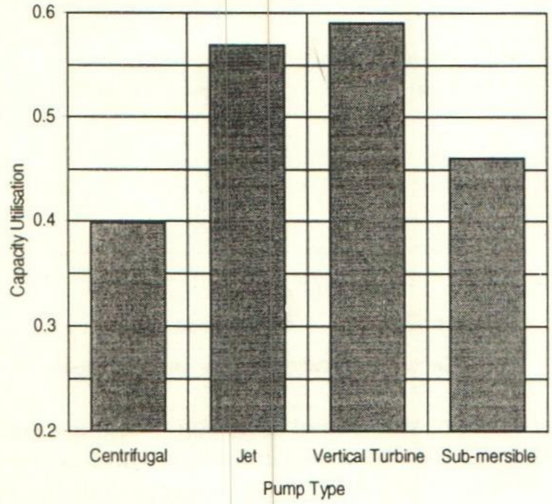

Fig. 3 (a). Average Capacity Utilisation and Type of Pumps in Northern Districts

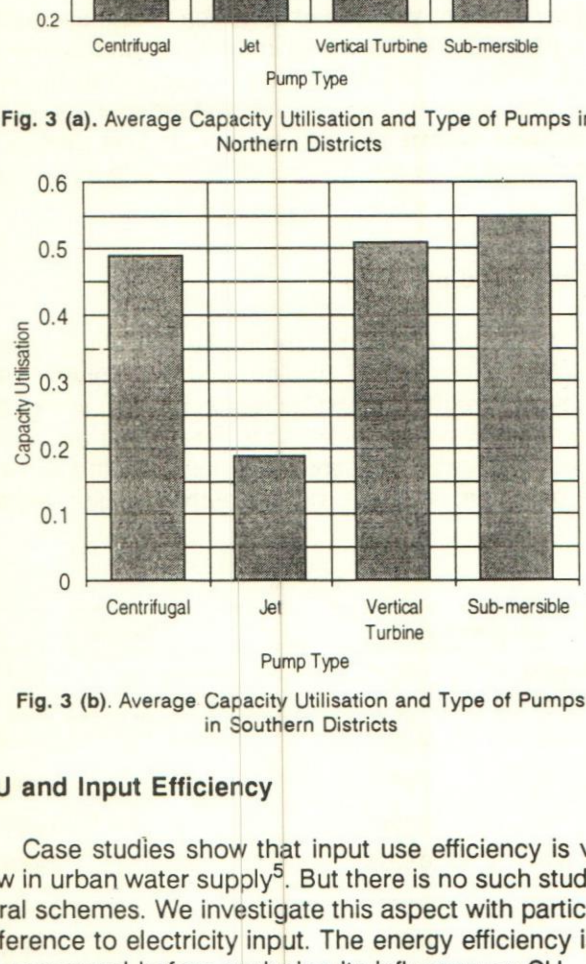

Fig. 3 (b). Average Capacity Utilisation and Type of Pumps in Southern Districts

CU and Input Efficiency

Case studies show that input use efficiency is very low in urban water supply[5]. But there is no such study in rural schemes. We investigate this aspect with particular reference to electricity input. The energy efficiency is to be measured before analysing its influence on CU.

Energy efficiency: Engineering approach

Energy efficiency (EE) is defined as the product of

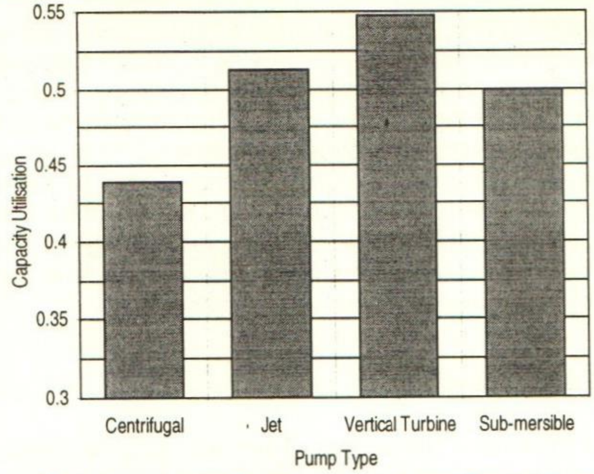

Fig. 3 (c). Average Capacity Utilisation and Type of Pumps in Kerala

motor efficiency (ME) and pump efficiency (PE).

EE = ME*PE

Where ME = Motor output/Motor input (MI)

PE = Pump output(PO)/pump point.

Since motor output is equal to the pump input,

EE = PO/MI ...(1)

For the estimation of (1), we have to measure motor input (MI) and pump output. Motor input (Kilowatt) is measured by the following equation:

MI = Number of revolutions*3600/k*t

= 5*3600/k*t = 18000/k*t ...(2)

where 3600 is the conversion factor from hour to second, k is the energy meter constant, t is the time taken to complete the given number of revolutions.

Pump output is the product of acceleration due to gravity (g), total head (H) and discharge (Q). Since pump output is the quantity of water pumped, it is usually called the hydraulic output.

PO = Hydraulic output = g*H*Q

Since g is a universal constant for acceleration due to gravity and is equal to 9.81,

PO = 9.81*H*Q ...(3)

Measurement of Motor Input & Pump Output

The pump output of each scheme was measured by

5. See Pushpangadan (1995).

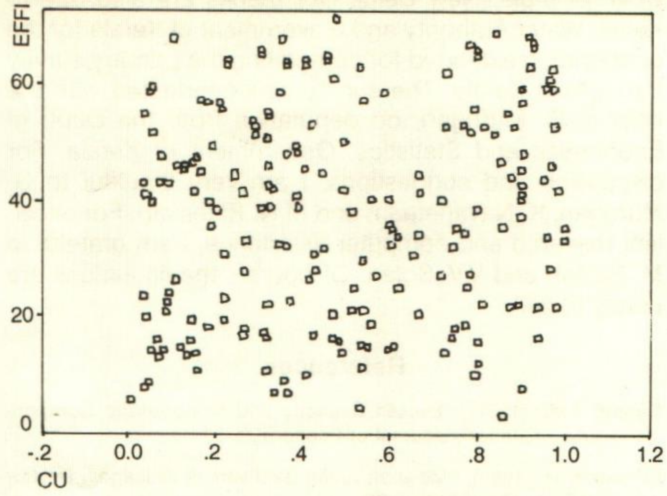

Fig. 4 (a). CU and Energy Efficiency in Northern Districts

Fig. 4 (b). CU and Energy Efficiency in Southern Districts

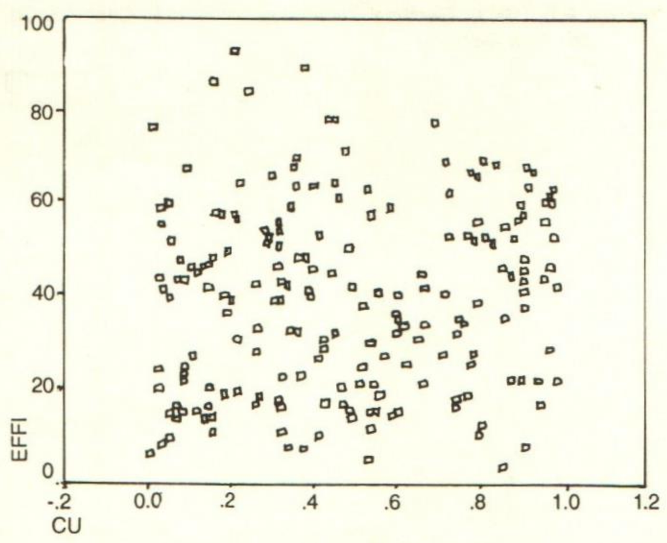

Fig. 4 (c). CU and Energy Efficiency in Kerala

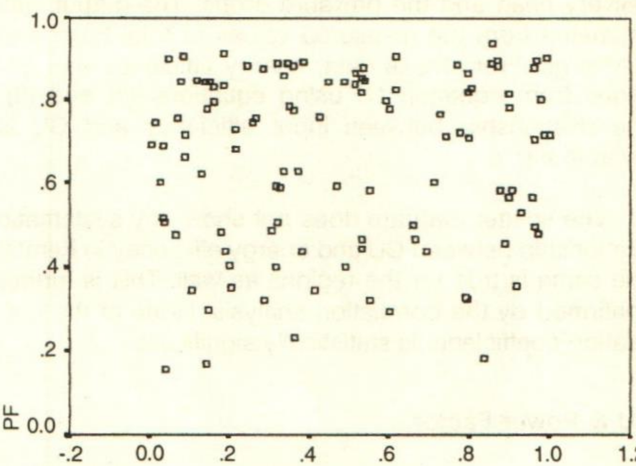

Fig. 5 (a). CU and Power Factor in Northern Districts

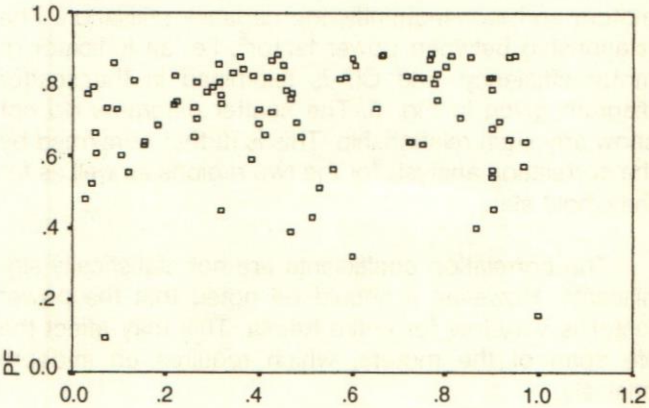

Fig. 5 (b). CU and Power Factor in Southern Districts

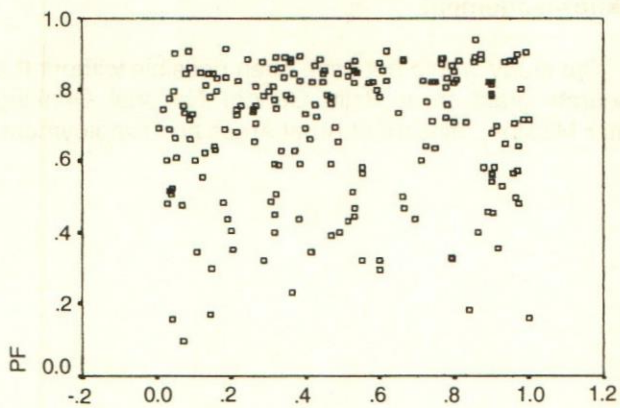

Fig. 5 (c). CU and Power Factor in Kerala

finding out the actual head and actual discharge. Dip Stick method was used to measure the discharge as discussed earlier[6]. Further actual head was measured with the help of pressure gauge and measuring tape.

6. See Khurmi (1992) for details.

Total head is obtained by summing the suction head, delivery head and the pressure drops. The output was estimated from the measured values of total head and discharge. From these data, energy efficiency was obtained from equation (1) using equations (2) and (3). The relationship between input efficiency and CU is given in Fig. 4.

The scatter diagram does not show any systematic relationship between CU and energy efficiency in Kerala. The same is true for the regions as well. This is further confirmed by the correlation analysis. None of the correlation coefficients is statistically significant[7].

CU & Power Factor

From the engineering point of view, power factor is an important parameter that determines the efficiency of motors and, consequently, the capacity utilisation. The relationship between power factor[8], i.e. an indicator of motor efficiency, and CU is examined in the scatter diagram given in Fig. 5. The scatter diagrams do not show any such relationship. This is further confirmed by the correlation analysis for the two regions as well as for the whole state.

The correlation coefficients are not statistically significant[9]. However, it should be noted that the power factor is very low for entire Kerala. This may affect the life span of the motors, which requires an in-depth analysis.

Acknowledgement

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□

7. The Pearson coefficient of correlation is: 0.14 for the southern region; 0.01 for the northern region; and 0.11 for all Kerala. None of them is statistically significant.

8. The technical definition of the power factor is the cosine of the angle between voltage and current at the input terminal. Power factor = input (KW)/1.732* voltage *current (Theraja, 1993).

9. The Pearson correlation coefficient between Cu and Power factor is: 0.05 for southern Kerala; 0.06 for northern Kerala; and 0.06 for all Kerala. None is significant.

Sustainable Irrigation Development: Water Use Policies & Practices

M. Venkata Reddy

Till recently irrigation was construed as merely constructing dams and canals and releasing water to as large an area as possible. Preventive measures necessary to avoid or reduce the possible negative externalities have hardly been incorporated in project designs. This, obviously, has led to environmental problems. Among other factors, farmer ability to adopt to irrigation technology that ensures environmental sustainability, and also the institutional and organisational strategies necessary to accomplish it have not properly been understood and analysed. This paper tries to analyse some of the irrigation-induced technologies and their relevance to ensure environment-friendly irrigation.

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In the recent past, especially after the World Commission on Environment and Development (WCED) published its report in 1987, the term "sustainable development" has become increasingly common. It is defined as "development that meets the needs of the present without compromising the ability of future generation to meet their own needs" (WCED, 1987). Further, it is said that what is needed now is a new era of economic growth – growth that is forceful and at the same time socially and environmentally sustainable. The evolving concept of sustainable development, therefore, has renewed interest in redefining and advancing water use practices and principles in canal command areas, especially in mega-irrigation projects. This calls for a new context of evidence, perceptions, inter-dependence, ethics and action within which to consider the principles and practice of water resources management (Dorcey, 1991).

Perspective

In the context of irrigation, sustainable development may be defined as "water resource systems that are able to satisfy the changing demands placed on them, now and on to the future, without system degradation". Irrigation, therefore, must not cause damage or destroy the basic fertility of soil and should enable provision of continuous flow of economically sustainable production, for which it requires, among other factors, sustainable social systems to ensure the equitable distribution of water. It is, therefore, necessary to identify the constraints and ground realities which tend to adversely affect the sustainable development of irrigation. The empirical evidences presented in this paper may hopefully help tracing the missing links, if any, required to weave the web of sustainable development and use of water resources.

Traditional technologies to harvest water for irrigation in India are age-old and were developed mostly based on the wisdom of local people, their needs and locally available resources. Least interference with the natural order of eco-system was considered as one, (albeit important), of the principles to be observed in the design, construction, operation and maintenance of irrigation systems. Whilst people-centred and environmentally sensitive traditional systems are necessary and will continue to be so in future, the frequent occurrence of natural calamities like droughts, and famines on the one hand, and mounting demand for food on the other, necessitated exploring additional ways and means of harvesting water, especially from large and perennial rivers. Furthermore, after independence a policy to ensure balanced regional development as one of the developmental strategies favoured the extension of irrigation facilities to frequently drought-prone and even to hydrologically less favourable regions.

Given such economic, social and political compulsions to bring more area under irrigation on the one hand, and agro-climatic and other resource constraints to accomplish it on the other, it was realised that traditional systems like tanks, wells and river-diversion schemes alone are not adequate to meet water requirements of agriculture. It had, therefore, become necessary in the post-independence period to build big storage dams to supply water for irrigation in the arid regions of the country to promote and increase agricultural production on a sustainable basis. This had obviously led to explosion of investment by the state in major and medium irrigation projects. Nearly 80 per cent of the total investment of Rs. 920 billion (at historical prices) in irrigation since independence (1951-52 to 1996-97) was on major and medium projects. The investment of such a magnitude in major irrigation projects is said to be justifiable, as it was perceived by the nationalist leaders inevitable to accelerate growth and development in modern India. But the impact, as revealed by various researches and evaluation studies, of mega-projects on economic, social and environmental conditions seems to be much less encouraging, falling well behind the expected levels and direction (Reddy, 1998).

While the benefits from mega projects are not upto the expected levels, they did contribute to augment agricultural production substantially, for, almost 60 per cent of agricultural production comes from irrigated farming. Even so, all is not well with irrigation down on the farm, because, it induces many changes in the eco-system by triggering off physical, biological and social processes in the area. Lack of vision and understanding of the prismatic effects of such processes seems to have led to a variety of adverse effects on soil fertility, ecological balance and income redistribution. It is in this context Whitecombe (1972) portrayed a bewildering array of adverse effects associated with canal irrigation. The tides of prosperity expected through irrigation may, ultimately be broken by the quagmires caused by it, depriving the benefits that could have otherwise been realised under rainfed cultivation (Reddy, 1990). This dimension of irrigation impact has not been adequately addressed by the researchers. While evaluating the impact of irrigation, attempts are normally made at describing the effects on biological and economic aspects, the social impact—the repercussions of irrigation on environment, individuals, groups and cultural norms—is hardly recognised as important (Carruthers, 1987).

In the contemporary developmental scenario, the ramifications of irrigation impact did raise a number of empirical and theoretical questions. For instance, the problems of environmental deterioration such as waterlogging, salinity, alkalinity and water-borne diseases are gaining increasing attention. Empirical evidences show that such adverse effects are mostly due to the disjunction between an increasingly large-scale complex and modern irrigation network and still largely traditional peasant farm users of that system (Shepperdson, 1981). Farmers are ill-equipped to perceive and assimilate irrigation-induced changes in farm technology and adopt suitable strategies to abate environmental problems. In such a situation it is necessary to properly understand and analyse the human dimensions in water resources development to ensure environmentally sustainable irrigation systems (Derrider & Erez 1977).

Problems of environmental deterioration are mostly due to the disjunction between an increasingly large-scale complex and modern irrigation network.

It is also alleged that environmentalists have become a major threat to irrigation development (Carruthers, 1987). For, they seem to have no clear understanding of the complex processes associated with design, construction, operation and maintenance of irrigation projects. Irrigation does not automatically and necessarily bring unmitigated benefits to mankind; it can, and does, extract high costs as well (Biswas 1978). What is necessary is a determined attempt to minimise the costs and maximise the benefits. This can be done if ecological/environmental principles are explicitly considered and integrated in the overall planning process. But at the same time it is essential that one has to guard against emerging environmental fundamentalism (Vaidyanathan, 1991). Otherwise, emotional and ideological overtones tend to camouflage economic rationality.

It is necessary to distill the experiences in irrigation projects over time and identify the techno-managerial strategies to promote sound policies of water use. For instance, land-based technologies like on-farm development (OFD) need to be promoted simultaneously with construction of canals and release of water to mitigate or avoid potential adverse effects of irrigation (Douglas, 1981, Chauhan & Seva Ram, 1977). Some of the serious environmental hazards like waterlogging and salinity are attributed particularly to lack of OFD and scientific water use and management (Bowonder & Ravi, 1989). Such adverse effects on soil, besides being environmentally hazardous, mean a loss of basic factor of production, namely land, and the consequent loss in agricultural output at the aggregate level. The opportunity cost of this loss in terms of private and social costs tends to be enormous with its attendant ramifications on the economics of investment in irrigation. It is, therefore, suggested that the design of an irrigation system must include not only engineering considerations of water storage, conveyance and delivery, but also agricultural, economic, social, political, legal and environmental considerations for long term stability (Thavaraj, 1979). This calls for a multi-disciplinary approach, in which each specialist understands the interaction between his discipline and that of his co-workers, to integrate various factors into a final design to ensure environmental safety.

Land-based technologies like on-farm development (OFD) need to be promoted simultaneously with construction of canals and release of water to mitigate or avoid potential adverse effects of irrigation.

Admittedly the human knowledge base is now higher than it was two decades ago; but unfortunately the capability to apply that increment in the knowledge base operationally to resolve environmental problems has not made the same progress (Biswas, 1990). Furthermore, there has been a phenomenal increase in research on environmental modelling and system analysis, as it is believed that would enable incorporating corrective measures in designing environmentally sustainable water resources projects. But it should be noted, as Biswas pointed out, that models can not ever replace experience, knowledge, and judgement, that can, however, if used properly, augment them significantly.

Therefore, in the fore-front of a move to make irrigation more efficient, productive and environment-friendly, stands a massive task of identifying field level constraints – institutional and organisational. For, the benefits of irrigation would be determined, to a larger extent, by the judicious use of water for crops. In order to avoid deleterious effects of irrigation and increase its positive gains, a host of other activities will have to be initiated simultaneously with construction of canals. They include systematic land development, scientific water management and use, suitable crop patterns, timely and adequate input supply and motivation of farmers to adopt modern farm technology. These are difficult tasks, non-accomplishment of which may give rise to a variety of issues and problems in command area development aggravating the adverse effects – biological and social.

Activities to be initiated with construction of canals include systematic land development, scientific water management and motivation of farmers to adopt modern farm technology.

The main objective of this study is, therefore, to examine, empirically, the wide range of water and land use practices and their inter connections with farmers' ability to understand and adopt water-related activities to make irrigation more environment-friendly. Data are drawn from a study in Malaprabha Command area on land development and water management. The study covered 258 cultivator households spread over three villages selected from three taluks benefited by Malaprabha project surveyed at two points of time – first survey in 1975-76 and second survey in 1986-87.

The Study Region: A Background

Malaprabha is one of the major irrigation projects in the semi-arid region of northern Karnataka, where rainfall is scanty and erratic. Deep black soils are ubiquitous in the command area. Farmers had no experience of irrigated farming before the construction of this irrigation project. Keeping in view the soil characteristics (deep black soils) and the need to spread irrigation to more area the project has been designed for protective irrigation. It is, therefore, localised only for irrigated dry (ID) crops. Water-intensive crops like paddy and sugarcane are obviously prohibited. Furthermore, the localisation is based on the agricultural seasons in the region, namely kharif and rabi. The proposed culturable command area (CCA) is ear-marked on a pre-determined proportion to each season. The earmarking is based on 40:20:40 ratio, i.e, 40 per cent for kharif, 20 per cent for two-seasonal and 40 per cent for rabi crops. The implicit rationale behind this strategy is to avoid higher intensity of cropping in black cotton soils. For, higher intensity of irrigation in deep black soils tends to create salinity and alkalinity problems in the long run.

Traditionally, the rainfed farming in this region was confined mainly to rabi season where crops like jowar and pulses were grown. The introduction of irrigation has, however, motivated farmers to grow crops during kharif season also, followed by a diversified cropping pattern. The shift was towards commercial crops like cotton and also maize and wheat. Since farmers had no experience in irrigated farming, rational scheduling of irrigation was a serious problem in the initial years.

Institutional & Organisational Setting

Efficient and economic use of water in command areas of river-basin projects depends, among other factors, to a large extent on cultivators' knowledge of irrigated farming. For, it is important and necessary that farmers are adequately equipped with knowledge and technology to take up land-based activities like systematic land development, soil testing to know nutritional status, suitable crop pattern, on-farm water use and control methods, crop-water requirements etc. to obtain optimum returns per unit of water, ensuring at the same time environmental safety. An attempt, therefore, made to analyse the land and water use practices followed by the farmers in the command area.

Efficient and economic use of water in river-basin projects depends to a large extent on cultivators' knowledge of irrigated farming.

On-Farm Development (OFD): Systematic land development is an essential pre-requisite for efficient use of water on the farm. For, it facilitates uniform spread of water on the field and improves moisture retention capacity of soil, provided it is done systematically and scientifically. As revealed by the survey results, 93 per cent of the sample farmers were aware of the need for and advantages of OFD. But for majority of them OFD means merely removing shrubs and bushes and levelling it in a crude way to facilitate waterspread; scientific development was hardly known. What surprises is, even by the crude or unscientific method only 33 per cent of the land notified for irrigation was developed at the time of first survey (1974-75), which had increased to 73 per cent by 1986-87. More than 33 per cent of the sample farmers did not take up land levelling work at all. This crucial aspect seems to have not been given adequate attention to ensure sustainable use of land in the command areas and avoid adverse effects of irrigation in the long-run.

For instance, not even 10 per cent of the sample farmers knew about drainage as one of the critical factors of OFD. The need to maintain natural drains as one of the means to avoid water logging was hardly known. Lack of awareness of the advantages has, therefore, resulted in farmers encroaching upon natural drains to augment their cultivable area. Such a tendency seemed to have aggravated waterlogging problems in the command area. None of the farmers knew about the necessity of soil survey, yet another important aspect of scientific OFD, to determine appropriate slope and gradient depending upon canal and field channel alignments. Same is true of consolidation of holdings, field irrigation channels and farm-roads. Lack of adequate finance, besides many other factors, was reported as the most important reason for not taking up land development (Reddy, 1998). The upshot of these observations is that the farmers have no adequate information and knowledge about the technology package needed to practice irrigated farming.

Soil Testing: Soil nutrients vary across the fields. Farmers need to know the characteristics of the soil to plan for watering schedules and to meet nutrient deficiencies, if any. Soil testing would help farmers understand the nature and quality of their lands and plan for suitable crop pattern, water requirements and fertiliser use. However, in the study region, at the time of first survey, only 7 per cent of the sample farmers was aware of the need for soil testing but none had got their soils tested. Even at the time of second survey in 1986-87, only 5 per cent had got their soils tested. It is an indication of farmers' ignorance or may be indifference towards a very critical aspect of OFD, from the view point of water use and crop planning. All these problems seemed to be essentially due to lack of a vision to create an institutional base to educate farmers about the irrigated farm technology. Therefore, agricultural extension net-work, equipped with soil testing and other associated labs to help farmers in adopting new technology, needs to be planned and promoted simultaneously with the release of water for irrigation.

Localisation Pattern: The delienation of a specified policy for land use, taking into account the availability of water and other agro-climatic considerations in a command area, is known as localisation pattern, This is done, with a view to provide irrigation to as large as an area as possible and also to sustain the fertility of the soil by restricting the intensity of irrigated farming. Successful implementing of such a policy, however, is contingent upon farmer awareness and will to follow it, depending upon field realities. In the command area under reference, it is a welcome trend to find that about 70 per cent of the farmers selected for the study was aware of the proposed localisation pattern (i.e., 40 per cent kharif season, 20 per cent bi-seasonal crops and 40 per cent rabi season). But, surprisingly only a solitary farmer had followed that pattern, inspite of awareness being fairly high. There must be strong reasons for such a poor performance. As revealed by the survey, subdivision and fragmentation of land holdings was the main factor responsible for non-adoption of the proposed localisation pattern. It is highly impracticable, as reported by the farmers, to aportion each parcel of the land in the ratio suggested by CADA. This had obviously led to the violation of localisation pattern and the consequent disparities in water use. Though consolidation of land holdings is one of the objectives of command area development authorities, it was hardly realised in any of the projects. Since the theoretically well-conceived plan could not be operationalised due to practical constraints, inequitable distribution of water got perpetuated with its attendant problems of social tensions and economic disparities.

Fragmentation of land holdings was the main factor responsible for non-adoption of the proposed localisation pattern.

Water Management: The accomplishment of water management is a complex process of integrating diverse, but mutually interdependent factors (table 1). All these factors should be promoted in perfect unison to ensure efficient use of water. The table presents the linkages between design parameters, construction, operation and maintenance of the canal, land preparation and use of water and finally the actions, behaviour and attitude of beneficiary farmers. A harmonious blend of engineering, agronomic and social factors, is an essential pre-requisite to forge a sustainable base to promote efficient water management. Because of the limitations of data we are unable to illustrate the disjuctions of this linkage model and its impact on water use efficiency.

Since deep black soils are ubiquitous in the command area under reference, irrigation methods need to be carefully planned and followed. For such soils are

Table 1: Imperatives for Ensuring Scientific Water Management—A "Six-Factor Model

Water Duty	Expressed in terms of area irrigated per unit of water. Should be computed by taking into account the proposed cropping pattern, crop-water requirement (delta) based on soil type, rainfall and other agro-climatic conditions in the command area.
Water Discharge	Water should be discharged into the canals at various points of the distribution network upto the pipe outlets as per the water-duty assumed.
Canal Design	Canals should be designed in such a way that they will carry water discharge without allowing any wastage by way of over-flowing or by other means.
Water Distribution	Water discharged in the canal should be distributed equitably among all the beneficiaries irrespective of the location of their plot, caste, community, sex or any other social consideration.
Land Development	Lands should be scientifically levelled with appropriate bunding and other associated on-farm developments to ensure uniform and quick spread of water across the field which reduces/avoids field application losses.
Beneficiaries Discipline	Beneficiaries (farmers) should behave with discipline to use water carefully without resorting to take in excess quantities depriving others of their legitimate share. Farmers organisations and associations with well articulated rules, regulations and roles will help ensuring discipline among user-farmers.

prone more to alkalinity and salinity, if over irrigated. In the initial years of irrigation, water-management had not got adequate attention due to a variety of reasons. For instance, land development was not undertaken, allegedly due to inadequate and untimely supply of water as revealed by the survey data. As high as 98 per cent of the sample farmers were in favour of learning scientific water-management practices. Because of technical and other constraints, only 38 per cent could adopt water management practices at least the way they were understood, if not scientifically. This seemed to have led to proliferation of problems related to water use at the field level. For instance, farmers at the head-reaches use more water than required depriving the tail-end farmers of their due share. This seemed to have led not only to a decline in productivity of crops but also created adverse effects on soil. The empirical results presented in Table 2 based on the intensity of water application by the farmers for four major crops in the command area, explain the field realities.

In deep black soils it is too hazardous to apply excessive water. Irrigation should be limited to ensure

Table 2: No. of Waterings applied by the farmers and Crop Yields (in Qtls/Acre)

No. of Waterings	Selected Crops							
	Maize		Jowar		Wheat		Cotton	
	Yield	% of farmers	Yield	% of farmers	Yield	% of farmers	Yield	% of farmers
1	–	–	1.1	4.9	0.7	1.8	1.0	4.3
2	–	–	1.9	19.5	1.0	3.6	–	–
3	2.0	1.3	2.3	7.3	–	–	–	–
4	2.1	3.9	3.3	34.1	3.0	14.3	–	–
5	5.3	9.2	4.0	7.3	4.4	12.5	3.0	4.3
6	6.4	14.5	7.4*	12.2	5.3*	21.4	–	–
7	7.5*	9.2	–	–	3.5	14.3	–	–
8	5.0	15.8	–	–	1.9	7.1	3.3*	13.0
9	6.0	1.3	–	–	–	–	–	–
10+	7.2	44.8	4.2	14.7	3.1	25.0	3.2	78.4
Total no. of farmers		76		41		56		23

Note: * Highest yield with optimum no. of waterings.

soil moisture adequate at the root zone of plants. This calls for timely and adequate quantity of water application. It is believed that excess application of water leads to soil salinity, while insufficient water reduces soil moisture level resulting in low yields of crops. It is in this context water use technology on the field becomes important.

Excess application of water leads to soil salinity, while insufficient water reduces soil moisture level resulting in low yields of crops. It is in this context water use technology on the field becomes important.

As revealed by the survey data presented in Table 2, excessive waterings led to a decline in yield of all the four crops selected. While the marginal productivity of water declines after an optimal level of application, its opportunity cost for those with relatively less accessibility, obviously, tends to be quite high, leading ultimately to overall cost ineffectiveness of the system. Furthermore, the data reveals that for traditional crops with which farmers are familiar, the percentage of farmers using excessive water is relatively lesser than those with which they had no experience. For instance, jowar was a traditionally important crop in the region. Farmers therefore, seem to be relatively more knowledgeable about its water requirements. That is why only 15 per cent of sample farmers applied more number of waterings to jowar than required. For other crops this percentage is quite high, especially for cotton. Since cotton is a commercial crop, farmers tend to be under illusion that more waterings increase the yield rate and augment the income. But in reality it is proved to be counter productive and also tends to create adverse effects on soil leading to environmental problems.

The relationship between number of waterings and yield has been tested by fitting a second degree equation. For maize and wheat the "points of inflexion" are observed at 8 waterings. These results support the empirical evidences as presented in Table 2.

The equations are as follows:

$$\text{Maize}: Y = 6.1 + 0.26X - 0.009X^2$$

$$\text{at } X = 7, \text{ and } Y = 7.5$$

$$\text{Jowar}: Y = -2.90 + 2.19X - 0.13X^2$$

$$\text{at } X = 8, Y = 6.3$$

$$\text{Wheat}: Y = 1.90 + 0.35X - 0.01X^2$$

$$\text{at } X = 8, Y = 4.0$$

Where X = number of waterings and Y = yield per acre (in Quintals)

Further, the optimum number of waterings for the selected crops as revealed by the survey data and the ones found by the experimental farm in the command area are the same. It testifies the reliability of survey data. Obviously there is a gap in transferring the knowledge from lab to land, because of which a sizeable proportion of farmers has used more water than required.

Given the fact that farmers do over irrigate the crops, may be out of ignorance, an attempt is made to examine the impact of land development and water management practices adopted by the farmers on water use efficiency, measured in terms of output (in value terms) per unit of water used. The quantity of water used per acre is arrived at by taking number of waterings, discharge capacity of channel pipe and number of hours taken for each watering into account. The gross value of output per acre (in value terms) is calculated using farm gate prices. The gross output thus arrived is divided by the quantity of water used to estimate the output per unit of water. For this purpose the crops have been categorised as commercial crops (cotton etc.) and others (maize, wheat, jowar etc). The details are presented in Table 3.

Table 3: Water Used Per Cropped Acre and Output Per Unit of Water

Status of Land Development and Water Management	Water Used Per Acre (in acre-inches)		
	Commercial Crops	Other Crops	All Crops
Land Development			
L D M-I	22.6(129)	10.6(51)	12.8(76)
L D M-II	24.8(128)	11.0(50)	13.4(75)
Undeveloped	24.4(96)	9.0(43)	9.5(47)
Water Management Practices			
Adopted	23.4(131)	13.6(50)	17.2(90)
Not Adopted	22.5(98)	9.1(46)	9.5(50)

Note: Figures in parentheses are value of output per acre-inch of water (in Rs.).

LDM - I = Plots developed according to the guide lines given by CADA.

LDM - II = Plots developed by the farmers based on their own wisdom and understanding.

It is observed from the table that the advantages of land development, particularly scientific development, are very perceptible. For instance, water used per cropped acre in a scientifically developed plot is lesser than in the undeveloped ones. It is, therefore, evident that land development not only promotes water use efficiency but also increases the productivity of crops, as crop-water requirements are fully met inspite of using lesser quantity of water.

Land development not only promotes water use efficiency but also increases the productivity of crops.

In a regime of water scarcity, the preferences of a farmer for a particular crop variety are guided by marketability, price and overall profitability. Since commercial crops are normally more profitable than conventional grain crops, farmers while allocating available water prefer to use a major share to profitable commercial crops and reap maximum benefits. The revealed preference is reflected in water use differentials as observed in the survey data. For instance, farmers used about 23 acre-inches of water for commercial crops, which is almost nearer to the recommended crop water requirement (crop delta) as against 10" to 12" for other crops, which is much less than recommended quantity. This tendency of farmers is likely to create environmental problems in the long run. For, they are prone to over irrigate high value crops. As observed earlier 78 per cent of sample farmers used more waterings than optimal requirement for cotton. In such a situation it is important to maintain a balance between commercial and other crops to maintain environmental sustainability. The advantages of water management are also distinctly observed. Because, farmers who have adopted water management practices and those who have not adopted have used more or less the same quantity of water. But the productivity of non-adopters is quite low when compared with adopters. Because, the adopters of water management had knowledge to use right quantity of water at the right time which enabled higher productivity. It is evident from these empirical results that land development and water management not only help increase water use efficiency but also promote higher levels of productivity. Efficient and sustainable development of irrigation is, therefore, contingent upon scientific land development and water management.

The preferences of farmers for a particular crop are guided by marketability, price and overall profitability. They are prone to over irrigate high value crops.

Given the field evidences of over irrigation adversely affecting crop yield, and the non-adoption of OFD and water management as factors leading to inefficient use of water and consequent environmental and other socio-economic problems, it becomes relevant to examine as to how these issues could be tackled at the field level. While farmers participation in water use and distribution is being advocated as an effective strategy, its adoption and operationalisation have been debatable. Debatable because, this shift in management paradigm depends upon, among other factors, the change in the mindset of both farmers and irrigation bureaucracy, the experience and ability of farmers to administer the change process and sustain the institutional base thus created. An attempt is, therefore, made to examine the change processes, if any, already initiated and the views and experiences of farmers about such initiatives.

Village Irrigation Committee (VIC): It is noteworthy to find that attempts were made to organise farmers at the village level to orient and motivate them to promote an institutional base with a vision to evolve problem solving mechanisms. In some of the villages in the Command area under reference, irrigation committees were informally formed simultaneously with the release of water, as reported by the farmers. Further, as high as 80 per cent of the sample farmers knew the existence and usefulness of such committees, while the remaining had no idea about it. What surprises more is that inspite of the awareness being quite high among the farmers their participation seemed to be very marginal. Because, only 12 per cent of those farmers actively participated in the committee. Even so, these committees seemed to have been able to solve partly some of the problems related to water release and allocation as reported by about 42 per cent of the respondent farmers, while the remaining felt its presence as inconsequential and made less difference. When asked about the need for consolidating or strengthening of the village committees, the reactions were mixed. Almost all the farmers were unanimous about timely and adequate release of water by the irrigation department for successful functioning of irrigation committees. In the absence of which the irrigation committees have no meaning. Some of them have felt that these committees were often used as platforms to settle longstanding personal scores between the members. In that sense they tend to some times breed social tensions in the community. Some others felt that the committees should be rejuvenated, may be with some structural changes and a proper interface with irrigation department. Therefore, there is an imperative need to promote and institutionalise irrigation committees in canal command areas to ensure environment-friendly and sustainable development of irrigation (For details see Reddy, 1991).

A Resume

Irrigation development is a complex process interlocked with a wide range of technical, economic, social and environmental factors. The successful functioning depends a great deal on appropriate and firm coupling of these factors. Merely constructing dam and releasing water into the canals may not by itself yield the desired results expected of irrigation. Based on past experiences it appears that designers of irrigation projects are yet to comprehend the complexities and interlinkages between irrigation-related technologies like OFD, water management, etc., and farmers ability to understand and practice it on the field.

Irrigation development is a complex process interlocked with a wide range of technical, economic, social and environmental factors.

It is clear from the empirical evidences that institutional and organisational backup is necessary to make an irrigation system efficient, productive, economically justifiable, socially relevant and environmentally sound.

Technical aspects should, no doubt, be considered on a priority basis while designing a project, but at the same time, social engineering and farmers abilities to assimilate and adopt new technology, agro-economic conditions in the proposed project need to be understood and integrated in the design.

An administrative planning with specific strategies, well-articulated rules for and roles of irrigation bureaucracy and farmers is necessary to implement theoretically well-conceived irrigation programmes. The operational plan should be an integral part of a technical design and construction and maintenance plan of a project. Construction of the water distribution network simultaneously with dam construction, on-farm development supported by agricultural extension methods to educate farmers on water management, suitable crop pattern and other related operational strategies are necessary to make irrigation sustainable and environment-friendly.

Human resource development is crucial. Farmers should be trained in crucial aspects of land and water use practices. Environmental threats arising out of over irrigation, not providing on-farm drainage, not maintaining natural drains, adverse effects of excessive use of chemical fertilizers and pesticides on land and water quality have to be told to the farmers right from the beginning. Operational manuals containing package of water use practices, corrective measures to be adopted to avoid adverse effects in the long run have to be prepared in local language and be made available to all the farmers and other stakeholders. Only then will environmentally sustainable irrigation development become a reality.

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"No matter how deep a study you make, what you really have to rely on is your own intuition and when it comes down to it, you really don't know what's going to happen until you do it".

– Konosuke Matsushita

"Does he have 17 years of experience or one of experience 17 times"?

– Paul R. Wiesenfield

People's Participation in Watershed Management Programmes

C.M. Wijayaratna

In water sheds, environmental problems mainly result from the cumulative effect of actions of many users. The author hence advocates an integrated approach in watershed management programmes, ensuring effective participation of all farmers involved.

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In agriculture-based economies in the developing world, limited agricultural and other related resources including land, water, and forestry are degrading and declining due to various reasons. In India, the ongoing degradation of resource base has adversely affected supply of food, fuel wood, fodder, and timber (Abrol 1995). Productivity of rain-fed croplands has declined and soil degradation is identified as a serious constraint in ensuring sustainability of irrigated production systems. In irrigated areas, stagnating or declining trends in productivity (and consequently profitability) are a great concern in regions where farmers operate on small farm holdings. This condition is further aggravated because they have limited "roots" in off-farm income sources. Opportunities for conventional alternatives such as slash-and-burn (or shifting) cultivation are fast disappearing and countries lack a strong sector of agriculture-based rural industries, which can act as the interface between the peasant farmer and the industrial world (Wijayaratna & Hemakeerthi, 1992).

Why Integrated Watershed Management?

In watershed literature, there is some confusion about the usage of terms such as "watershed", "river basin", "catchment area", or "drainage basin" (Pereira, 1989). Such definitions can broadly be classified into two groups. In one group the area that drains water into a river is described as a watershed and the boundary line between adjacent watersheds is called the divide. The other group defines the area drained by a river as catchment area or river basin. Brooks et al, (1991) made a distinction between a watershed and a river basin, based on scale. The line between adjacent areas is called the watershed. The river basin is larger than a watershed and covers the total area that drains through the river and its tributary system. However, in this paper, the term watershed is treated as the area of land surface that drains water into a common point along a stream or river. Hence, the river basin is considered as the highest order watershed. Areas that generate separate streams/tributaries within a larger watershed (or a river basin) can be conveniently defined as sub-watersheds and micro-watersheds (Wijayaratna, 2000a).

While recognising the importance of further improvements in irrigated areas, it can be argued that a great deal of intensification and commercialisation is required in rain-fed highlands. Today, nearly two thirds of the cultivated area in the world is rain-fed. Obviously, soil and water conservation play a critical role in rain-fed upland farming. Soil degradation, both in quantity and quality, is one of the major factors that contributes to low productivity levels in upland agriculture. High degree of soil erosion reduces long-term productivity of lands since the topsoil is eroded. Soil erosion could also have adverse effects downstream with eroded sediments settling there and in irrigation canals and reservoirs, reducing their capacity. It is clear that the irrigated commands and their catchments are interdependent. The form of this interdependency is influenced primarily by hydrological and other climatological factors, socio-economic and management factors, and various other secondary factors. Therefore, benefits of integrated natural resources (mainly land and water) management based on a watershed/river basin could be large. The watershed is a physical entity geographically defined by an important natural resource, water; the ways in which water in upper parts of the watershed is used, affect the ways in which the downstream can be used, and also the land resource associated with it. Thus, various parts of watershed are physically and operationally linked in important ways, and the potential benefits from integrated use can be large.

However, water is only one input in the agricultural production process and this resource should be judiciously matched with other factors—mainly crops and cropping patterns, soil conservation measures, management of other complementary inputs, and, above all, markets and prices. Such a process should also take into account the relevant social and environmental considerations. Based on this, different land and water use options can be evaluated.

Watershed Degradation: Adverse Effects

"Watershed degradation is the loss of value over time, including the protective potential of land and water, accompanied by marked changes in the hydrological behaviour of a river system resulting in inferior quality, quantity, and timing of water flow. Watershed degradation usually results from the interaction of physiographic features, climate, and poor land use, e.g., indiscriminate deforestation, inappropriate cultivation, disturbance of slopes by mining, the movement of animals, road construction and badly controlled diversion, and storage, transportation and use of water" (FAO 1994, p. 3-6). Improper cultivation of hilltops and steep slopes, non-adoption of conservation practices and bad land management and crop husbandry cause soil erosion. Soil erosion reduces the long-term productivity of lands since the topsoil is eroded. Some studies have shown that crop yields have declined 3-7.5 per cent after 1 mm of soil loss due to natural erosion and 10-25 per cent after 8 mm of soil loss (Marsh, 1971). Experiments on Alfisols in Africa showed that removal of 3 cm., 10 cm, and 22.5 cm of top soil resulted in yield declines of 30.5 per cent, 73 per cent, and 93.5 per cent, respectively (Lal, 1987). El-Swaify et al, (1984) working on Alfisols on relatively mild topographies at ICRISAT (Hyderabad, India) had estimated a mean annual erosion rate exceeding 40 tons per hectare or approximately 5 mm.

Watershed degradation is the loss of value over time of land and water, resulting in inferior quality, quantity, and timing of water flow.

Water quality, including groundwater contamination and salinisation, too is a serious environmental concern. Agriculture's contribution to groundwater contamination is primarily from pesticides and nitrates (Bradley et al, 1987). Nitrates are common in groundwater mainly because of the widespread use of commercial fertilisers providing nitrogen to crops. Such contamination of wells and aquifers is generally difficult and costly to correct, and it is easier to control the application of those chemicals at farm-level. Different segments of a watershed are in a continuum and linked physically and, therefore, changes in one area would affect other areas. For example, changes in forest cover upstream may result in changes in hydrological regimes that, in turn, could lead to soil erosion. A good forest/vegetation has the capacity of converting rainfall into a favourable steady flow of water. If this is lost, especially in slopy areas, droughts can occur during dry spells due to low river flows and lowering of the water table. In addition, micro-climatic changes such as fluctuations in temperature on the exposed top soil, convection, and turbulence close to soil, variations in relative humidity, wind effects, etc., may also occur.

Watershed Management: Need for People's Participation

Most of these effects are due to the fact that watersheds are being used, mainly for agriculture. As such, availability of profitable and acceptable alternatives as well as user participation in soil conservation and watershed management is highly important. The socio-economic and ecological consequences of soil degradation affect many areas of India, especially the rural poor, tribal, and landless people who rely heavily on communal and public lands in the uplands. This situation leads to overexploitation of natural resources. For instance, overgrazing by livestock, commercial and industrial exploitation of timber, gathering of fuel wood, agricultural use of land without proper conservation practices, etc., aggravate degradation (Abrol 1995). The people in the different components of the watershed having access to different aspects of the natural resources base may be engaged in different economic activities, and may be of different social and/or cultural backgrounds. For example, people in upper catchment areas may have very different environmental, economic, and social conditions from those in irrigated commands and those in downstream areas. Thus, the personal and economic interests in the different areas do not necessarily coincide, introducing problems for planning and implementation. Moreover, physical boundaries of the watershed are rarely congruent with boundaries of administrative or constituent political entities. This situation complicates the processes of planning and implementation.

Watersheds in many countries are being "used" (sometimes "illegally") by small farmers. This is partly due to the lack of alternative employment opportunities. As most of the watersheds are degraded mainly because they are "being used", and because watershed resources can be used profitably if due consideration is given to conservation concerns, watershed management must be considered as a process of participatory planning/formulating, implementing, and monitoring/adjusting and evaluating a course of action involving natural, human, and other resources. An integrated/holistic soil conservation and watershed management approach should consider those physical, socio-economic, political, and institutional linkages that exist between upstream and downstream of a river basin/watershed, and between systems within a watershed. For land and water, it should be aimed at maximising efficiencies of resource (land and water) use watershed-wide.

Watershed management must be considered as a process of participatory planning, implementing, monitoring and evaluating a course of action involving natural, human, and other resources.

This implies that socio-economic and institutional factors too influence the linkages between upstream and downstream. For example, the interrelationships between shifting or slash-and-burn cultivation in the catchment areas of irrigation reservoirs in the watershed and farming in the irrigated commands and drainage areas (downstream) are influenced by socio-economic factors. Such factors as land tenure, power structure, village institutions, community traditions, etc., can influence land and water use patterns. As people are the final decision makers regarding the use of land and water resources, they not only influence these linkages and relationships but also can change the production potential of land and water resources either favourably or adversely. In watersheds where a large number of small farmers are engaged, environmental problems mainly result from the cumulative effect of actions of many individuals. Hence, remedial measures should be user-oriented and participatory. In addition, people in different zones or components of the watershed having access to different aspects of the natural resources base may have different environment conditions, may be engaged in different economic activities, and may be of different social and/or cultural backgrounds. Thus, the personal and economic interests in the different areas do not necessarily coincide, introducing problems for planning and implementation.

Requisites

Participatory Project/Program Preparation

Many development analysts[1] have identified the lack of an effective linkage among donor agencies, recipient government agencies, and beneficiaries resulting in a tendency among governments/donor agencies to impose plans on people without securing their participation, as an important factor, for poor project performance. Lack of constructive interaction between development professionals and the intended beneficiaries of development projects biases project design, implementation, and evaluation, and leads to inefficient development interventions. (Alsam & Wilson, 1995). On the other hand, it has been observed that attempts made by project planners and sponsors to secure beneficiary participation in project implementation have been successful. Finsterbush and Van Wicklin (1987) reviewed 52 projects sponsored by the U.S.

1. A. Waterston-Development Planning—Lessons of Experience; Chambers 1982; Salmen, 1987.

Agency for International Development and found evidence that beneficiary participation during project implementation phase increased project effectiveness (cited in Aslam & Wilson, ICID Journal 44 (1): 43). Nevertheless, even after designing strategies for involvement of beneficiaries in project implementation, there have been failures resulting from the lack of still another element of participation, namely, participation of beneficiaries in the very design of projects. The most important stage of a project cycle is the design stage. In donor-funded projects, it is the basis on which funds are allocated. Beneficiary participation at this stage, therefore, is considered crucial to successful project performance.

Lack of participation of all parties involved, agency staff, design team members, local officials, and the beneficiaries, makes the project document less transparent. The bottom-up design approach, on the other hand, is carried out with greater beneficiary participation. Given the fact that local people have no experiences in project design, what in fact happens is that a team that works with the local people including the government agencies takes the responsibility for preparation of the document. Several strategies could be adopted to work with the people such as meetings, workshops, dialogues, and group consultations. The people make the ideas and suggestions and develop a feeling of belonging to the project. The ideas are workable, as they are much closer to reality. The people own the ideas, strategies, and methodologies themselves and the final outcome is improved ability for implementation and greater accountability. Local knowledge combined with modern technical skills would result in a project design with fewer flaws and errors.

Need for Integrated Approach

More often than not, watershed management projects/programs do not follow a holistic approach. Instead, such efforts focus only on one or two components such as reforestation, reducing soil movement, improving water available to plant growth and fertility, improving infiltration (at the same time reducing surface runoff and soil erosion), improving surface storage and water quality, etc. However, when people occupy watersheds and when watershed management has to deal with human-induced degradation, it involves changes in attitudes and behaviour. Physical outcomes may be achieved only through socio-economic and organisational action. In other words, one cannot ignore institutional, policy, and socio-economic, and market factors. In watershed management these different components are complementary to one another.

Easter et al, (1987) proposed that integrated watershed management effort should consider linkages between upstream and downstream of a particular watershed and not only the physical, but socio-economic, institutional, and organisational aspects also should be included. He interprets integrated watershed management as a process of formulating and implementing a course of action involving natural, agricultural, and human resources management. Brooks et al, (1991) too, advocate recognising the interrelationships among land use, soil, and water and the links between the upstream and downstream. Certain others treat watershed management in a narrow sense and consider only water development. Bottral (1993) is of the opinion that watershed management could include (or exclude) a wide range of factors in varying degrees. The scope of planning and implementation could also vary in terms of the type of activities included, for example from "water only" to comprehensive management of water, land, and other resources.

Integrated watershed management should consider linkages between upstream and downstream and physical, socio-economic, institutional, and organisational aspects also should be included.

Different combinations of various sources of water can be used and the challenge to a watershed management program is to examine the temporal variations of rainfall and other "sources of supply" available to the production system and to assist users in managing those supplies in an optimal manner, among various users and uses. The potential use at a given point will depend on the qualitative and quantitative aspects of water use upstream, terrain and soil characteristics, vegetation cover, methods employed in recapturing, etc. Hence, characterisation of the geographic space of the landscape systematically by appropriate unit of analysis (sub/micro watershed, farm plot, etc.) based on supply characteristics of water (quality and quantity over time) and land (capability and fertility levels, drainage quality, depth, etc.) is useful in a watershed management effort. Based on this, and socio-economic (including market potential) and environmental considerations, different land and water use options can be evaluated. This calls for a user-oriented and participatory approach.

Action at multiple levels should aim at adopting an integrated package of technology, organisations, resources and policies. The package may include *measures, such as type of vegetation/crops and* appropriate land and water saving and conservation practices. The package should be selected jointly by the professionals and users. User rights to earn economic and other benefits from the (participatory) conservation of natural resources are more effective in protecting environmentally fragile lands in water basins and watersheds. Hence, important conservation and production or other profitable uses of natural resources should be incorporated into this package. These measures are expected to strike a balance between production and protection (or conservation) in relation to the utilization of land and water resources through the intensification and institutionalization of participatory processes coupled with appropriate technologies, cost-effective sustainable programs and policies. Important characteristics of such programs are:

- soil and water conservation
- water saving; water quality improvements in watersheds
- profitable enterprises—mainly cropping patterns and practices that are conducive to sustainable utilization of land and water resources
- community participation in resource use planning and implementation
- collective action by user groups, organisations and small farmer companies, and
- natural resource tenurial security and state-user partnerships in natural resources management

Need for "Market-oriented" Approach

The typical processes used for environmental protection in the industrial sector—establishment of environmental standards, monitoring of impacts, and enforcement of rules—can be effective because most of the practices with environmental impacts can be identified with the individual producer. In the agriculture sector, particularly in farming, adverse impacts are usually the result of the cumulative effects of the actions of many and are difficult to identify with individuals against whom corrective actions can be taken. These problems, typically of a non-point source, cannot be effectively dealt with using the point source control mechanisms. These cumulative effects, such as erosion resulting from inappropriate cultivation practices, pesticide and nitrate contamination of groundwater and nitrate or phosphorous eutrophication of reservoirs and streams, are the results of decisions made in the normal course of farming. Unless the actors are informed by the knowledge of potential impact, and unless profitable alternatives exist for these cultivation practices and management of chemicals, environmentally inappropriate decisions will continue to be made. Other environmental impacts may be the result of failure to use appropriate protection practices because they are technically too difficult or too expensive. Erosion control practices that require physical structures are an example (Wijayaratna 2000b).

Unless profitable alternatives exist for cultivation practices and management of chemicals, environmentally inappropriate decisions will continue to be made.

It is essential to provide incentives to motivate the resource users, especially small farmers, to adopt resource conservation measures or sustainable crop husbandry. As the benefits to conservation would come in the long run and because of the fact that it is the downstream users who would benefit from the conservation practices adopted by upstream inhabitants, there is a need for providing incentives. In many countries there are disincentives associated with a number of practices designed for environmental protection. In some cases the disincentives are economic while in others they are institutional. For example, when physical works such as terraces and protected waterways, or tree planting are required, the time necessary to recover the costs is too long for the resource user to bear. The customary way to reduce this economic disincentive is to pay some or all of the cost incurred in following this practice. Nevertheless, there exist technologies (such as crops, cropping systems and other enterprises), that have conservation benefits as well as profits to users, if those technologies are judiciously combined with other resources, appropriate organisation and policy.

Increased income generation of arable lands through increased quality and quantity of agricultural products, processing and value addition through organised action by the watershed resource users, and diversification of production would stop the expansion of the arable frontier to the detriment of natural and fragile ecosystems including to their bio-diversity. Such a pragmatic and market-oriented approach to natural resource conservation in a watershed context would include, as its major components: development of agricultural production systems integrating production goals and conservation concerns as well as incorporation of attractive non-agricultural uses such as participatory micro hydropower generation coupled with participatory hydro catchment management (for users to capture agroforestry benefits as well as to ensure the sustainability of the hydropower generation) and relevant policy and institutional arrangements. This strategy recognises the major constraints to sustainable production, including the population pressure on limited natural resource base—especially land and water, low rural income, inadequate employment opportunities, inadequacies in the information systems—such as the information on profitable yet conservation based technologies, market conditions etc.

There exist a variety of conservation farming measures, that could be used profitably by resource poor small farmers. These would include: selection of crops and agricultural, aquacultural and other enterprises or cropping systems which are environment friendly and at the same time earn profits to the farmer, agroforestry[2] systems, organic farming techniques, soil and water conservation measures, water harvesting methods etc. Agroforestry systems provide higher total biomass per unit area besides yielding different products such as fodder, fuel, fibre, fertiliser, fruits, fence materials etc. These systems use off-season rainfall and also utilise the moisture available in the zones below the root zones of other (ordinary) crops. Under rainfed conditions, deep percolation losses may vary from 20 to 25 per cent of total rainfall, depending on the soil and climate conditions (Singh R.P. 1988). Conservation farming and agroforestry systems, including community-based agroforestry, coupled with appropriate usufructory rights are capable of enhancing farmer incomes, providing additional employment and, at the same time maintaining the sustainable productivity of land and water resources in watersheds through reducing erosion, runoff and nutrient losses.

Conservation farming and agroforestry systems are capable of enhancing farmer incomes, providing additional employment and, maintaining the sustainable productivity of land and water resources through reducing erosion, runoff and nutrient losses.

Need for Information

To understand environmental cause and effect relationships, and to evaluate their physical, economic, and social impacts, information on the environment as well as on environmentally friendly yet profitable production technologies must be available at a scale that permits appropriate decision making. For this information to be available, data must be collected, processed, analysed and made accessible in usable form by the decision- makers and users. Unfortunately, there is a serious lack of this basic information, particularly at the level of detail necessary for agricultural and resource utilisation planning. In addition, even the available data are not conveniently available to those who could best benefit from them. To assist in the identification of potential opportunities, the information must encompass a wider range. Information on technology, infrastructure, water sources, population centres, marketing etc., becomes important when attempting to discover new economic potentials.

Need for Group Action

To achieve economies of scale, and to utilise group solidarity to promote responsible behaviour, group action can be used as the primary vehicle. For example, the production inputs such as credit, seeds, fertiliser and technical information must be available at reasonable effort and cost. The total cost to farmers, particularly small holders, often includes a high proportion of "transaction costs", monetary and non-monetary payments associated with obtaining necessary approvals, ensuring timely availability of inputs, etc. Some of these input constraints can be reduced through organised group action.

Two aspects are important at the infant stages of group activity: the impact on the ability to organise for group economic activities, and availability of supporting services when they attempt to expand and/or modify their economic activities. Watershed management strategy should also increase the share of control of the natural resources by watershed users and support them as they attempt to intensify, expand, or move into new economic activities.

In a sub-/micro watershed where several farmers are operating, generally on smallholdings, co-operation between farmers is required to achieve full benefits of conservation efforts, e.g., planting along contours or graded bunds or regulating runoff to arrest soil movement, etc., need to continue across private lands. Under such circumstances too, farmer/user organisations (at lower levels) and farmer/user companies (at higher levels on commercial purposes) with appropriate legal rights provide effective mechanisms for overcoming the difficulties. Farmer Companies (and in certain cases farmer cooperatives) have better legal power and recognition and are readily accepted by the organized private sector. This is an important condition for business ventures. For example, farmer companies could establish legal contracts with organized private sector companies

2. (Agroforestry systems are defined as the growing of perennial woody tree species deliberately on the same land management system where crops and animals are raised [Singh R.P., 1988])

for forward sale of agricultural products. Moreover, farmer companies are independent business organisations, which could avoid political and other problems. Investments through farmer companies can produce competitive economic ventures for which a necessary condition will be partnerships with the organized private sector and the State.

The physical boundaries of watersheds are not necessarily congruent with boundaries of administrative or constituent political entities. This situation complicates the process of planning and implementation. Hence, co-ordination between relevant line agencies and between local authorities of such administrative units as well as co-ordination/integration of relevant projects and programs become important in watershed management. An integrated participatory approach is useful to overcome these problems and to make a substantial effort in linkage and co-ordination. Integrated planning and improved co-ordination of natural resources (land and water)-related activities and projects on a watershed basis should be the focus of watershed management. Institutionalisation of such an approach will shift the strategy of development of land and water resources (in watersheds) from an uncoordinated project or activity mode to a well-co-ordinated program mode.

The physical boundaries of watersheds are not necessarily congruent with boundaries of administrative or constituent political entities.

Usufructuary Rights

Land (and water) tenurial security is widely claimed to be a major factor that impacts on conservation and productive use of land and water resources. The degree of control users can exercise over land and water resources relates to the security of tenure under which they use specific areas of land (or volumes of water) over a specific period of time. Security of tenure will reduce the users' temptation for exploitative use of natural resources, and allow recovery of investment in production and environment protection practices that have relatively long cost-recovery periods. Security of tenure is usually assured by ownership title, but other mechanisms are available to provide effective security. For example, irrigation schemes in Sri Lanka offer de facto security, as do various types of traditional tenancy. Hence, a different interpretation of property rights defining in the context of "sense of ownership" or individual and communal access to natural resources, based on culture, local values, and local market conditions, is necessary. Instead of exclusive individual property rights (for example, a complete transfer of ownership of State land to individuals), the concept of shared control, usufructuary rights, longer-term lease arrangement and state-user partnerships are suggested as effective alternatives that are acceptable to both users and the state. Such alternatives will provide a sense of ownership which is a necessary condition for sustainable production/integrating environmental concerns into production goals in a watershed context.

Instead of exclusive individual property rights, shared control, usufructuary rights, longer-term lease arrangement and state-user partnerships are effective alternatives.

Multi-Level Interventions

With watersheds as basic units, the activities and scope of watershed management cut across multiple levels. Figure 1 illustrates an organisational structure to facilitate such a multi-level operation. At the lowest level, the sub-or micro-watershed, which typically includes one or two villages, where local officials, resource users, and catalysts/change agents, interact to understand the present resource use pattern, develop a vision for the future and translate it into action plans. At the watershed level, representatives of farmers/watershed users and relevant officials/professionals could discuss the action plans and problems emerging from grass roots levels and assist in Monitoring and Evaluation and problem solving. At much higher levels (like the provincial level), which may sometimes cover several watersheds, action may be mostly related to review of progress and remedial measures to cover gaps and lapses. At the national level, primary emphasis is on policy and process reforms, based on experiences and inferences from lower levels. As constraints to group activities are identified, the catalysts/relevant agency and SWRMTs and WRMTs can assist in this removal. When constraints are seen as the result of policies, rules, regulations, or actions of a higher level, the program workers/officials/teams can work at those levels to achieve the desired ends. Demand-driven changes are likely to be more expeditiously addressed than recommendations for change from above.

Monitoring and Evaluation (M&E) and Management Information Systems (MIS)

A continuous flow of information is required to en-

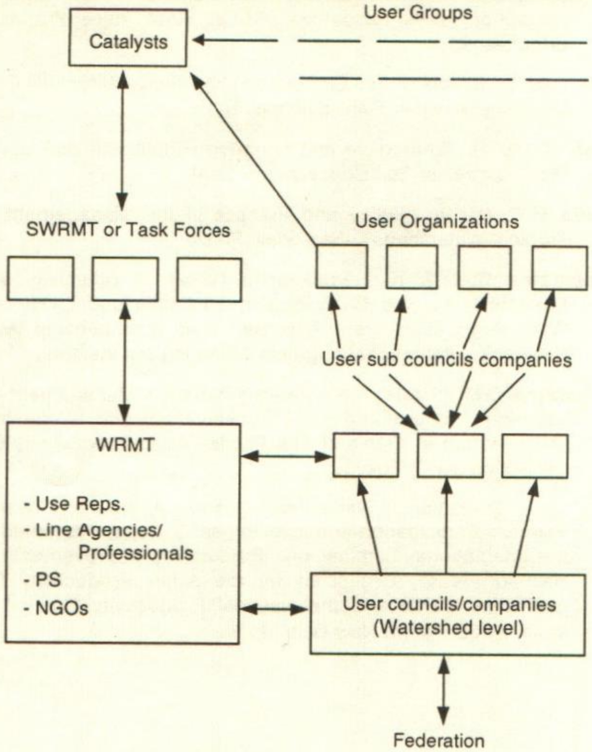

Fig. 1. Organisational Structure for Participatory Watershed Management

rich the participatory watershed management process in facilitating interaction among participants. Participatory M&E and MIS could be integrated into watershed action planning. In selected sub-watersheds, participatory appraisal of the characteristics of resource uses and users, including mapping of current resource could be done by groups comprising resource users/farmers, local officials of government agencies and other actors such as NGOs. It is essentially a participatory appraisal of the current levels of management of natural resources in degraded watersheds, participatory design of a future vision of reconciling environmental concerns and production goals, and the development of collaborative action plans to achieve such goals. People should know that the task is not just information gathering (for the sake of knowledge generation) but developing and implementing their own project. Based on this a future vision could be developed and a detailed action plan could be formulated. Such a participatory planning process would assist resource users to review the progress and employ feedback/correcting mechanism to ensure that project inputs, work schedules, targeted outputs, and other related actions proceed according to plan. This mechanism will also provide data for continuous and periodic evaluations to determine systematically and objectively the relevance, efficiency, and effectiveness (and impact) of project activities.

The formulation of a participatory resource management mini project could be the output of this planning process. Such mini projects should aim at changing the present land and water use pattern to a more profitable and diversified process combining production and conservation with use of appropriate technology, shared control arrangements, and resource augmentation. This means that villagers in such sub-watersheds have action plans that guide them along a path to a planned future from the current status of resource use. These sub-watershed plans could then be aggregated to form the development plan for the total watershed.

Conclusion

Environmentally sound natural resources management should consider physical, socio-economic, and institutional linkages that exist between upstream and downstream of a river basin/watershed, and between systems within watersheds. It should also consider the role of users, both in terms of production and protection. Sustainable development requires an integrated approach that not only optimises production, but also ensures protection of the natural resource base with the active participation of users. The main thrust of a participatory watershed management process could be summed up as an attempt to internalize, a combined strategy of effective application of already known and new technology, strengthening/forming appropriate organisations, especially small farmer companies to take advantage of scale, pool resources, secure credit from banks, secure assured markets and schedule production, add value to agri-products, acquire appropriate managerial competence, etc., and resource augmentation through measures such as profitable conservation, water harvesting, and human resources development, and innovative policy changes relating to natural resources management coupled with new state-user partnerships. Both indigenous knowledge and information on modern technology (related to production and conservation – price relations, markets etc.) should be considered in such a participatory process.

Sustainable development requires an integrated approach that not only optimises production, but also ensures protection of the natural resource base with the active participation of users.

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> "Don't ever make the mistake of thinking of building, computers, consultants, or even employees as your company's greatest assets. Every company's greatest assets are its customers, because without customers there is no company. It's that simple".
>
> — **Michael Leboeuf**

Watershed Management: Remote Sensing & GIS Approach

V.K. Srivastava

Watershed government practices enhance the quality of land-water-vegetation of the geographical area under control of a hydrological system. Non conventional technique of Remote Sensing provides dynamic form of spatial data for such study over the region which is further processed, analyzed in relation to attribute data through Geographical Information System.

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Watershed management refers to management of an entire land area served by various rivers and acquifers that drain into a particular body of water. The area of watershed is determined by the topographic or watershed divide. The divide represents the highest elevation points along the watershed perimeter. This is the most appropriate unit for studying water resources where water circulates, being transformed from precipitation to river flows, soil-moisture, and groundwater. Soil moisture is the water available for plant production and is represented by the seepage of water into the soil.

Watersheds: Features

Watersheds can be classified as first, second, third or higher order watershed based on the order of drainage system. However for watershed management first or second order drainage system is preferred. Functioning of watershed is related with the hydrologic system where precipitation (input) and run off (output) are determined by the intermediate processes such as evapotranspiration, infiltration, interception, surface run off, soil moisture storage, subsurface runoff and ground storage and discharge including the physiographic characteristics of the watershed basin (topography, soil, vegetation cover, land use practices etc.) Availability of water for improving human life and quality depends on the availability of groundwater and surface flows. In a natural set up, there exists a balance between various natural processes and human actions but with undue and excessive interference by human beings, the hydrological system of a region gets disturbed and results in deterioration of natural resources and environment. Therefore, it becomes necessary to identify those processes and phenomena detrimental to natural resources in reference to the hydrologic system of a watershed unit. Finally management strategy must be planned for improving sustainable growth with due regard to physical, biological and socio-economic aspects or the region.

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Data Requirements & Analysis

Effective management of watershed requires up-to-date spatial information about the form and status of land-water-vegetation and their inter-relationship which must be integrated with the attribute data (Rao, 1995). According to technical guidelines of Integrated Mission for Sustainable Development (IMSD), NRSA (Dec, 1995) following types of spatial data (maps) and non-spatial data are required.

Spatial Data: Thematic Information

- Drainage, watershed and surface waterbody
- Slope aspect and attitude
- Hydromorphology and groundwater prospects
- Soil-physiography
- Land use/land cover pattern
- Transport network, settlement location and village boundary

Non-Spatial Data: Attribute Data

- Rainfall and climate
- Groundwater fluctuation and quality
- Socio-economic and demographic datasets

Such spatial thematic information is either generated through conventional surveys or non conventional survey techniques, like remote sensing. As conventional techniques are uneconomical, labour intensive and time consuming the technique of remote sensing is being extensively used to generate thematic maps which are analyzed in reference to attribute data through a computerized Geographic Information System.

Remote Sensing & GIS

The technique of remote sensing refers to collection of information about the earth surface features by sensors kept either in aircraft or in spacecraft. Collection of data by airplane has limitations but the development of sensor technology, data reception and data recording

Table 1: Sensor Characteristics of Indian Satellites for Earth Observation

Satellite Sensors	Launch year	Spectral bands (μm)	Ground Res. (m)	Swath (km)
Bhaskara I/II (TV)	1979/1981	0.54-0.66 0.75-0.85	1 km	341
Bhaskara I/II (Samir)	1979/1981	19,22,37 GHz	125 km	–
IRS-IA/IB	1988/1991	0.45-0.52 0.52-0.59 0.62-0.68 0.77-0.86	72.50 36.25	148/2×74
IRS-P2 (LISS II)	1993	As above	37×32	131
IRS-IC/ID (LISS III)	1995/1998	0.52-0.59 0.62-0.68 0.77-0.86 1.55-1.70	~23 (VNIR) ~70 (MIR)	~140
IRS-IC/ID (PAN) Steerable ± 26°	1995/1998	0.5-0.75	5.8	70
IRS-IC/ID (WiFS)	1995/1998	0.62-0.68 0.77-0.86	188	~770
IRS-P3 (WiFS)	1996	0.62-0.68 0.77-0.68 1.55-1.70	188	~774
IRS-P3 (MOS-A)+		0.7567 0.7606 0.7635 0.7664 Band width 0.0014	2520	248
(MOS-B)+		0.408, 0.443 0.485, 0.520 0.570, 0.615 0.650, 0.685 0.750, 0.815 0.870, 1.010 0.445 Band width 0.01	720×580	248
(MOS-C)+		1.600 Band width 0.1	1000×720	248
IRS-P4 OCM	1997	0.412, 0.443 0.490, 0.510 0.555, 0.670 Band width 0.20 0.765, 0.865 Band width 0.04 1.550 to 1.700	250, 1500 500	1500 1500
MFSR		6.6, 10.6, 18 and 21 GHz	120, 75, 45, 40	1500

\+ Payloads designed and developed by DLR, Germany, Central wavelength is given against the spectral bands.

IRD-IC launched by the PSLV rocket from Sriharikota, A.P., on 29th Sept. 1997.

Source: Navalgund et al, 1996.

have established the importance of satellite remote sensing for acquiring spatial coverage of an area over time. The synoptic and temporal modes facilitate monitoring of dynamic changes as data input for hydrological modelling. Fortunately India has its own series of remote sensing satellites for earth observations. Table 1 shows the sensor details of various Indian remote sensing satellites. Several researchers (Chakraborty, 1995, Datta et al, 1996) have extensively used Remote Sensing and GIS technique in such studies. However, the use of remote sensing technology involves huge amount of spatial data management and analysis in conjunction with attribute data. This requires an efficient database management system to handle and integrate both spatial and non spatial data sets through computerised Information System, i.e., Geographic Information System(GIS). A GIS automatic database management system allows storage, retrieval and analysis of the geographically referenced data spatial in nature (maps) and associated non spatial data (attribute data) for decision making through sophisticated computer software and hardware system. Main features of Geographic Information System are:

- Data capture and archival of survey data
- Integration of data sets
- Designing of different data structures, database with user interface
- Integrated analysis of data sets and results preparation.

Desk Top to Work station based Commercial GIS software packages are available to users in India. Details are avoided here due to obvious reasons. Based on the analysis and delineation of causes and area to be improved, action plan maps should be prepared with following objectives:

- To conserve soil and water
- To improve the ability and capability of land to hold water by techniques of rain water harvesting and ground water recharge.
- To increase the vegetation quality and cover.

Thus watershed management leads to overall sustainable growth of the region and allows improvements in the status of land capability, ground water regime, vegetation cover, air quality with the involvement of local people.

Conclusion

For overall socio-economic development, watershed management practices must be adopted which implies development of natural resources by optimal utilisation of precipitated rain water with least disturbance to hydrological setup. For such study, spatial and non spatial information about the georesources and geo environmental set up could be collected conveniently through Remote Sensing and Geographic Information System. Remote Sensing technique particularly from Satellite provides a means of collecting real time spatial data about the form and status of land-vegetation-soil and hydrological set up of a watershed. Geographic Information System, a computerized database management technique allows processing and integration of these spatial data (maps) with the attribute data (tabular data) for decision making results required for watershed management practices.

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Technological Options for Salinity Management in Agriculture

K.K. Datta

Concern about the proper utilisation of poor quality waters for crop production in areas, where their use is inevitable, is not new. Efforts have been made for the development of management practices for using poor quality waters. Although it is widely acknowledged that preventive strategies like irrigation improvement intervention have only a limited scope for immediate benefits to the farmers and that curative measures like subsurface drainage (SSD) are needed to tackle the problem of water logging and salinity, SSD development was neglected both at the national, state and at the farm. Since subsurface drainage technology is indivisible in nature, it needs collective action, which calls for new institutional set up to tackle the problem. Keeping this in view, this paper suggests the scope and prospects of different technological options and the form of institutional set up needed to promote equity among all stakeholders.

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Sustainability of irrigated agriculture in the arid and semi-arid regions of the country faces challenge because of alkalinity/salinity problems associated with soils and irrigation waters. Many problems of irrigated agriculture arise from inefficient management of irrigation water especially when it carries high salt concentrations. One of the major problems confronting present day agriculture is decreasing availability of good quality irrigation water. With increasing demand and decreasing availability of good quality waters, there is growing tendency among farmers to use poor quality waters for crop production. Indiscriminate use of poor quality waters in the absence of proper soil-water-crop management practices poses grave risks to soil health and environment. In India about 36 per cent of irrigated land has been damaged at different levels due to such practices.

Irrigation Improvement Intervention

This disappointing picture caused due to faulty irrigation development has now resulted in planners giving greater attention right at the planning stage to include irrigation improvement intervention as a preventive strategy. However, failure of institutional aspects of implementing the improvement strategies, lack of provision of drainage coupled with social aspects relating to ineffective communication between farmers and the agencies have all contributed to failure of efforts to prevent the growing problem of water logging and salinity. For example, increase in area under canal irrigation during the last three decades was only 19 per cent, increase through tubewells has been of the order of 160 and 189 per cent in Haryana and Punjab, respectively. Whereas, the scenario on ground water utilisation is not the same in several other states, specific areas are being disadvantaged either with poor quality aquifer yields. Surveys rate 32-84 per cent of the presently 'running' wells of different states to be of poor quality.

by the CSSRI for reclamation of alkali soils, such as reclamation for crop production with rice based cropping system, afforestation activity singly and/or in conjunction with appropriate crops in between, and cultivation of forage and grasses without application of any soil amendment, etc. For the option of reclamation for crop production, management strategies are amelioration through soil amendment and appropriate cropping practices and in poor resource endowment situations, through biological amelioration – growing salt resistant varieties of paddy and wheat.

proper network for gypsum base infrastructure can be evolved and it may be linked with easy rural credit facilities at the village level.

If the yield gap between recommended and farmers' level of technology could be narrowed, alkali soils after reclamation have great potential in increasing production of rice and wheat.

Failure of institutional aspects of implementing strategies, lack of provision of drainage coupled with social aspects relating to ineffective communication have contributed to water logging and salinity.

In the seventies irrigation enjoyed a favoured status in terms of investment in agricultural sector. More than 75 per cent World Bank assistance was for irrigation, the resultant outcome being the unprecedented rise in agricultural productivity. Afterwards, there began a declining trend of investment on irrigation, one reason for disillusionment being its economic performance. The poor performance is mainly due to poorly managed operations; inadequate supplies in the tail ends and untimely and unreliable water deliveries. In the fresh ground water zone, there is a threat of serious water scarcity due to overuse of ground water and consequent decline in water table. Farmers are generally disinclined towards the use of saline ground water. Non-exploitation of poor quality ground water and mismanagement of surface canal water create the problem of water logging and secondary salini-sation. As a result, about 15-20 per cent command area has become afflicted with the menace of water logging and salinity. The northwest states of India like Haryana, Punjab, Rajasthan and Gujarat are mostly underlain with marginal and poor quality underground water. In Gujarat about 9 per cent of the total geographical area is affected by salinity and sodicity. About 20-30 per cent of the area in the Chambal Command of Madhya Pradesh has gone out of cultivation because of water logging and salinity.

Acquifers surveyed in different states have indicated that about 32-84 per cent of the ground water is of poor quality in nature. Central Ground water Board reported that area under saline ground water in Haryana, Punjab, Rajasthan, Gujarat and Uttar Pradesh is about 4, 3, 82, 10 and 1 per cent respectively. The document of Eighth Five Year Plan has reported that 17.61 million ha area is affected by the problem of waterlogging (8.53 million ha), alkalinity (3.58 million ha), and salinity and sandy area (5.50 million ha) (GOI 1991). Recent estimate shows that the extent of salt affected soils in India is 8.6 mha and 4.5 mha is waterlogged (Singh 1994).

Technological Options

Various remedial measures such as better water management, conjunctive use of canal and ground waters, improvement of surface drainage, on-farm development, introduction of forestry, amendment of soils and shallow ground water management were mooted earlier. Out of those, it has been suggested to adopt the technology of vertical drainage where ground water quality is good and water table is at a reasonable level; skimming well/*doruvu* technology where shallow ground water management is needed; and subsurface drainage (SSD) is suggested where water table is high and quality of ground water is poor. Similarly for reclamation or to make alkali soils productive, gypsum base reclamation strategies are suggested where resource base of the farming community is sound. In the poor resource base-farming situation, adoption of salt resistant varieties like CSR10 and KLR1-4 for paddy-wheat cropping sequence is recommended in the first year of the reclamation programme, small doses of gypsum along with salt resistant varieties fetch higher returns.

Case studies

Sub surface drainage

In Haryana, subsurface drainage was installed in 589 ha at 13 different locations in order to enable reclamation of areas which were already affected by water logging and soil salinity. About 2000 ha in two different locations was selected for SSD under Indo-Dutch collaboration. In the Chambal Command area at Rajasthan, SSD was installed, on 10 thousand hectare under Canadian funded project. In collaboration with CSSRI, WALMI in Gujarat installed SSD in 200 ha in four different locations. The cost of installation of SSD mainly depends on soil type, depth and spacing of drains, location under drainage and the type of the drainage material used. At 1994-95 prices the cost of manually installed SSD varies from Rs. 22, 310 to Rs. 18,5252 per ha in Haryana (Datta & de Jong, 1997).

Installation of subsurface drainage system enables control of watertable level and desalinisation of soil by leaching, either with irrigation water or with the monsoon rains. Operational research on Sampla Farm showed that salinity in the topsoil decreased rapidly after drainage from about 50 dSm^{-1} in June 1984 to about 5 dSm^{-1} in November 1985, in spite of low rainfall in these years. In all small-scale pilot projects in Haryana the short-term effects of subsurface drainage were:

- considerable increase in cropping intensity
- shift in the cropping pattern towards more remunerative crops
- remarkable increase in crop yields
- increase in the efficiency, or productivity of fertilisers

strained farmers located in Uttar Pradesh. It has been observed that adoption of chemical amendment technology for reclamation is more where productivity in normal soil is high, i.e. resource rich environment whereas dissemination of gypsum base technology has been slow in the resource poor areas (Datta & Joshi 1992).

Constraints & Policy Needs

In the institutional aspects, poor performance of irrigation arises mainly due to larger systems, lack of reliable and responsive management, and no management in terms of deliberate water allocation in response to actual circumstance. The inherent lacuna of the institutional set up in irrigation system promotes irregularity, uncertainity, favoritism, exploitation and corruption. To overcome some of the problems, during seventies and eighties emphasis shifted towards improvement of irrigation performance through on-farm development (OFD), participation in the form of involving water users and strengthening of irrigation agencies. But there was no effort to harness the synergetic benefits of those options, with the result that no progress was achieved in testing these strategies together. From 90's onwards rethinking is going on to transfer of responsibility and authority for irrigation management from government to non-governmental authority. Such transfer will help the water users to maintain transparency and accountability for managing, operating and maintaining irrigation systems. In the approach paper of the Ninth Five Year Plan (1997-2001), it is proposed to improve the efficiency of end-use of water through adoption of water-efficient devices and promote conjunctive use of surface and ground water. The initiative has been taken but proposed solutions are not tested and modified for sustainability in long term. And attempt is always in terms of diverting fund from one specific scheme to another alternative option. As a preventive measure for short run, these solutions may be effective but for long term, subsurface drainage (SSD) has been proved to be the only option to reclaim waterlogged saline lands, where salts have accumulated both in soil and ground water.

The main drawback in the system is that it assumes that free market mechanism will work implicitly i.e., well-capitalized and market-oriented farmers will take care of the operation and maintenance. But in reality it is difficult because the inherent drawback of unsatisfactory performance of irrigation system is due to non-fulfillment of the target, incompatible action with collective rationality and finally quantity-constrained behavior compelling the individual to adjust private decisions. Even if the market fully reflected the value for individual goods and services, the market would still allocate less than a socially optimum amount because farms are unable to fully appropriate the gains from R&D. Without internalization of environmental externality and holistic approach, shifting of power alone will not improve the system.

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To tap and use the shallow ground water, farmers are forced to draw water that collects in dugout conical pits "Doruvus" leading to wastage of 20 per cent productive land.

saline environment. The irrigation authority should take care that canal water must be available in the saline ground water zone at least during sowing season to encourage farmers to bring more area under crop production; they who can use saline ground water for subsequent irrigation as per the crop's requirement.

Technology for Alkali Soil

Several management options have been advocated

Re-Use of Sewage Effluents for Irrigation

Wasmiya Al-Essa

Water resources being limited, the State of Kuwait has initiated special projects for treating sewage effluent and using it for irrigation. This article presents the details of the wastewater management infrastructure in the country.

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The state of Kuwait lies in the north western corner of the Arabian Gulf. Its area is about 18,000 sq. km and population, 2.225 million. Kuwait is of tropical climate, temperature in summer ranging between 40-50 degree celsius; in winter between 2-20 degree celsius; rain is scanty (5 mm), but it may reach up to 15 mm. Potable water production is mainly by desalination of sea water, distilled water is blended with about 8 per cent of brackish water to give potable taste. About 80 per cent of the buildings are connected to the drinking water network, the rest get their water by tankers through filling stations, water consumption being more than 120 gallon/day/capita.

Effluent Treatment

Before 1956, waste water from septic tanks was collected by tankers and discharged in areas chosen for forestry as green belt for Kuwait city. Treatment of waste water began after 1956, and treated effluent was used on an experimental farm related to the agricultural department, to irrigate Alfa alfa, palm trees, wind breaks and some flowers. At that time waster water was about 250,000 gallon/day. In late 1987 the Ministry of Public Works commissioned consultants to assist with the preparation of a 20-year sanitary master plan for Kuwait. The master plan was to address the wastewater management needs of a community whose population was expected to increase from around 1,900,000 in 1990 to 2,684,000 in 2010. Kuwait's population in 1970, when the first components of the wastewater management infrastructure were put in place, was less than 800,000 persons.

In 1990 wastewater management system of Kuwait centred around three major wastewater treatment plants – Ardiya, serving the northeastern part of the city, including the downtown area, Jahra serving the western part of the urban area and Rikka which serves the southern part of the urban area. The catchment areas of these three treatment plants are shown in Figs. 1 & 2. The collection system in the catchment areas comprised 5,000 km of gravity sewers, 17 major pumping

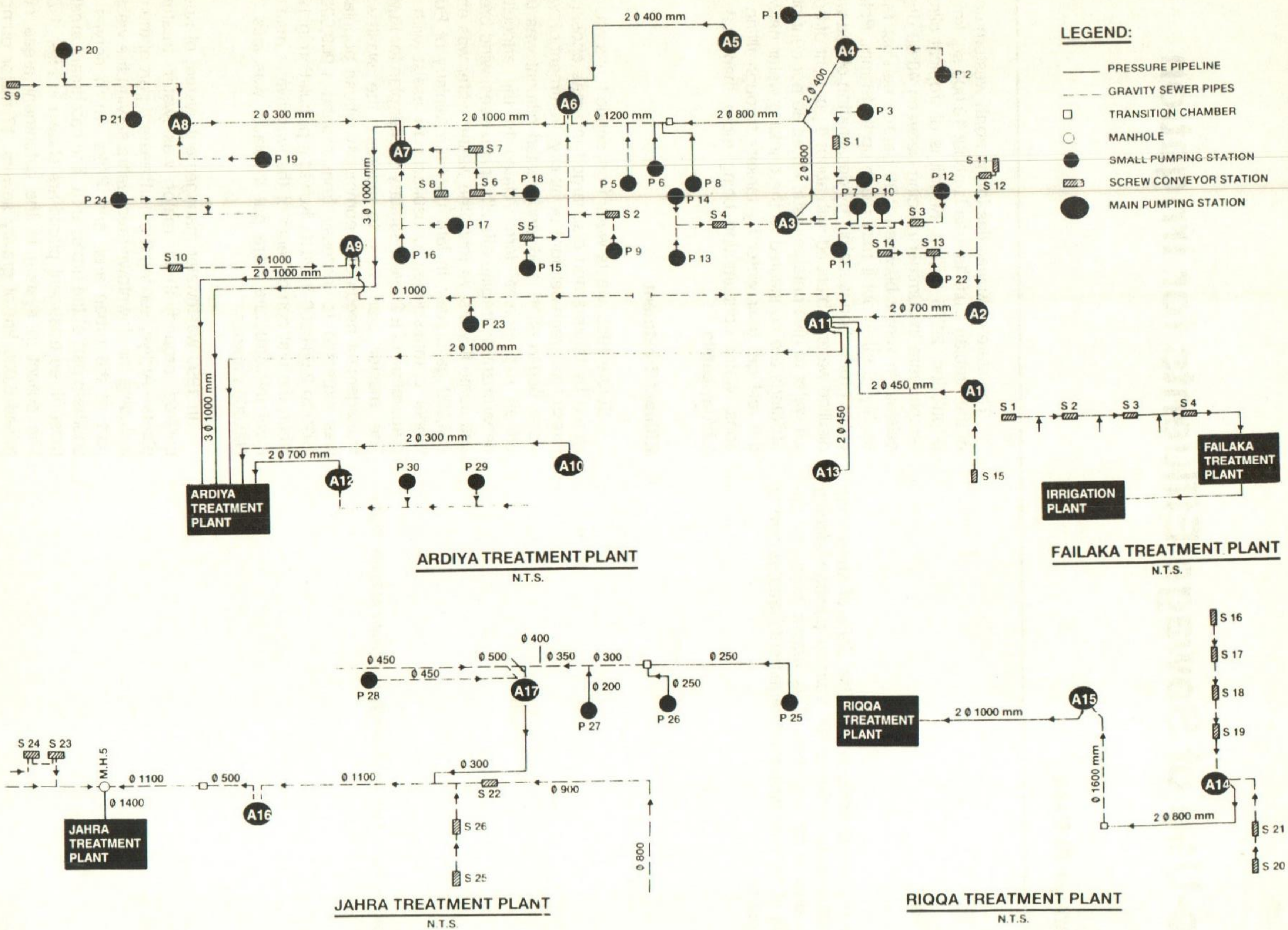

Fig. 1. Schematic of Kuwait Sanitary Scheme showing connection of lifting, secondary pumping and major pumping stations to treatment plants

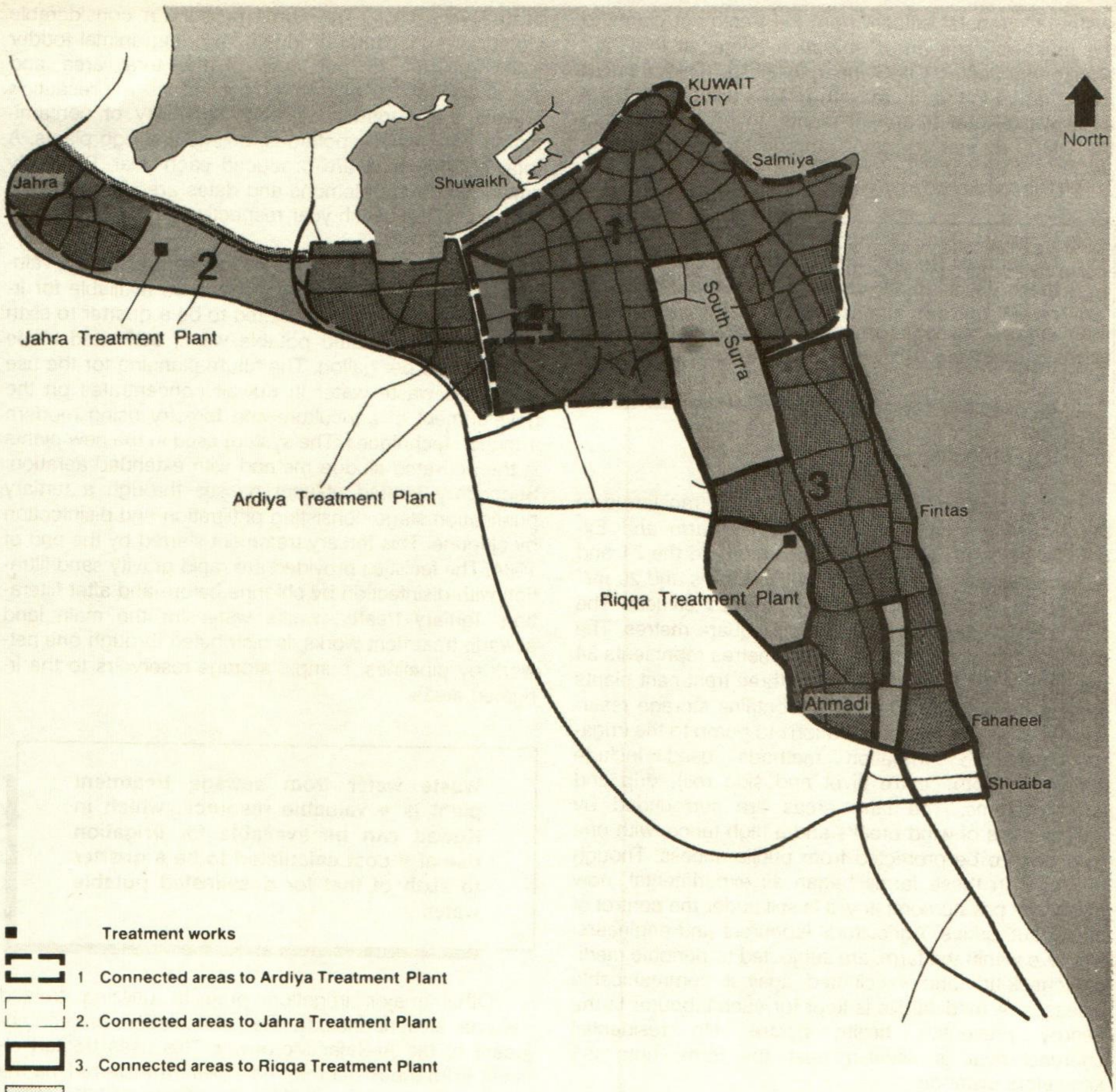

Fig. 2. Areas connected to Sewerage System in Kuwait.

stations, 57 secondary pumping stations and 1600 km of pressure main. Ardiya plant was developed in a number of stages of expansion, Rikka and Jahra plants are of more recent construction (1982). Rikka plant has been expanded recently; the three treatment plants together have a design capacity of approximately 350,000 cu m/day. A fourth plant is under construction at the southern border area (called Umm Al-Hymann). However, the master plan investigations suggested that the actual treatment capacity available at these plants was 10 to 15 per cent less than the design capacity, due to underestimation of the wastewater to be treated.

All of the treatment plants provide tertiary treatment through sand filtration and disinfection and mainly use extended aeration activated sludge for secondary process. At each of the existing treatment plants there is a local scheme for effluent reuse, but there is also a system to transfer effluent from the treatment plants to the reuse storage and distribution center at the Data Monitoring Center (DMC) near Sulaibiya. This concept may change in the future, with treated effluent from the three wastewater treatment plants, to be conveyed to the DMC, as well as other storage tanks around the area.

At each of the existing treatment plants there is a local scheme for effluent reuse, there is also a system to transfer effluent to the reuse storage and distribution center.

Irrigation Projects Using Treated Effluent

From the DMC the treated effluent is transferred to the following locations: Z1 Farm, Z3 Farm and Experimental Farm. The major consumers are the Z1 and Z3 farms which use 11 million cubic metres and 20 million cubic metres respectively of treated effluent. The total area of each farm is 9 million square metres. The combined total of 31 million cubic metres represents 34 per cent of the total inflow to the three treatment plants serving Kuwait City. Each farm contains storage reservoirs and on-site pumping stations to pump to the irrigation networks. Irrigation methods used include sprinklers (both centre pivot and side roll), drip and flood systems. The farm areas are surrounded by several rows of wind breaks and a high fence, with one gate only to be protected from public access. Though the work in these farms began as experimental, now given to a private company, it is still under the control of health authorities. Agricultural labourers and engineers, who live within the farm, are subjected to periodic medical check-up, and vaccinated against communicable diseases. A medical file is kept for each labourer in the nearby preventive health centre. No residential encroachment is allowed near the farm, upto 2-3 kilometers distance.

In this farm, Alfa alfa is grown using sprinklers of 2 types: big guns and side rollers. Other fodder plants such as barley, field corn, palm trees, olive trees and salt-tolerant vines are also grown. Vegetables such as potatoes, dry onion and garlic are grown, but irrigation stops for 2-3 weeks before collection of crops. Other vegetables as egg plant, squash, cabbage, cauliflower, beans and okra are irrigated by furrows or basin irrigation. Tomatoes and cucumber are grown vertically and furrow irrigated. About 20 per cent of this farm is still not used, where sludge from the treatment plant is mixed with the soil as a conditioner and this area will be cultivated very soon. The farms produce a considerable variety of agricultural products including animal fodder which utilizes 75 per cent of the total area and vegetables which are eaten cooked as a precaution against the extremely unlikely possibility of contamination eg. Spinach, potatoes, onions and egg plants. A total of 3000 tons are produced each year. Relatively small quantities of lemons and dates are also grown, 5 tons and 2 tons each year respectively.

Waste water from sewage treatment plant is a valuable resource, which in Kuwait can be available for irrigation use at a cost calculated to be a quarter to sixth of that for desalinated potable water, estimated to be about 30 fils per gallon. The future planning for the use of treated waste water in Kuwait concentrates on the development of agriculture and forestry using modern irrigation techniques. The system used in the new plants is the activated sludge method with extended aeration. Secondary treated effluent passes through a tertiary purification stage consisting of filtration and disinfection by chlorine. This tertiary treatment started by the end of 1984. The facilities provided are rapid gravity sand filtration with disinfection by chlorine before and after filteration. Tertiary treated waste water for the main land sewage treatment works, is distributed through one network by pipelines, pumps, storage reservoirs to the irrigated areas.

Waste water from sewage treatment plant is a valuable resource, which in Kuwait can be available for irrigation use at a cost calculated to be a quarter to sixth of that for desalinated potable water.

Other major irrigation projects utilizing treated sewage effluent include the afforestation project adjacent to the Al-Safar Motorway. This uses treated effluent from the Rikka treatment plant transferred via the six coastal pumping stations to irrigate 26,300 foliage trees and 24,200 palm trees, representing 10 per cent of the total number of palm trees in Kuwait at present. The irrigation system uses the latest technology and is the first application in Kuwait of solar- powered controllers to provide a completely automated system; at present 500 m^3 of treated effluent is used per day and this is expected to increase to 700 m^3 as the trees mature.

Standardized Specification of Tertiary Treated Effluent

- Effluent should not contain more than 10 mg/l of suspended solids.

- The BOD of effluent should not exceed 10 mg/l.
- The COD of effluent should not exceed 40 mg/l.
- Free residual chlorine in effluent after 12 hours contact, at 20c, should not be less than 1 mg/l.
- For forestry, fodder and crops not eaten raw, effluent should not contain more than 10,000 coliform/100 ml.
- For crops eaten raw, effluent should not contain more than 100 coliform/100 ml. It is advised not to used this effluent for salad greens or strawberries.

The data monitoring centre (DMC) established by the Ministry of Public Works, is equipped with quality control laboratories for the tertiary treatment procedures and for testing the final effluent for bacteria, heavy metals, and toxic materials, before pumping for irrigation. The Public Health Laboratories are responsible for monitoring the quality of water used for irrigation and the quality of the products before marketing. The health education department is responsible for programmes and publicity, through all information routes, newspapers, magazines and audiovisual aids (television & radio). The Preventive Medicine Department deals with the health of the labourers by surveillance of any disease outbreak, investigating the source and analysing the data collected. In the period from 1976 up till to day, only sporadic cases of Salmonella, Shigella, common colds and some parasitic infestations were notified and treated.

Greenery & Landscope Projects

Effluent re-use forms an important part of the new programme to expand the green areas of Kuwait. Although all future projects for planting and site development will be the responsibility of the Agricultural and Fisheries Resource Agency, the Ministry of Public Works will retain responsibility for producing, transferring, pumping and storing treated effluent. The Ministry of Public Works (MPW) and Public Authority for Agriculture Affairs and Fisheries (PAAF) have been undertaking studies to utilize the Treated Swage Effluent (TSE) for the whole State of Kuwait greenery and landscape projects.

The TSE project has been divided into three phases with a total TSE water requirement of 60.00 million gallons/day for the Kuwait Master Plan. Part of the Phase I project is completed with a total water demand of 5.1 million gallons/day. Total water demand of 23 million gallon/day for phase I project of TSE is from Rikka and Ardiya plants Upon MPW & PAAF review of the TSE Master Plan, the area of Phase II is to be served by Rikka and future Plants in Shuaiba and Umm Al-Hymann with a total TSE estimated water requirement of 11.43 million gallons/day. The area of phase III is to be served by Ardiya and Jahra blauts with an estimated water requirement of 28.58 million gallons/day. The Kuwait Master Plan projects will be monitored and controlled from one station through Telemetry and Satellite Control System.

Kuwait's water resources is limited and no plants can grow without irrigation. Rainfall which amounts to an annual average of 120 mm is inadequate to support any kind of plantation or rainfed agriculture. All TSE will be used to irrigate the landscape and beautification projects in and around Kuwait City in particular for highways, major roads and internal roads. The type of irrigation system to be used mostly will be drip system. The Public Authority for Agriculture Affairs and Fisheries (PAAF) is the main government body entrusted for implementing the desire of H.H. The Emir for greening Kuwait City. PAAF is co-operating with other governmental bodies such as the Ministry of Public Works (MPW), Ministry of Electricity and Water (MEW), Kuwait Institute for Scientific Research (KISR) and others for carrying out the greenery plans.

Brackish groundwater is the main source of irrigation for landscape areas. Fresh water is also used through tankers. Treated Sewage Effluent (TSE) has not been extensively used in the past due to the lack of proper distribution network and facilities. The use of TSE have been a long cherished desire of government of Kuwait in general and MPW/PAAF in particular. Special projects and studies have been initiated in co-operation with MPW and PAAF for expanding the TSE, usage. Some projects are under implementation whereas studies are continuing for Phase II and Phase III. □

Soil Aquifer Treatment for Wastewater Quality Improvement

M.N. Viswanathan, M. Al-Otaibi, T. Rashed & M.N. Al-Senafy

Soil aquifer treatment (SAT) is a proven technique for improvement of wastewater quality. The method involves the flow of wastewater through soil matrix of unsaturated zones and in aquifers, thereby, improving its quality. The experimental study undertaken at a pilot plant in Kuwait proved that the method could be successfully used in arid environments. Wastewater quality improvement after SAT was significant and the treated wastewater is suitable for unrestricted irrigation. The article presents the results of a pilot study in this regard.

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In arid countries, wastewater plays a major role in water resources management. At present, with a population of about two million people, Kuwait produces about 300,000 m^3 of wastewater per day. About 60% of wastewater produced is discharged in to sea and the rest is used for landscaping and irrigation. The wastewater discharge to the sea contains high levels of pathogenic bacteria and organic nutrients, resulting in pollution of the marine environment. Further treatment of this wastewater is necessary for unrestricted usage. Soil aquifer-treatment (SAT) is capable of providing this additional treatment (Bouwer et al, 1980) provided the soil conditions, weather conditions, and influent quality are suitable.

Reuse of wastewater will greatly reduce the demand for fresh water. However, reuse of wastewater faces several obstacles such as cost of treatment, level of treatment that is suitable for unrestricted use, public acceptance, and need for large storage area where the treated wastewater could be stored when the supply exceeds demand. Conventional wastewater treatment plants are capable of treating wastewater to any required level of water quality. However, one major drawback of such plants is the high cost of treatment. Alternatively, land treatment methods are becoming increasingly popular. Land treatment systems are of three types: overland flow systems, low rate application systems and high rate application systems (Bouwer et al,1980). Overland flow systems are used where the soil is too impermeable or the suspended solids content of the wastewater is too high to allow significant infiltration

Reuse of wastewater faces several obstacles such as cost of treatment, level of treatment, public acceptance, and need for large storage area.

rates, causing most of the wastewater to run off. With low-rate application systems, all wastewater applied infiltrates into the soil, but the rates are small and of the same order as the water requirements of the crop or vegetation. The infiltration rates are 2-10 cm per week. With high rate application systems, all the water infiltrates into the soil, with rates of infiltration in excess of 0.5 m per week. High rate infiltration systems are also known as soil aquifer treatment (SAT) systems.

Soil Aquifer Treatment

SAT system operates by infiltration of wastewater effluent through the vadose zone (Fig. 1). Water quality improves from removal mechanisms in the soil that include filtration, biological degradation, physical adsorption, ion exchange, and precipitation. These mechanisms can be effective in removing nitrogen, phosphates, biochemical oxygen demand (BOD), suspended solids, organic compounds, trace metals, bacteria and viruses. The removal of nitrogen, organic compounds (BOD), bacteria and viruses can be a continuous regenerative process that relies primarily on biodegradation. Removal of trace metals, phosphates and non- biodegradable organics occurs by chemical and physical mechanisms that have limited capacity. Efficiencies for removal of specific wastewater quality constituents vary widely with type of soil, level of effluent pretreatment, loading rate, loading cycle and temperature.

> **SAT operates by infiltration of wastewater effluent through the vadose zone.**

SAT is widely used for wastewater treatment in the United States and other countries throughout the world. After 20 years of operation and extensive study, no measurable impact on groundwater quality or human health was reported in Los Angeles (Nellor et al, 1985). Extensive studies were undertaken by Bouwer et al, (1980) in Arizona, Idelovitch et al, (1980) in Israel and Ho et al, (1992) in Australia. An experimental study was undertaken in Kuwait to study the feasibility of using SAT in Arid regions.

Methodology

The area of Kuwait constitutes a part of the interior homocline of the Arabian Peninsula. The rocks exposed range in age from Eocene to Recent (Al-Sulaimi et al, 1990). Most of Kuwait consists of a fluvial sequence of cross-bedded sands and gravel, usually cemented by

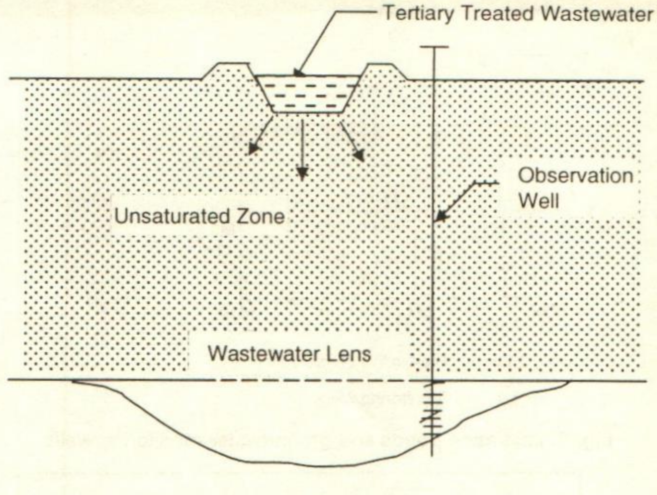

Fig. 1. Soil aquifer treatment process

gypsum and carbonates. One of the characteristic features of Kuwait is the formation of gatch material. Gatch is the local name of a partially consolidated sediment of a massive calcrete type found in Kuwait at variable depth, but generally about 2m below the surface. This deposit, which can attain thickness of tens of meters, consists basically of quartz sands cemented predominantly by carbonates (calcite and/or dolomite). Permeability tests were undertaken under laboratory conditions using the falling head method. The permeability of gatch material varies between 0.004 cm/d and 3.0 cm/d.

Pilot Plant

A total of seven infiltration ponds were constructed at the site for recharge of wastewater. Figure 2 shows the arrangement of infiltration ponds. Ponds numbered 1-6 are 7 × 15 m in area and pond number 7 is 18 × 15 m. The depth is 2 m. The side walls of ponds are lined with concrete and floors are unlined. A total of 114 monitoring wells were constructed to study the recharge of wastewater and changes in groundwater quality. The depth to groundwater is 30 m and the monitoring wells are 40 m deep. While drilling well number M4, which is located at the center of the ponds, soil samples were collected at 5 m intervals and properties of soil samples collected are presented in Fig. 3. Percentage fines passing through a sieve size 0.063 mm varied between 2 and 20 per cent. The drill time was high at depths 5 to 10 m, probably due to the presence of the gatch layer. The cation exchange capacity varied between 0.1 and .7 meq/g. The total organic matter varied between almost zero and about 800 mg/kg. The hydraulic conductivity was measured in the laboratory and varied between 0.5 and 6 m/d.

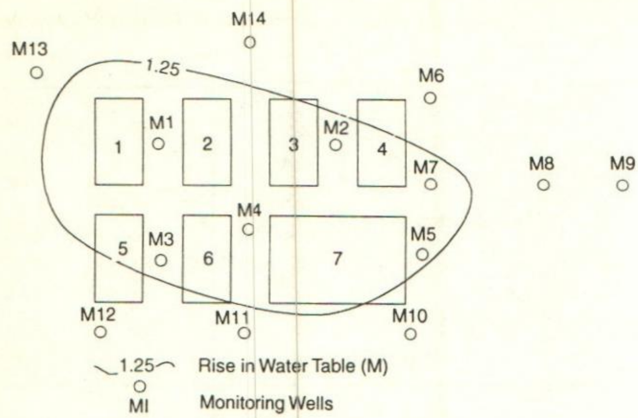

Fig. 2. Infiltration ponds and groundwater monitoring wells

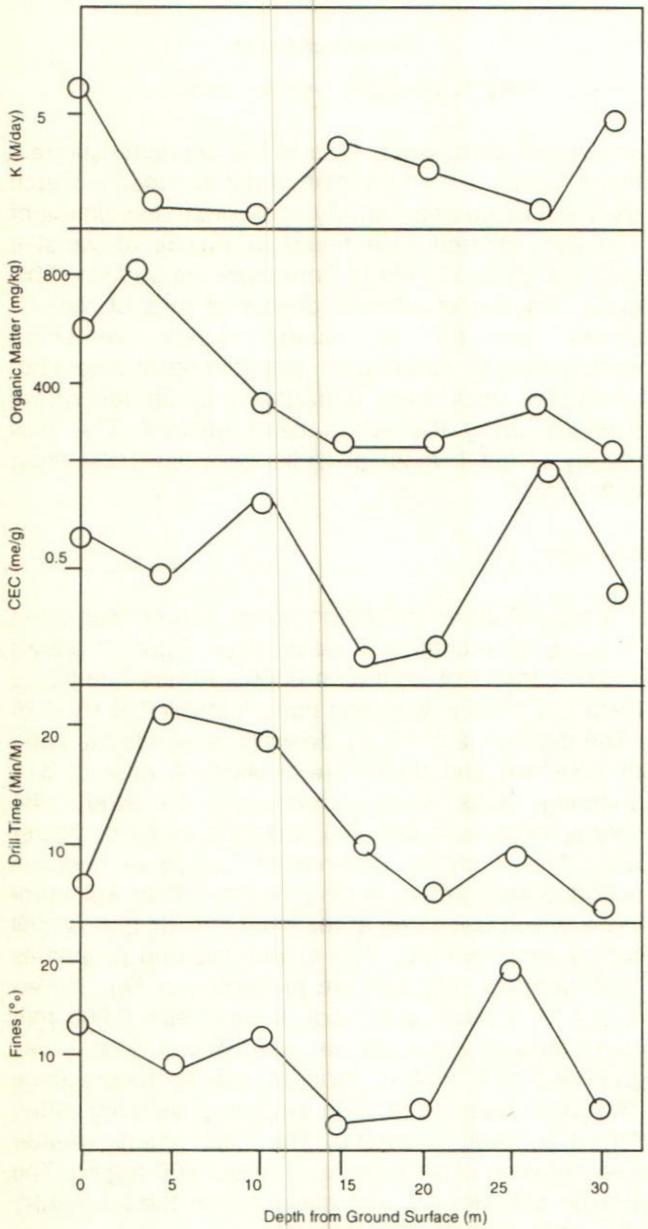

Fig. 3. Subsurface soil properties

Experimental Procedure

Tertiary treated wastewater recharge commenced in May 1998. The average raw, secondary and tertiary wastewater quality parameters are presented in Tables 1, 2 and 3 (Ebrahim & Abdel Jawad, 1995). The recharging was done between 3 p.m. and 6 a.m. daily, and between 6 a.m. and 3 p.m. wastewater supply to the ponds was stopped due to non-availability of supply. The study period was between May 1998 and December 1999. During the study period, the ponds were cleaned at three monthly intervals due to the build-up of slime and growth of algae at the bottom. Such growth reduced infiltration rates to the original level. Groundwater samples were collected from all the 14 monitoring wells at monthly intervals and analyzed for wastewater quality parameters. Tables 1, 2 and 3 also present wastewater quality parameters, concentrations of trace metals and microbiological parameters measured in December 1999 at well number M4 before and after SAT. The wastewater parameters at other monitoring wells were similar.

Table 1: Wastewater Quality Parameters

Parameter	Raw Waste-water	Secon-dary Treated Waste-water	Tertiary Treated Waste-water	After SAT	% Removal by SAT PH
TSS	222	8	6	6	0
VSM	161	6	5	3	40
COD	689	40	23	5	78
BOD_5	242	9	3	0	100
TDS	1470	1390	1220	2160	–
Ammonia	65	15	15	0	100
Nitrates	1	9	2	2.9	–
Phosphates	18	11	12	0	100
Turbidity FTU	NA	NA	7	2	71

Except pH and turbidity, all other units are in mg/l.
TSS: Total suspended solids
VSM: Volatile suspended matter

Evaluation of Results

Loading Rates: The total flow of wastewater to all the ponds between May 1998 and December 1999 was 8740 m^3. The average loading rate was about 0.8 m/yr. The low loading rates were attributed to the presence of low permeability layers in the unsaturated zones. The rise in water table due to recharge of wastewater was about 1.25 m within the proximity of the ponds.

Table 2: Trace Metals in Wastewater

Parameter	Raw Waste-water	Secon-dary Treated Waste-water	Tertiary Treated Waste-water	After SAT	% Removal by SAT
Cadmium	5	5	4	3	25
Lead	12	11	11	5	55
Chromium	14	14	12	5	58
Copper	19	19	17	9	47
Zinc	62	60	60	12	80
Iron	92	65	55	8	85
Nickel	10	10	9	5	44
Vanadium	23	22	21	7	67
Mercury	5	4	4	ND	100

Units: $\mu g/l$.

Table 3: Wastewater Microbiological Parameters

Parameter	Raw Waste-water	Secon-dary Treated Waste-water	Tertiary Treated Waste-water	After SAT	% Remo-val by SAT
Total Coliform	3.9×10^8	2.7×10^7	4.4×10^4	2×10^0	100
Faecal Coliform	3.3×10^8	1.5×10^7	2.9×10^4	0	100
Faecal Streptococci	3.7×10^5	5.6×10^4	1.3×10^1	0	100
Salmonella	2.3×10^7	7.2×10^5	4.6×10^0	0	100

Units: MPN per 100 ml.

pH: The pH of soil and the pH of wastewater can be modified by the chemical reactions in the soil. The slight increase in pH is probably due to biodegradation of organic acids as the wastewater moves down the soil.

Total Dissolved Solids: The total dissolved solids (TDS) increased after SAT, partly due to the leaching of salts from the soil in the unsaturated zones. In addition, evaporation of wastewater from the ponds also increased the TDS of the effluent. At the pilot plant site, the pan A evaporation varied from 3.1 mm in the winter months to about 31 mm in the summer months and, hence, considerable increase of TDS in summer months could be attributed to evaporation from the infiltration ponds.

Oxygen Demand: Wastewater contains a variety of natural and synthetic organic compounds, usually not individually identified, but collectively expressed in terms of biological oxygen demand (BOD_5, determined after five days incubation), and chemical oxygen demand (COD, usually determined with the dichromate technique). In the present study, BOD_5 removal was about 100 per cent, probably due to the presence of readily biodegradable material in the wastewater. COD removal was about 78 per cent, probably due to the presence of refractory material in the wastewater. Complete removal of COD is rarely achieved in land treatment systems.

Nitrate and Ammonia: If the nitrogen in wastewater is predominantly in organic or ammonium form, as is usually the case with sewage water, an aerobic phase in the soil is necessary first to convert the nitrogen to nitrate before denitrification can take place. During this aerobic phase, organic carbon in the wastewater also will be oxidized by the numerous heterotrophic aerobic bacteria in the soil, leaving less organic carbon for denitirification when the wastewater moves into aerobic zones. In the present study, ammonia was completely removed, indicating highly aerobic conditions. Nitrate removal was only 21 per cent indicating limited anaerobic conditions and lack of sufficient organic carbon. This suggests longer flooding periods might be necessary if better nitrate removal is required.

Phosphates: Although some phosphates were removed during the treatment process before SAT, its concentration in the recharge effluent was still significant. Excellent phosphate removal occurred during SAT, presumably by adsorption on clay and silt lenses and by chemical precipitation, both in the unsaturated zone and in the aquifer. In the present case, complete removal of phosphates was observed.

Bacteria: Of the numerous microorganisms present in the wastewater, the fate of pathogenic bacteria and viruses when the water moves through the soil is of utmost concern. The retention of microorganisms in the soil is largely due to physical entrapment for the larger organisms and to adsorption to clay and organic matter for viruses and other amphoteric organisms. Normally, faecal coliform bacteria are essentially completely removed after the water has traveled 1 m or, at most, 2 or 3 m through the soil. Considering the high level of fines at depths of 20-25 m, total removal of bacteria was expected. For unrestricted irrigation use, the World Health Organisation insists that the faecal coliform should be less than 100 MPN/100 ml (Bouwer et al, 1980), whereas the State of California, USA, stipulates that it should be less than 2.2 MPN/100 ml. The wastewater before SAT fails to satisfy WHO standards, but after SAT, the treated effluent satisfied both WHO and State of California standards.

Trace Metals: The concentration of heavy metals in various wastewaters is generally low if there is no specific metal pollution. In the present study, trace metals in the influent wastewater were low and their removal varied between 25 and 100 per cent. Stable organic matter in the soil may significantly contribute to the binding of metals.

Storage of Treated Wastewater: One of the major advantages of SAT is the possibility of treated wastewater storage in aquifers. The TDS of groundwater at the pilot plant site was about 5000 mg/l. The TDS of treated wastewater was about 2010 mg/l and, hence, the treated wastewater can be stored as a lens over the brackish groundwater. The unsaturated zone is about 30 m thick and, hence, the aquifer provides a large space for the storage of wastewater.

Economic Aspects: The main capital costs of a wastewater renovation system based on the principle of SAT are for the land and wells. Assuming land cost of about US $ 2000 per hectare, the cost of renovated wastewater will be about US $ 1.5 per 1000 m^3. This includes costs of maintenance and energy for pumping. Treatment of wastewater using conventional methods to the same standards of SAT is likely to cost between US $ 120 and 600 per 1000 m^3 (Bouwer, 1993).

SAT technology is particularly useful in developing countries where funds are limited for the construction of high technology wastewater treatment plants. SAT requires personnel with very limited technical expertise and the method is totally reliable. The effect on environment or groundwater is negligible. The method provides water for unrestricted irrigation. Hence, the use of potable water for irrigation could be minimized thereby making it available for potable purposes.

Acknowledgment

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Economics of Irrigation Methods for Kinnow Orchard

H.S. Gulati & S.D. Khepar

This paper deals with the selection and economics of surface, sprinkler and drip methods of irrigation. The economics have been worked out for three situations. The paper reveals that adoption of sprinkler and drip methods is more advantageous under scarce water conditions.

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With the improvement in crop production technology and introduction of high yielding varieties, demand of water has increased in Punjab. Further because of inflation, water has become not only scarce but also costly resource. Hence it becomes necessary that water is used both judiciously and efficiently so that maximum benefit per unit of water available could be obtained. Although modern irrigation methods like sprinkler and drip, which are far more efficient as compared to conventional surface method, have been introduced, they are not being adopted by farmers as their economic viability is not yet established. Since the initial cost of these modern methods is quite high they could be proved economical only for high value crops. Hence, an attempt has been made to underline conditions and situations under which these methods can be used. Further the comparative economics of these methods have been worked out.

Selection of Irrigation Method

Broadly irrigation methods are classified into surface, sprinkler and drip irrigation. Selection of a particular method depends on a number of factors such as topographic and soil conditions, water scarcity scenario in terms of volume and stream size available, cost effectiveness of irrigation system, besides the economic and managerial caliber of the farmer.

Selection of a particular method of irrigation depends on a number of factors such as topographic and soil conditions, cost effectiveness of irrigation system, and managerial caliber of the farmer.

Surface Method

In surface (border) method, the field is divided into number of strips. Water is released into each strip individually from the head end. When the water front reaches the tail end of the strip, the stream is cut off. The border method of irrigation is most suitable for close growing crops like wheat and paddy. In surface method of irrigation the water is carried through irrigation channels in which about 15-40 per cent water is lost through seepage. Further about 30-50 per cent of the applied water is lost below the root zone as deep percolation loss. Thus overall irrigation efficiency of surface method is only 30-50 per cent as compared to attainable level of 60-70 per cent.

Sprinkler Method

In sprinkler method water is applied over the whole crop area in the form of spray resembling rainfall. Water is carried through pipes (main, submain, and laterals); so the conveyance losses are almost eliminated. Moreover the area that is to come under irrigation channels and bunds can be brought under cultivation. In this system water is applied at a rate less than the infiltration rate of the soil. This helps in eliminating runoff losses. Further the controlled depth of water can be sprayed uniformly over the entire area—so deep percolation losses are also eliminated. However some evaporation losses do occur in sprinkler irrigation where day temperature is more and wind speed high. The overall irrigation efficiency of sprinkler method is 75-80 per cent.

Because of its high initial cost, the use of sprinkler system in Punjab is recommended only under following situations: Scarcity of water, Undulating topography, High intake rate soils and Low stream size. Sprinkler irrigation has also some other advantages—it can be used for environment control and fertilizer can be applied along with water. In addition to high initial cost there are some other limitations in use of sprinkler system. It requires relatively clean water to avoid clogging of sprinkler's nozzles. It requires an operating pressure of about 30m and thus increases the horse power requirement.

Drip Method

In drip method water is applied only around the base of plants drop by drop through devices called drippers or emitter. In this system water is applied at a low rate (2-10 liters per hour) over a longer duration (2-8 hours) at frequent intervals (almost daily). Water is carried through pipes and controlled and precise depth of water can be applied. Hence conveyance and deep percolation losses are eliminated. Since partial area only around the base of the plant is wetted evaporation losses as well as weed problem also get reduced.

The drip system is recommended under all situations for which sprinklers are suitable. But drip irrigation has certain advantages over sprinkler system. In drip irrigation there are no evaporation losses under adverse climatic conditions of high temperature and greater wind velocity. In drip system poor quality ground water also can be used without affecting plant growth adversely. It requires lesser operating pressure of about 10-15 m as compared to about 30 m needed for sprinkler system. Hence power requirement and thereby energy consumption in drip is substantially less as compared to sprinkler system.

Areas suitable in Punjab

In Punjab, the Kandi zone and south-west zone are most suitable areas for adoption of sprinkler and drip irrigation methods. The topographic, soil and climatic conditions of these zones are conducive for growing high value crops such as fruits and vegetables. Kandi zone comprises 19 per cent geographical area of state in Gurdaspur, Hoshiarpur and Ropar districts of Punjab. The average annual rainfall of this region is about 1000 mm. The ground water is sweet but is available at deeper layers because of rocky underground geological conditions. This area, if converted into horticulture—olericulture based agriculture, possesses maximum scope for sprinkler and drip irrigation. But presently it is the most backward and techno-economically the least developed area. There is a great need to take concerted back up program to popularize these modern methods in this zone.

South-west zone comprises 34 per cent geographical area of state in Ferozepur, Faridkot, Muktsar, Mansa and Bathinda districts of Punjub The average annual rainfall of this region is 400 mm. The native ground water quality is brackish and main source of irrigation is canal water. Excessive seepage from canal network and inefficient use of canal water have created both water logging as well as salinity problem in this region. To check this problem there is need for conjunctive use of surface canal water and poor quality ground water. Skimming well through multiple well point technology in conjunction with drip system can help greatly in arresting this problem. The climatic condition of this region is also favourable for growing fruit crops like kinnow and grapes and thus drip irrigation has vast scope in this region.

Comparative Area Irrigated

With the same volume of water, the comparative

Table 1: Comparative Areas Expected to be Irrigated

Item	Surface	Sprinkler	Drip
Peak consumptive use rate (mm per day)	9	9	9
Irrigation interval during peak consumptive use (days)	10	10	1
Depth of water required (mm) (3) = (1)*(20)	90	90	9
Crop coefficient for Kinnow (fraction)	0.65	0.65	0.65
Net depth of water required D, (mm) (5) = (3)*(4)	58.5	58.5	5.85
Wetting percentage. WP, (fraction)	1.00	1.00	0.60
Efficiency of irrigation system. E, (fraction)	0.50	0.80	0.90
Amount of water required for 0.4 ha (1 acre) (litres/acre/irrigation)	$\frac{4000*58.5*1.0}{0.50}$ = 4,68,000	$\frac{4000*58.5*1.0}{0.80}$ = 2,92,500	$\frac{4000*5.85*0.6}{0.90}$ = 15,600
$\frac{A(sq.m.)*D(mm)*WP(fraction)}{E\ (fraction)}$			
Area to be irrigated (ha)	0.4	0.4	4
Amount of water required for each irrigation (litres) (10) = (8)*(9)	4,68,000	2,92,500	1,56,000
Expected number of irrigations per year	20	20	200
Number of irrigations required to irrigate 4 hectares	10	10	1
Total amount of water expected to be utilized (litres) (13) = (10)*(11)*(12)	93,60,000	58,50,000	31,20,000
Proportional area expected to be irrigated	1.0	1.6	3.0

area irrigated by surface, sprinkler and drip methods of irrigation has been worked out in Table 1. The volume of water has been determined for peak consumptive demand (9mm/day) expected to occur in the months of May, June in Punjab. The volume of water required per 0.4 ha for each irrigation for Kinnow orchard in case of surface, sprinkler and drip methods were found to be 4,68,000, 2,92,500 and 15,600 litres respectively. The number of irrigation expected to occur in a year are 20, 20 and 200 respectively. Hence the total volume of water per 0.4 ha per annum for surface, sprinkler and drip is 93,60,000, 58,50,000 and 31,20,000 litres respectively. If the volume of water utilized in surface irrigation (93.60,000) is considered as 1 unit, then the proportionate area irrigated by sprinkler method (93,60,000/58,50,000) is about 1.6 units. Similarly the proportionate area irrigated by drip method would be (93,60,000/31,20,000) about 3 units. It can be said that in case of Kinnow orchard with the same volume of water, about 1.5 times area can be irrigated with sprinkler and about 3 times area can be irrigated with drip system.

Pumping capacity, Horse Power and Energy Consumption

The requirements of pumping capacity, total head, horse power and energy consumption of surface, sprinkler and drip methods of irrigation are presented in Table 2. The pumping capacity of each system has been worked out on the assumption that maximum number of hours electricity is available is 8 hours per day. Table 2 shows that pumping capacity required for surface, sprinkler and drip methods are 16.25, 10.16 and 5.41 litres per second respectively.

Table 2: Comparative Requirements of Pumping Capacity, Head, and Horse Power

Item	Surface	Sprinkler	Drip
Amount of water required (v) for each irrigation	4,68,000	2,92,500	1,56,000
Maximum operational hours (H) available per day. (hours)	8	8	8
Pumping capacity required (Q) (litres per second) Q = V/(H*60*60)	$\frac{4,68,000}{8*60*60}$ = 16.25	$\frac{2,92,500}{8*60*60}$ = 10.16	$\frac{1,56,000}{8*60*60}$ = 5.41
Head for tube well under normal Punjab condition (m)	20	20	20
Operating head required (m)	–	30	15
Losses in the system (m) Assume 20% of operating head	–	6	3
Total head (H), (m) (7) = (4) + (5) + (6)	20	56	38
Pump horsepower (HP) required $HP = \frac{Q*H}{75*Pump\ Efficiency}$	$\frac{16.25*20}{75*0.70}$ =6.19	$\frac{10.16*56}{75*0.70}$ = 10.84	$\frac{5.41*38}{75*0.70}$ = 3.91
Approximate horse power (HP) required for electrical pumpset (Assumed efficiency of electric motor as 0.90)	6.88	12.03	4.34
Actual horse power of electrical motor used	7.5	12.5	5.0
Approximate horse power (HP) required for diesel pump set (Assumed efficiency of diesel engine as 0.65)	9.52	16.7	6.6
Actual horse power of diesel engine used	10	17.5	7.5

For determining total head required for three systems, the head needed for ordinary tubewell under normal Punjab situations has been considered equal to 20 m. The operating head required for surface, sprinkler and drip has been taken as zero, 30 and 15 m respectively. Considering system losses in sprinkler and drip system of the order of 20 per cent of their operating pressure, the total head worked out for surface, sprinkler and drip are 20, 56 and 38 m respectively. Further horse power required for electrical pump set for three systems are 7.5 HP, 12.5 HP and 5 HP respectively. Similarly for diesel pump set the HP requirements for three systems are 10 HP, 17.5 HP and 7.5 HP respectively.

Cost of Irrigation System

The cost of any irrigation system depends upon the type of components or equipment involved in the system. The main components of any irrigation system include source of power, conveyance unit and application unit. The cost further depends upon the requirement of the size and capacity of each unit or component.

In surface irrigation system, water is carried through irrigation channels and then applied in the field. Hence the cost involved on components may be considered nil. Further the cost of irrigation depends upon source of irrigation. If the source of irrigation is canal water, then there is no need of any pumping unit. However if the source is tube well then cost involved on installation of tube well and cost on energy consumption are to be included.

In sprinkler irrigation system, water is carried through a network of pipes (main, sub-main, and laterals) and is then applied in the form of spray with the help of sprinkler nozzles. The cost involved depends upon the sizes and capacities of these components. These specifications in turn depend upon the size of the unit or command area. Further for developing necessary pressure in the sprinkler system a pumping unit has to be utilized. The cost of installation on pumping unit shall depend upon the type and size of the unit. The cost on energy consumption depends upon the horse power of the prime mover. The approximate cost of a sprinkler system for a 4 ha unit of Kinnow orchard, with a 10 days irrigation interval, has been estimated as Rs. 1,10,000. Hence the cost of sprinkler system is about Rs. 11,000 per acre.

In drip irrigation system, the components can be classified broadly into two units namely control unit and distribution network. The control unit comprises pumping set, filtration unit and fertilization tank. The filtration unit required depends upon the source of water and impurities contained in it. If the source of water is tube well and it does not contain much sand particles, then use of only mesh filter is enough. On the other hand if the source is canal water, then to avoid the entry of silt particles into drip system, the use of both sand filter and mesh filter is essential. The distribution network comprises pipes (main, sub main and laterals) and water emitting devices called emitters or drippers. The cost involved depends upon the specifications (ie. size and capacities) of the equipment. This is turn depends upon the size of the unit or command area. In drip irrigation, the requirement of pipe lengths and emitters goes on increasing in the same proportion as the size of the unit or command area. On the other hand the size of control unit does not increase in the same proportion as the area increases. Hence it has been observed that overall cost of drip system per unit area goes on reducing with increase in command area. The cost on energy consumption depends upon horse power of prime mover. The cost of a drip system for a 4 ha unit for a Kinnow orchard without sand filter has been estimated to be about Rs. 1,25,000. If the sand filter is also to be included then additional amount of Rs. 25,000 – 30,000 is to be added in the cost.

Overall cost of drip system per unit area goes on reducing with increase in command area.

Economics of Irrigation Methods

The economics of any system/method is normally determined in terms of benefit-cost ratio. For this annual benefit derived from the system and the annual cost incurred on the system require to be estimated.

Annual Benefit

Annual benefit is determined by subtracting annual cost from annual revenue. Annual revenue is the total market value of the produce. The market value depends upon the quantity and quality of the produce likely to be harvested. In case of orchards, this is normally decided jointly by the farmer and contractor after visiting the orchard. For Kinnow orchard, the annual net revenue is about Rs. 50,000 per hectare under conventional method of surface irrigation. Under drip irrigation, it has been observed by the scientist that about 20 per cent Kinnow yield increases. So in this study both the cases – yield at same level and yield at 20 per cent enhanced level, in case of drip method have been considered.

Table 3: Fixed Cost of Different Irrigation Systems for Kinnow Orchard for a 4 ha (10 acres) unit

Item	Surface	Sprinkler	Drip
Total cost of installation (Rs.) For a 4 ha (10 acres) unit excluding cost of tube well bore and pumping unit	Nil	75,000	1,00,000
Horse Power (HP) required of a pumping unit.	7.5	12.5	5.0
Approximate cost of a tube well bore and pumping unit (Rs.)	30,000	35,000	25,000
Total cost (TC) for a 4 ha (10 acres) unit (Rs.)	30,000	1,10,000	1,25,000
Salvage value (SV), (Rs.) (Assume @ 10% of initial cost)	3000	11000	12500
Useful life (L) of equipment in years	15	15	10
Annual depreciation (Rs.) $\frac{TC-SV}{L}$	$\frac{30{,}000-3000}{15} = 1800$	$\frac{1{,}10{,}000-11000}{15} = 6600$	$\frac{1{,}25{,}000-12500}{10} = 11250$
Annual interest (I) on investment (Rs.) (Assume annual interest @ 10%) $\frac{TC-SV}{2} * \frac{I}{100}$	$\frac{(30000-3000)^{*} 10}{2 * 100} = 135.0$	$\frac{(110000-11000) * 10}{2 * 100} = 4950$	$\frac{(125000-12500) * 10}{2 * 100} = 5625$
Total annual fixed cost for 4 ha (10 acres) unit. (Rs.) (9) = (7) + (8)	1935.0	11550.0	16825.0
Total annual fixed cost per acre (Rs.)	193.50	1155.00	1682.50
Total annual fixed cost per hectare (Rs.)	483.75	2887.5	4211.25

Annual Cost

The annual cost incurred on the system comprises two components–fixed cost and variable cost. The fixed cost remains constant irrespective of usage time whereas variable cost changes with the usage time.

Fixed cost of the three irrigation methods has been worked out in Table 3. Initial investment on surface, sprinkler and drip systems for 4 ha Kinnow orchard are Rs. 30,000, Rs. 1,10,000 and Rs. 1,25,000 respectively. Assuming useful life of three systems as 15, 15, and 10 years and salvage value for all the systems as 10 per cent, the annual depreciation for surface, sprinkler and drip systems for a 4 ha unit have been found as Rs. 1800, Rs. 6600 and Rs. 11250 respectively. Further assuming interest on investment as 10 per cent per annum, the annual interest on investment has been worked out as Rs. 135, Rs. 4950 and Rs. 5625 respectively. Further adding annual depreciation and annual interest, the annual total cost for a 4 ha Kinnow orchard on three irrigation systems are Rs. 1935, Rs. 11550 and Rs. 16825 respectively. This shows that annual fixed cost per ha of Kinnow orchard for surface, sprinkler and drip method are Rs. 487.75, Rs. 2887.50 and Rs. 4211.25 respectively.

Variable cost involves the cost of all inputs such as seed, fertilizer, hoeing, irrigation, pesticides etc. needed for production. Here only those inputs which are directly or indirectly connected with irrigation have been included. The factors included are cost of energy for pumpage, cost on labour required for irrigation, and for hoeing and cost on repair and maintenance of irrigation system. Since the cost on energy depends upon the source of power (ie electric motor or diesel engine), the economics have been worked out for both the situations separately.

Economics with Electric Motor Source

The economics of three irrigation systems with electrical motor as source of power have been computed in Table 4. Horse power of electrical motor pumping unit has been determined based on discharge and total head requirement. Horse power requirement of the surface, sprinkler and drip systems are 7.5, 12.5 and 5 HP respectively. Annual electrical energy consumption has been worked out considering annual operational hours and conversion factor (1 HP = 0.746 KWH). Considering cost of electricity as Rs. 2 per unit, the annual cost on electrical energy for 4 ha Kinnow orchard for surface, sprinkler and drip methods have been found to be Rs. 17904, Rs. 29840 and Rs. 11936 respectively.

The labour requirement for irrigation in surface method has been taken as 20 hours per ha whereas in

Table 4: Comparative Economics of Different Systems of Irrigation for a 4 Hectares (10 acres) unit (using electrical energy)

Item	Surface	Sprinkler	Drip
Horse power (HP) of electrical motor required of electrical operated pumping unit	7.5	12.5	5.0
Operational time available each day for each irrigation (hours)	8	8	8
Expected number of irrigation per year	20	20	200
Number of irrigation turns required to cover 4 ha of land	10	10	1
Total operational hours required each year (5) = (2)*(3)*(4)	1600	1600	1600
Electrical energy consumption per year (units)	7.5*0.746*1600 = 8952	12.5*0.746*1600 = 14920	5.0*0.746*1600 = 5968
Annual cost of electrical energy (Rs.) (Assumed @ Rs. 2 per unit)	17904	29840	11936
Labour time required for each irrigation (hours)	8	2 (For shifting pipes)	1 (For inspection)
Total labour hours required each year (10 acres.) (hours)	1600	400	200
Total cost of labour for irrigation each year (Rs.) (Assumed @ Rs. 8 per hour)	12800	3200	1600
Labour required for hoeing one hectare each year (man days)	40	40	20 (Because 50% wetted area)
Total annual labour cost for hoeing 4 ha (Rs.)	40*4*64 = 10240	40*4*64 = 10240	20*4*64 = 5120
An. repair and maintenance cost (Rs.) (Assumed @ 5 per cent of initial cost)	1500	5500	6250
Total annual variable cost (Rs.) (14 = (7) + (10) + (12) + (13)	42444 (24540)	48780 (18940)	24906 (12970)
Total annual variable cost per hectare (Rs.)	10611.00 (6135.00)	12195.00 (4735.00)	6226.50 (3242,50)
Total annual fixed cost per hectare (Rs.) (Table 3)	483.75	2887.50	4211.25
Total annual cost per hectare (Rs.) (17) = (15) + (16)	11094.75 (6618.75)	15082.50 (7622.50)	10437.75 (7453.75)
Annual gross return per ha from Kinnow at same yield level (Rs.)	50,000	50,000	20,000
Net annual return per ha at same yield level (Rs.) (19) = (18) − (17)	38905.25 (43381.25)	34917.50 (42377.50)	39562.50 (42546.25)
Comparative income factor at same yield level	1.00 (1.00)	0.89 (0.97)	1.02 (0.98)
Benefit-cost ratio at same yield level	3.51:1 (7.07:1)	2.36:1 (8.95:1)	3.79:1 (13.12:1)
Net annual revenue per ha at enhanced yield level (Rs.)	50,000	50,000	60,000
Net annual return per ha at enhanced yield level (Rs.)	38905.25 (43381.25)	34917.50 (42377.50)	49562.25 (52546.25)
Comparative income factor at enhanced yield level	1.00 (1.00)	0.89 (0.97)	1.27 (1.21)
Benefit-cost ratio at enhanced yield level	3.51:1 (7.07:1)	2.31:1 (8.95:1)	5.15:1 (17.5:1)

Note: Values in parentheses are for situation when cost of electricity is considered nil.

sprinkler method it is taken as 5 hours per ha, which is considered mainly for shifting of pipes after each irrigation, labour requirement for drip irrigation has been taken to be only 1 hour per day, which is required for inspection of leakage and blockage of drip system. The annual labour cost of irrigation for surface, sprinkler and drip has been worked out as Rs. 12800, Rs. 3200 and Rs. 1600 respectively. Annual labour requirement for hoeing of 1 ha of Kinnow has been taken as 40 man days for both surface and sprinkler methods whereas in case of drip method it has been assumed as 20 man days because of only 50 per cent wetted area. Considering labour cost as Rs. 64 per man day, the annual labour cost on hoeing in case of surface, sprinkler and drip has been determined as Rs. 10240, Rs. 10240 and Rs. 5120 respectively. Annual cost on repair and maintenance has been taken as 5 per cent of the initial cost of the system. The annual repair and maintenance cost of surface, sprinkler and drip methods for 4 ha Kinnow orchard has been worked out as Rs. 1500, Rs. 5500 and Rs. 6250 respectively.

The total annual variable cost for 4 ha and then the annual variable cost per ha for surface, sprinkler and drip methods have been estimated as Rs. 10611, Rs. 12195 and Rs. 6226.50 respectively. Total annual cost has been determined by adding total annual variable cost with total annual fixed cost. Total annual cost per ha for surface, sprinkler and drip methods have been determined as Rs. 11094.75, Rs. 15082.50 and Rs. 10437.75 respectively. Net annual benefit has been obtained by subtracting total annual cost from total annual revenue. Using these values, the benefit-cost ratio and comparative income factor have been determined. Benefit-cost ratio has been determined by dividing total annual benefit with total annual cost. Table 4 shows that surface method has the maximum benefit-cost ratio of 4.78:1 followed by 3.71:1 of drip and 3.48:1 of sprinkler system. This shows that all the three systems are economically viable. The comparative income factor has been computed by assuming that net annual benefit obtained from surface method is 1. Then net annual benefit of sprinkler and drip methods proportionate to surface method are determined. Table 4 shows comparative income factor of surface, sprinkler and drip methods as 1.00, 0.89 and 1.02 respectively. This shows that there is no advantage in adopting sprinkler or drip method, if the source of power is electricity.

This shows that there is no advantage in adopting sprinkler or drip method, if the source of power is electricity.

However yield of Kinnow is enhanced by 20 per cent in drip irrigation. Hence, total annual revenue from Kinnow orchard is Rs. 60,000. The comparative income factor in drip method becomes 1.27. This shows that in case of electrical power source, if the yield level is also improved by 20 per cent in drip irrigation, it becomes economically viable to adopt drip method.

Economics with Diesel Engine Source

As the overall efficiency of diesel pump set is low as compared to electrical pump set, the horse power requirements of diesel pump sets are higher (surface, 10 HP; sprinkler, 17.5 HP and drip 7.5 HP). Diesel consumption has been worked out (Table 5) considering annual working hours and specific fuel consumption of diesel engine (176 cc/BHP/hr). Diesel fuel required per annum for a 4 ha Kinnow orchard has been determined as 2816 lit., 4928 lit. and 2112 lit. for surface, sprinkler drip methods respectively. Considering market price of diesel fuel as Rs. 15 per lit. annual cost of diesel energy for three methods has been determined as Rs. 42240, Rs. 73920 and Rs. 31680 respectively.

Considering other variable cost and fixed cost, total annual cost per ha for surface, sprinkler and drip methods are Rs. 17178.75, Rs. 26102.50 and Rs. 15373.75 respectively. Considering annual revenue of Rs. 50000 per ha for all the three systems, the net annual benefit for surface, sprinkler and drip are Rs. 32821.25, Rs. 23897.50 and Rs. 34626.25 respectively. The benefit-cost ratio for three methods are 1.9:1, 0.95:1 and 2.2:1 respectively. It shows that sprinkler method is not economically viable when source of power is diesel energy. The comparative income factor for surface, sprinkler and drip are 1.00, 0.76 and 1.06 respectively. This shows that drip method gives the maximum annual net benefit. Table 5 further shows that if yield of Kinnow increases by 20 per cent in case of drip method, the comparative income factor increases to 1.36.

Economics with Water Scarce Conditions

It has been found in case of Kinnow orchard (Table 1) that with the same amount of water about 1.5 times area (with sprinkler) and about 3 times area (with drip) can be irrigated as compared to surface method considering that a unit of 4 ha of land is available. If it is assumed that there is enough water available to irrigate 4 ha of Kinnow orchard with drip irrigation, then with the same volume of water, if sprinkler system is installed, it would be possible to cover only 2 ha of Kinnow orchard. It is further assumed that remaining 2 ha shall be sown under rainfed crops. Similarly if the same volume of water is to be used in surface irrigation, then it would be

Table 5: Comparative Economics of Different Systems of Irrigation for a 4 ha Unit for Kinnow Orchard Using Diesel Energy source

Item	Surface	Sprinkler	Drip
Horse power (HP) of diesel engine required	10	17.5	7.5
Annual operational hours required to irrigate 4 ha (hours)	1600	1600	1600
Expected diesel fuel consumption per year (liters) (Assumed @ 176 cc/BHP/hr)	$\frac{10 * 176 * 1600}{1000} = 2816$	$\frac{17.5 * 176 * 1600}{1000} = 4928$	$\frac{7.5 * 176 * 1600}{1000} = 2112$
Annual cost of diesel fuel (Rs.) for 4 ha (Assumed @ Rs. 15 per liter)	42240	73920	31680
Annual cost of diesel fuel per ha (Rs.)	10560	18480	7920
Annual labour cost for irrigation per ha (Rs.)	3200	800	400
Annual labour cost for hoeing per ha (Rs.)	2560	2560	1280
Annual repair and maintenance cost per ha (Rs.)	375	1375	1562.50
Total annual variable cost per ha (Rs.) (9) = (5) + (6) + (7) + (8)	16695.0	23215.0	11162.5
Annual fixed cost per ha (Rs.) (Table 3)	483.75	2887.50	4211.25
Total annual cost per ha (Rs.) (11) = (9) + (10)	17178.75	26102. 50	15373.75
Total annual revenue per ha at same yield level (Rs.)	50,000	50,000	50,000
Net annual benefit per ha (Rs.) (13) = (12)-(11)	32821.25	23897.50	34626.25
Comparative income factor at same yield level	1.00	0.76	1.06
Benefit-cost ratio at same yield level	1.90:1	0.95:1	2.25:1
Total annual revenue per ha at enhanced yield level (Rs.)	50,000	50,000	60,000
Net annual benefit per ha (Rs.) (17) = (16)-(11)	32821.25	23897.50	44626.25
Comparative income factor at enhanced yield level	1.00	0.73	1.36
Benefit-cost ratio at enhanced yield level	1.90:1	0.95:1	2.90:1

possible only to cover 1.33 ha under Kinnow orchard and the remaining 2.67 ha shall be under rain fed crops. Considering these situations, the economics have been worked out in Table 6.

All the annual cost and annual revenue have been worked out using the same methodology. Total annual cost for the surface, sprinkler and drip methods are Rs. 14753.75, Rs. 30165.00 and Rs. 41751.00 respectively. The total annual revenue has been found in two parts: Annual revenue from Kinnow orchard and Annual revenue from rain fed crops (assumed @ Rs. 10,000 per acre). Total annual revenue expected to be achieved from surface, sprinkler and drip methods is Rs. 93280, Rs. 120000 and Rs. 200000 respectively.

The net annual benefit estimated for three methods is Rs. 78526.25, Rs. 89835.00 and 158249.00 respectively. The benefit-cost ratio determined for surface, sprinkler and drip methods is 5.3:1, 3.69:1 and 3.79:1 respectively. The comparative income factors are 1.00, 1.20 and 2.02 respectively. This shows that although all the three methods are economically viable drip method provides almost double the annual benefit than surface and sprinkler methods. Considering the second case of enhanced yield of 20 per cent in case of drip irrigation, the benefit-cost ratio and comparative income factor rose to 4.75:1 and 2.53 respectively.

Conclusions

When water is not scarce and source of power is electrical motor. There are two cases:

Case A. When electricity cost is nil (at present the electricity is free to tube wells in Punjab): The economic analysis reveals that comparative income factors for sprinkler as well as drip method is 0.98 as compared to 1.00 of surface method. It clearly shows that there is no

Table 6: Comparative Economics of Different Systems of Irrigation for a 4 hectares (10 acres) Unit with Increased Area Coverage with Same Amount of Water

Item	Surface	Sprinkler	Drip
Proportionate area irrigated of Kinnow orchard with the same quantity of water (hectares)	1.33	2	4
Area remaining assumed to be under rainfed crops (hectares)	2.67	2	0
Annual fixed cost of the system installed for Kinnow orchard (Rs.)	483.75*1.33 = 640.70	2887.50*2 = 5775.00	4211.25*4 = 16845.00
Annual labour cost of irrigation for Kinnow orchard (Rs.)	(20mh/ha)(20irri)(1.33ha) (Rs.8/mh) = 4256.00	(5mh/ha)(20irr)(2ha) (Rs.8/mh) = 1600	(1 mh/irr)(200irri) (Rs.8/mh) = 1600
Annual labour cost of hoeing for Kinnow orchard (Rs.)	(40md/ha)(1.33ha)(Rs.64/md) = 3404.80	(40md/ha)(2ha) (Rs.64/md) = 5120.00	(20md/ha)(4 ha)(Rs.64/md) = 5120
Annual cost on repair and maintenance (Rs.)	(Rs.375/ha)(1.33ac) = 498.75	(Rs. 1375/ha)(2ha) = 2750	(Rs.1562.5/ha)(4ha) = 6250
An. cost on electrical energy for Kinnow orchard (Rs.)	(Rs.4476/ha)(1.33ha) = 5960.70	(Rs. 7460/ha)(2ha) = 14920	(2984/ha)(4ha) = 11936
Total annual variable cost (Rs.) (8) = (4)+(5)+(6)+(7)	14120.25	24390.00	24906
Total annual cost (Rs.) (9) = (3)+(8)	14760.95	30165	41751
Annual return from Kinnow orchard (Rs.) at same yield level	(Rs.50,000/ha)*(1.33ha) = 66,600	(Rs.50,000/ha)*(2ha) = 1,00,000	(Rs.50,000/ha)*(4ha) = 2,00,000
Annual return from rainfed sown crops (Rs.)	(Rs. 10000/ha)*(2.67ha) = 26,700	(Rs. 10000/ha)* (2ha) = 20,000	(Rs. 10000/ha)*(0ha) = 0
Total annual return from 4 ha (10 acres) area (Rs.) (12) = (10+(11)	93300	1,20,000	2,00,000
Total annual return over total annual cost (Rs.) (13) = (12)-(9)	78,539.05	89835.00	1,58,249
Comparative income factor	1.00	1.20	2.02
Comparative Benefit–Cost ratio (15) = (13)/(9)	5.3:1	3.69:1	3.79:1
Annual return from Kinnow at enhanced yield level (Rs.)	66,600	1,00,000	2,40,000
Total annual return from 4 ha area (Rs.) (17) = (16)+(11)	93,300	1,20,000	2,40,000
Total annual benefit (Rs.) (18) = (17)-(9)	78539.05	89835.00	1,98,249.00
Comparative income factor	1.00	1.14	2.53
Benefit-cost ratio	5.3:1	3.69:1	4.75:1

advantage in using sprinkler or drip methods over surface method.

Case B. When electricity cost is considered @ Rs. 2 per unit. The economic analysis shows that comparative income factors for sprinkler and drip methods are 0.98 and 1.02 respectively. This shows that there is no advantage in using sprinkler method, however there is slight advantage in adopting drip method over surface method as it gives about 2 per cent more annual benefit in Kinnow orchard.

When water is not scarce and source of power is diesel engine. The economic analysis reveals that comparative income factors for surface, sprinkler and drip methods are 1.00, 0.76 and 1.06 respectively. This clearly shows that sprinkler method should not be used as it gives 24 per cent less annual benefit as that of surface method. However in case of drip method there is 6 per cent more annual benefit than that of surface method. When yield of Kinnow improves by 20 per cent, the comparative income factor improves to 1.4 in drip method.

When water is scarce but sufficient land is available. The economic analysis shows that the comparative income factors for sprinkler and drip methods are 1.20 and 2.02 respectively as compared to 1.00 of surface method. This clearly shows that under such situations it is advantageous to go for sprinkler or drip methods over the surface method. □

Portable Meter for Pump Discharge Measurement

S.C. Nayak, J.C. Paul, S.D. Sharma & S. Sahoo

This study was undertaken to develop a portable type of orifice meter for measuring discharge of pumps and tube wells, which is relatively easy to transport and handle. Discharge is readily computable and the meter can be made out of materials available everywhere at a reasonable price.

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Measurement of irrigation water is of great importance for efficient water management to ensure an appropriate amount of water flowing to crop fields. It is useful for identifying strategies to expand command area, to minimise water losses and hence irrigation cost, and to ensure equal distribution of water. Pump irrigation system serves a major portion of irrigated areas in Orissa. Knowledge of pump discharge is a basic information needed for proper planning, designing, installing and managing the systems. However discharge of pump is seldom measured after installation or commissioning. Whenever pump discharge is required, the rated capacity of the unit is used. Studies revealed that most pumping units discharge much less than their rated capacity due to variation in site conditions from the specified conditions of the pump sets. Hence, reliable information about discharge of a pump is a basic requirement for proper water management in lift irrigation systems.

Measurement of irrigation water is useful for identifying strategies to expand command area, to minimise water losses and hence irrigation cost, and to ensure equal distribution of water.

Considering the high cost of lifting, delivering and distributing water in pump irrigation systems, it is not economically advisable to merely pump the water without the least knowledge of how much is being drawn or used. Some times, the pump discharge is known only at the time of well construction and pump installation. Not many know how much water is actually discharged at any particular time or show an interest in measuring it. There are several reasons for this: lack of awareness of the importance of knowing the actual discharge, non availability of a simple and suitable measur-

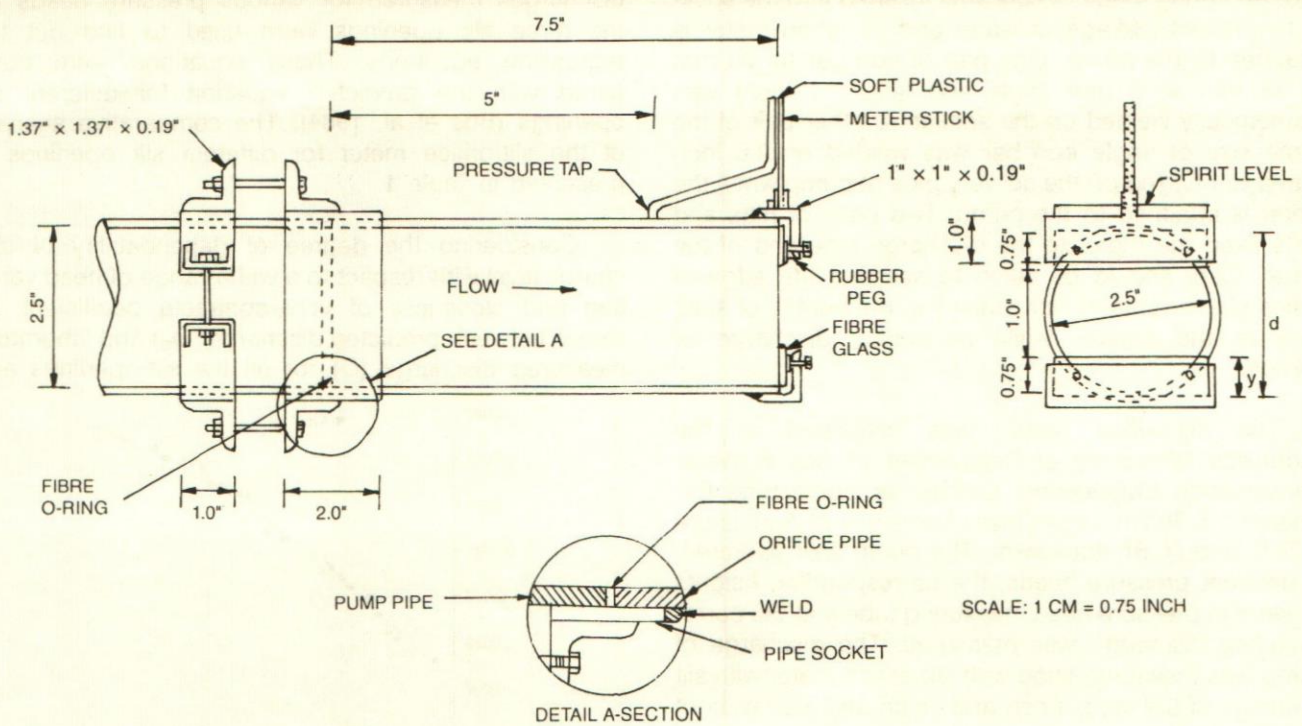

Fig. 1. Plan for the 2.5-inch Slit-Orifice Meter with coupling arrangement.

ing device that can be handled in the field and lack of skill and knowledge of flow measurements and its role in water management practices. Although there are some flow measuring devices available, most of them are known to and used by researchers only. Almost all these devices require special care for proper installation in the channels to obtain reliable results. For example, the device used for pump flow measurement which is known as water meter, currently in use, is a very heavy piece of equipment and relatively expensive. Hence, this study was undertaken to develop an orifice meter which is comparatively simple, inexpensive and easy to transport, install and use.

Materials & Methods

Constructional aspects of slit-orifice meter

In Orissa most of the pumps used for irrigating agricultural lands have 2.5 inch diameter delivery pipe (Sahoo, 1997). The dimensions of the slit-orifice meter were determined by the Froud scaled version taking 4 inch as model as suggested by Hasan et al, (1989). The orifice meter was fabricated from a 2.5 inch diameter, 7.5 inch long mild steel pipe cut smoothly and fixed with screws in adjustable clamps holding a rectangular fibre glass strip across the bottom of one pipe end to form a dam. Another similar piece of glass strip was placed across the top of the same pipe end to form a similar dam (Fig. 1). The fibre glass strip used was 2.0 mm thick, less than 1/30th of the pipe diameter (ASME, 1959) and had sharp edge. A spirit level was provided to keep the edge of orifice plate horizontal. The space between the two glass strip is referred as the slit-orifice opening. The slit-orifice meter uses conventional tools and materials which are readily available. An added advantage with the device is that the water flowing out of the slit-orifice meter spreads out like a fan which reduces erosive forces.

The pressure tap was located at a distance of 2.5 inch from the orifice, which is one half to four times the pipe diameter from the orifice where similar pressure head is detected (ASME, 1959). Based on this information, for the 2.5 inch upstream of the orifice, the diameter of the drilled pressure hole was of 3/8 inch with a nozzle and connecting the 1/2 inch diameter plastic transparent tube at the tip of the nozzle at a distance of 2.25 inches, which is greater than 2.5 times the pressure hole diameter.

To attach the orifice meter with the delivery pipe of the pump, a socket (of 2.5 inch diameter and 6 cm length pipe) with the threads removed from the inside surface was inserted into the other end of the pipe (see figure) for a distance of 3 cm and welded on the pipe end. An O-ring made of fibre was inserted into the socket to prevent leakage of water and air when meter is attached to the pump. One pair of iron bar (of 35 mm × 35 mm × 5 mm angle and length 1 inch) was diametrically welded on the socket. Another pair of the same size of angle iron bar was welded on 2.5 inch clamp to be fixed on the delivery pipe of pump when the meter is attached to the pump. Two pairs of nuts and bolts fixed the meter to the discharge pipe end of the pump. Care should be taken to see that the edge of orifice plates remains horizontal (i.e. the bubble of spirit level at the centre) while measuring discharge of pumps.

The slit-orifice meter was calibrated in the hydraulics laboratory of Department of Soil & Water Conservation Engineering, College of Agricultural Engineering & Technology, Orissa University of Agriculture & Technology, Bhubaneswar. The pump was operated, at different pressure heads, the corresponding heights of water in pressure head measuring tube and the corresponding discharge was measured. The discharge of pump was measured fitted with slit-orifice meter with slit openings of 0.9 inch, 1inch and 1inch and also without slit-orifice meter.

Results & Discussion

The slit-orifice meter was calibrated in the laboratory with three slit openings (0.9, 1.0, 1.1 inch). The discharge of the pump was measured with and without the meter and was found to be the same. The

Table 1: Comparative analysis of 2.5 inch slit-orifice meter for different slit openings

Parameters	Slit opening (inch)		
	0.9	1.0	1.1
Area of orifice (m^2)	0.0014	0.0015	0.0017
Ratio of A_o/A_p	0.4482	0.4953	0.5415
Vera contracta coefficient (C)	0.6911	0.7113	0.7331
Q_p	$0.0044\ (h)^{0.5}$	$0.0049\ (h)^{0.5}$	$0.0059\ (h)^{0.5}$
Q	$0.0049\ (h)^{0.5}$	$0.0051\ (h)^{0.5}$	$0.0068\ (h)^{0.5}$
Correlation Coefficient (r^2)	0.96	0.99	0.98
Value of R.M.S.D. for Q	0.00026	0.00015	0.00039
Minimum Errors (%) $(Q_p\text{-}Q)/Q$	4.76	0.67	2.77

A_o = Area of orifice
A_p = Area of pipe
Q_p = Predicted discharge
Q = Laboratory discharge
R.M.S.D = Root mean square deviation.

discharges measured for various pressure heads for the three slit openings were used to find out the regression equations. These equations were compared with the predicted equation for different slit openings (Bos et al, 1984). The comparative analysis of the slit-orifice meter for different slit openings is presented in Table 1.

Considering the degree of dependability of discharge level with respect to a wider range of head variation and closeness of vena-contracta coefficient 'C' values between predicted discharge (Q_p) and laboratory measured discharge (Q) for all the slit-openings and

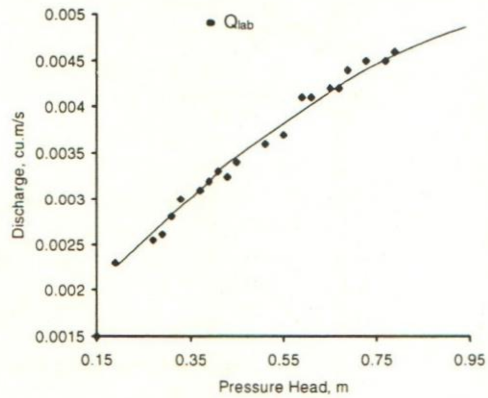

Fig. 2. Head-discharge relationship of 2.5-inch Slit-Orifice Meter with 1.0-inch slit opening.

personal observations, slit-opening of 1 inch is considered to be the most suitable for measuring the pump discharge of a 2.5 inch delivery pipe. For 1 inch slit opening, the graph showing predicted discharge (by Bos et al, 1984) and the discharge measured in the laboratory versus the pressure head of the slit-orifice meter are shown in Fig. 2. The regression equation for 1 inch slit is given by $Q = 0.0051(h)^{0.5}$.

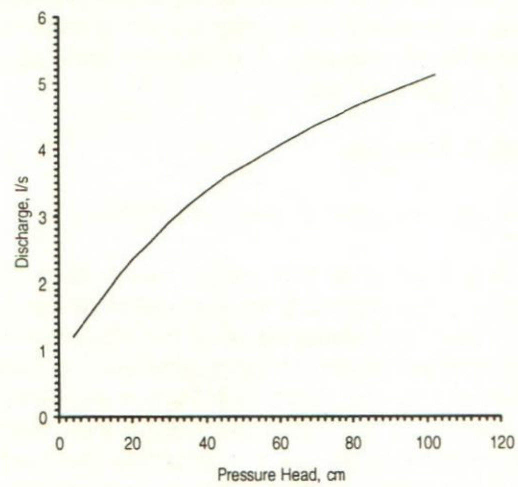

Fig. 3. Discharge of 2.5-inch Orifice Meter (1.0-inch Slit Opening)

Conclusion

A calibration chart for 2.5 inch orifice meter with best slit opening (1 inch) was plotted taking discharge versus the pressure head of the meter (Fig. 3). This can be used in the field to measure the discharge of pumps by knowing the pressure head of the meters only. This orifice meter can be used to replace conventional meters which are heavy, expensive and very elaborate to handle. This meter can be fabricated in workshops with materials which are easily available at a reasonable price at Orissa. The cost of the meter was estimated to be Rs. 200 which is widely acceptable to farmers and various organisations associated with irrigation works for measuring the discharge of pumps and tube wells. This device can be used to check the discharge of the pump periodically in fields. Adjustment of pumping hours required to serve the cropped area can be made accordingly to satisfy the need to deliver the right amount of irrigation water at right time. There is a possibility that substantial saving in fuel cost can be achieved.

Acknowledgement

The authors are grateful to Er. K.B. Routray, Assistant Engineer, Orissa Lift Irrigation Corporation, Bhubaneswar for providing facilities for this study.

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"I never did anything worth doing by accident, nor did any of my inventions come by accident; they came by work".

– Thomas Alva Edison

Modernised Rainfed Tanks in South India

I. Sekar & K. Palanisami

An attempt has been made in this study to analyse the modernised rainfed tanks in Tamil Nadu with the objectives of quantifying the benefits accrued through modernisation of tanks, measuring the period of realisation of benefits and prioritizing the benefits of modernisation from farmer's perception.

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Irrigation tanks are small reservoirs impounding run-off water. Irrigation water is vital to the Indian economy as it relieves agriculture of its dependence on the monsoon (Eswaramoorthy et al, & 1989). Among the semi arid tropical parts of South India, Tamil Nadu has the maximum area irrigated by tanks, accounting for about 32 per cent of the total irrigated area (Ramu Govindasamy & R. Balasubramanian, 1990). There are 39202 tanks catering to the needs of about 26% (originally about 32%) of the total irrigated area in Tamil Nadu. The available surface and ground water resources in Tamil Nadu have already been utilized to about 95% and 60% respectively for irrigating nearly 6 mha of command area. There are many reasons for the poor performance of tank irrigation system which has remained underutilized due to mismanagement. Uma Shankari (1991) has indicated that non participation of farmers in cleaning the channels, encroachment of tankbed, inadequate repairs, weed infestation and siltation were responsible for disintegration of conventional tank management.

Non participation of farmers in cleaning the channels, encroachment of tankbed, inadequate repairs, weed infestation and siltation were responsible for disintegration of conventional tank management.

Reddy et al's (1993) study which examined the deterioration of tank irrigation in Andhra Pradesh mentions that financial constraints of the Public Works Development Department contributed to decline in tank irrigation. Having surveyed 32 tanks in Andhra Pradesh and Maharashtra, Von Oppen and Subba Rao (1980) indicated that in areas of dense population, tank irrigation has been declining due to deforestation, soil erosion, siltation, tank bed cultivation and lack of administrative structure to provide timely repair and maintenance. Keeping in view the poor performance of sick tanks, modernisation of rainfed minor irrigation tanks has been executed by Tamil Nadu Public Works Department in 1987, getting financial assistance from European Community (EC). So far about 422 PWD tanks and 80 Ex-zamin tanks have been modernised during the period 1987-1996 in the tank intensive 13 districts of Tamil Nadu. These modernisation works have been carried out with the aim of sourcing prolific results in terms of net return, equity and sustainability. As Chandrakanth and Romm (1990) opine irrigation tanks exert positive externalities. Hence, a study was attempted to analyse the rainfed tanks of Tamil Nadu.

Methodology

For the purpose of empirical work, four rainfed tanks were chosen in four districts comprising three different regions viz. north, central and south regions of Tamil Nadu state. Somangalam tank in Chengai MGR district of Northern region, Pandalkudy in Kamarajar district and Kilavanur in Pasumpon Thevar district of Southern region and Menellikulam in Trichy district of Central region wherein 160 samples constituting 40 tankfed farmers in each tank have been selected for the study. Yield differentials and cost of cultivation of paddy crop grown before and after rehabilitation were obtained from the farmers. The cost involved in tank rehabilitation was obtained from Government records. The data collected for the study pertains to pre project year 1993-94 and post project year 1996-97. Quantum of rainfall received and storage of tanks have been considered to reveal the existence of similarity for both pre and post project years. "Before" and "After" approach is followed in this study to divulge the difference after modernisation. Simple percentage change analysis has been employed to assess the yield and net benefits of paddy in modernised rainfed tanks. 'Paired T test' has been used to test the significance in difference of means of paddy yield of tankfed farms before and after modernisation. Frequency distribution analysis has been employed to rank the potential benefits accrued by the sample farmers, where

$$S = \sqrt{\frac{\sum d_i^2 - \frac{(\sum d_i)^2}{n}}{n-1}}$$

i = 1, 2 ...... n

d = difference in means

n = number of observations

$$\text{'t' value} = \frac{s}{\sqrt{n}}$$

Results & Discussion

Productivity data in respect of paddy crop in four tank commands before and after modernisation are presented in Table 1. Productivity is defined here in terms of physical output of paddy per hectare. Productivity change has been estimated in the form differential before and after the implementation of modernisation programme. Productivity increase of paddy varies from 11.02 quintals in Somangalam to 4.85 quintals in Kilavanur tank. The increase is more than 10 quintals per hectare in two tank commands and less than 10 quintals per hectare in another two tank commands. Out of four commands, the range of increase varies from 17 per cent in Kilavanur to 31 per cent in Pandalkudy. The study indicates that substantial productivity increase of paddy exists in rainfed tanks such as Pandalkudy and Somangalam and moderate productivity exists in Menellikulam and Kilavanur. 'T' value results show that there is significant difference before and after modernisation of tanks in yield of paddy. Nevertheless, there is a disparity in 't' value among modernised tanks, the least being 2.22 significant at 5 per cent level in Kilavanur tank.

Substantial productivity increase of paddy exists in rainfed tank regions.

Table 1: Yield of Paddy in tank command areas

Tanks	Before modernisation	After modernisation	Increase	% increase
Somangalam	40.03	51.05	11.02	27.53
Pandalkudy	35.20	46.13	10.93	31.05
Kilavanur	28.16	33.01	4.85	17.22
Menellikulam	36.61	44.26	7.65	20.89

Table 2: "T" values of yield of paddy

Tanks	"t" value	Significance level
Somangalam	9.19	HS
Pandalkudy	7.07	HS
Kilavanur	2.22	5%
Menellikulam	6.88	HS

HS-Highly significant

A comparison of the production cost with "BA" approach reveals perceptible increase of production cost in "After modernisation" farms for paddy (Table 3). This

Table 3: Net Benefits in modernised tanks

Rs/ha

Tanks	Before modernisation			After modernisation			Additional net benefits due to modernisation
	Gross return per ha	Production cost per ha	Net return per ha	Gross return per ha	Production cost per ha	Net return per ha	
Somangalam	15946	9629	6317	20438	11325	9113	2796
Pandalkudy	13977	9951	4039	18510	11576	6934	2895
Kilavanur	9966	8695	1270	11729	9564	2165	895
Menellikulam	14646	10414	4232	17941	6132	1900	

higher input use gets reflected in substantial differences in gross returns per hectare between the two categories. Additional net benefit attributable to modernisation varies from Rs. 895 per hectare in the case of Kilavanur tank to Rs. 2895 in Panadalkudy tank. Invariably in all tanks, the value of additional yield of paddy and the increase in production cost differ substantially, leaving sizable margin. Dismal performance of net benefit in Kilavanur tank demands a thorough initial scrutinization while prioritizing the tanks for modernisation. Reason being, net return before modernisation was lesser because of problems encountered by farmers due to poor water supply to the tank and conflict with the adjacent village near the catchment area of the tank. Since resources are scarce, such tanks may be given lesser priority for modernisation.

it is evident from Table 4 that the magnitude of increase of returns per rupee invested in production cost is rather less in Kilavanur tank though it increases in remaining tanks. More importantly in Kilavanur tank, returns per rupee invested in production cost before modernisation is the least among all the four study tanks. Hence it is important to carryout ex ante appraisal while prioritizing tanks for modernisation so that such tanks like Kilavanur which has comparatively lesser returns may be given least preference.

Table 4: Returns per rupee invested in production cost

Tanks	Before modernisation	After modernisation	Change
Somangalam	1.66	1.88	+ 0.22
Pandalkudy	1.40	1.60	+ 0.20
Kilavanur	1.15	1.23	+ 0.08
Menellikulam	1.41	1.52	+ 0.11

An analysis of initial investment and benefits in the first year (Table 5) shows that modernisation accrues substantial benefits to Somangalam, Pandalkudy and Menellikulam farmers except Kilavanur. Even if the interest of initial investment and maintenance cost of about 5 per cent are included, benefit to initial investment and

It is important to carryout ex ante appraisal while prioritizing the tanks for modernisation. Tanks which yield better benefit in short duration of time may be included for modernisation.

pay back period are quite reasonable in two tanks viz. Somangalam and Pandalkudy. To realise benefits of the initial investment takes more than 16 years in Kilavanur tank which is quite discouraging. Somangalam and Pandalkudy tanks produce fairly good results as their pay back periods are 3.6 and 4.8 years respectively. Hence it is important that such tanks which take longer to realise full benefits be excluded and those tanks which yield better benefit in short duration of time may be included while prioritizing tanks for modernisation during ex-ante evaluation.

Table 5: Benefits of and Investment in tanks for modernisation

Tanks	Benefits in the first year (Rs)	Investment (Rs)	Pay back period (years)
Somangalam	644338	2327800	3.6
Pandalkudy	161656	792000	4.8
Kilavanur	42127	687200	16.3
Menellikulam	62358	581000	9.3

Feedback was elicited from tankfed farmers about the execution of modernisation work (Table 6). About 42 per cent of the total farmers are dissatisfied with the sufficiency of physical work done in the modernisation programme. Though majority (60%) are satisfied with the quality of work done during the process of modernisation, 40 per cent still responded negatively. Nearly 47 per cent showed discontent over timely execution of work. While putting farmers' perspective in place, there exists scope for further improvement atleast in two categories viz. quality and timely execution of modernisation works with the available investment.

Table 6: Farmer's perception on tank modernisation

Tanks	Satisfaction towards					
	Adequate coverage of work		Quality of work		Adherence to work schedule	
	positive response	negative response	positive response	negative response	positive response	negative response
Somangalam	23 (58)	17 (43)	27 (68)	13 (33)	22 (55)	18 (45)
Pandalkudy	28 (70)	12 (30)	20 (50)	20 (50)	20 (50)	20 (50)
Kilavanur	20 (50)	20 (50)	23 (58)	17 (43)	19 (48)	21 (53)
Menellikulam	21 (53)	19 (48)	26 (65)	14 (35)	23 (58)	17 (43)
Total	92 (58)	68 (42)	96 (60)	64 (40)	84 (53)	76 (47)

Figures in parenthesis indicate percentages to total farmers

Table 7: Benefits of modernisation prioritized by the tankfed farmers

Benefits realised	Somangalam	Pandalkudy	Kilavanur	Menellikulam	Rank
Tail end gets water easily and in time due to channel lining	37	35	32	28	I
Water storage period has increased	30	33	22	24	II
Sufficient water is available in tank after modernisation	30	24	7	9	III
More possibility for cultivating high yielding long duration crops	28	8	3	6	IV
Physical improvements have reduced risk factor during floods	15	5	2	4	V

There exists scope for further improvement atleast in two categories viz. quality and timely execution of modernisation works.

Table 8: Farmer's involvement in tank modernisation

Tanks	Farmers' involvement	
	Positive response	Negative response
Somangalam	21 (52)	19 (48)
Pandalkudy	16 (40)	24 (60)
Kilavanur	4 (11)	36 (89)
Menellikulam	4 (10)	36 (90)

Figures in parenthesis indicate percentage to total farmers

Investment to improve the physical systems is bound to have positive impacts in the command area, though quantum of benefits may vary inter tank and intra tank. An attempt was made to rank the benefit that has got more acceptance among farmers (Table 7). The most useful benefit identified by the farmers is the lining of channels which aims at achieving equity and timeliness in water supply. Obviously, the lining of channels makes the water distribution work easier particularly during drought periods. The second important benefit, the farmers identified is prolonged water storage period. It is reasonable to infer that rectifying defective sluices and weirs, a component of modernisation programme, helps to prolong water storage period in the tank. Physical improvements such as standardising bunds for safety considerations have occupied the last place and farmers refuse to recognise this as one of the major advantages of modernisation. These being rainfed tanks seldom encounter floods and even if it occurs, there exists spontaneous cooperation of people from all quarters in the village to strengthen the weak bunds.

Success of modernisation depends on user involvement at every stage of the project, right from planning till end. While assessing farmer participation, it is evident that nearly 90 per cent of the farmers in Kilavanur and Menellikulam showed disinterest in the modernisation programme (Table 8) which may be one of the reasons for the poor performance of these tanks. Though seemingly better performance is noticed in Somangalam and Pandalkudy, concerted efforts are still needed to motivate farmers to make them participate in modernisation as well as maintenance works through forming farmers' association. Community organisers in the concerned villages will have to play a crucial role in forming the association, motivating the farmers and mobilizing resources so that the benefits of modernisation could be fully secured.

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"You don't hear things that are bad about your company unless your ask. It is easy to hear good tidings, but you have to scratch to get the bad news".

– Thomas J. Watson Jr.

Abatement Cost of Industrial Pollution Control

M. Ravichandran & C. Durga Devi

Negative externalities due to industrial pollution are evident in the form of loss of air and water quality. Any effort on the part of polluting units to bring down pollutants to tolerance limit entails cost—a vital issue from the point of view of economics. Pollution abatement cost of a distillery unit in Tamil Nadu is presented in this study. Estimates of the pollution control cost with all relevant variables provide useful insights which may be considered as inputs for policy making in this regard.

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Industrial pollution is no longer a problem of developed countries alone; the impact of industrial effluents, emissions are evident in developing countries too. Measures have been taken from time to time to control pollution to the tolerance level. Despite the fact that it is mandatory on the part of erring units to abate pollution, evidences suggest that most of the polluting units do not have adequate provision for this purpose. Generally environmental strategies place more emphasis on emission standards, and by so doing, give the impression that pollution abatement is the answer to industrial environmental problems. But the question is at what level of resource use or financial cost. (Royston, 1979).

The Central Pollution Control Board identified about 17 categories of polluting units in India way back in 1986. Distillery happens to be one of the highly polluting categories of industrial units. To raise issues pertaining to pollution abatement of a distillery unit in Tamil Nadu and highlight abatement cost with respect to various economic parameters of the unit, an exercise, on a case study basis was undertaken. How a unit absorbs pollution abatement cost is relevant because there is resistance on the part of industrial units to invest on pollution abatement. Some units even claim that investment on pollution control has an adverse effect on the economy of the unit. This necessitates a research study to probe whether or not pollution control is viable at the factory level and to assess whether the economics related to pollution control are being given due consideration by the unit or not.

How a unit absorbs pollution abatement cost is relevant because there is resistance on the part of industrial units to invest on pollution control.

Methodology

A distillery unit (anonymity is maintained as per the advise of the factory authorities) in Tamil Nadu was selected for study. Because quantum and quality of pollution load differ from unit to unit and pollution control equipment adopted also vary, each unit ought to be studied separately and it is seldom possible to generalize the results for all other polluting units. The variation will be much larger in the case of distilleries due to differences in raw materials used. On the basis of this method, all relevant information about the select unit was collected from the records of the unit, despite resistance from the factory to divulge the necessary information. The fermentation process, usage of water, production and cost structure of distilleries, influent discharge (quantum of wastes), pollution control standards, effluent treatment plant installed, pollution load, volume of wastewater treated and other related materials were the data collected from the concerned distillery unit. More specific pollution abatement cost was also gathered from the unit.

The study depended upon the data furnished by the concerned factory. The available data from the factory can be classified into two categories: information regarding production, quantum of inputs used, number of skilled and unskilled labourers, energy requirements and operation and maintenance cost of the unit as a whole, formed the first classification. And secondly, data relating to pollution control technology, manpower, space, power, fuel required to operate and maintain pollution control technology formed the other classification. These two classified information were compared and analyzed to ascertain the influence of pollution control measures on the economy of the firm. The impact of pollution abatement cost on all economic parameters of the firm was also analyzed.

Results & Discussion

The abatement cost of polluting units is crucial from the point of view of both the industry and the regulating authority. If a unit adopts only primary treatment stage, the abatement cost is minimal and it progressively increases with secondary and tertiary stages. The marginal abatement cost increases at a faster rate after secondary treatment stage and is maximum in tertiary state.

Pollution control cost varies across different categories of industries. Type of products produced, inputs, technology and space used as well as plant size and scale of production influence the abatement cost. The proportion of abatement cost in relation to various parameters like total cost of production, total turnover, operation and maintenance cost and total investment on plant and machinery would suggest how polluting units are in a position to internalise abatement cost.

Type of products produced, inputs, technology and space used as well as plant size and scale of production influence abatement cost.

Cost of factory's own environmental activities can be classified into capital cost and operational maintenance cost. Capital cost includes cost of treatment plant and cost of construction, while operational maintenance cost includes power and fuel, labor and chemicals used in the treatment process. Annualised pollution abatement cost is estimated on the basis of depreciation of capital, interest on total investment and operational maintenance cost.

The firm has the capacity to produce 80kl alcohol per day and the effluent produced ranges between 750kl and 800kl per day for that capacity. The firm has set up an ETP with an investment of Rs. 3 crores to process wastewater up to 4000M3 per day. The area covered for pollution control as percentage of the unit was 60; number of persons employed for pollution abatement as percentage of the unit was 8.2. The capital cost of pollution abatement as percentage of capital cost of the unit was 14.3. A correlation coefficient of 0.99 showed a perfect and significant relationship between output and spent wash. The 't' values also confirmed the level of significance. The regression coefficient suggested that 1 per cent change in production of alcohol would result in 13 per cent change in spent wash (Table 1).

Table 1: Alcohol Production and Spent Wash

(in KL)

Year	Total output	Spent Wash
1988-89	14315	186092
1989-90	12527	162849
1990-91	16687	216926
1991-92	16498	214474
1992-93	18977	246701
1993-94	10075	130975
1994-95	14196	184548
1995-96	16543	215059
1996-97	8643	112359
1997-98	4416	57408

Relationship between output and spent wash

Independent Variable	Correlation coefficient	Regression coefficient	't' Value
Output	0.99	12.99	19.84*

*Significant at both 5% and 1% level.

The investment in pollution control was compared with total investment; similarly annualized pollution abatement cost was compared with the total cost of production and annual turnover; and the annual maintenance with other economic indicators of the firm. The mean value of total investment on pollution abatement as percentage of the total investment of the unit was 20.4, excepting this proportion, all other average values were in the moderate range (Table 2).

Table 2: Total Investment on Pollution Control and Total Investment of the Unit

Year	Total Investment on PA as Percentage of total investment of the unit
1989-90	38.1
1990-91	29.8
1991-92	21.8
1992-93	19.9
1993-94	18.8
1994-95	12.0
1995-96	13.2
1996-97	15.7
1997-98	14.5
Mean	20.4

Table 3: Annualised Pollution Abatement Cost

Year	Depreciation	Interest	Maintenance cost	Annualised PAC
1989-90	1.25	–	32.79	'34.04
1990-91	1.11	–	22.50	28.61
1991-92	4.98	–	26.66	31.64
1992-63	6.22	6.99	28.35	41.56
1993-94	0.71	4.33	20.18	25.22
1994-95	0.60	1.71	26.88	29.19
1995-96	0.54	0.11	28.06	28.71
1996-97	0.63	–	20.53	21.16
1997-98	3.08	–	27.37	30.45

Tables 3 & 4, show the details of the annualised pollution abatement cost in relation to total cost and annual turnover. The mean value of the annualised pollution abatement cost as percentage of annualized total cost of the unit was 2.23; and also the mean value of the annualised PAC in relation to the annual turnover, was only 1.5. (Table 5). The unit ultimately shifted the burden of pollution abatement cost on to the price of alcohol to the extent of Rs. 0.50 per liter. Even if the cost is passed on the consumers, it would not result in a great hike in prices and can be easily absorbed by the industry and consumers.

Table 4: Annualised Cost of Production

Year	Depreciation	Interest	Maintenance Cost	Annualised TC (Rs. in crores)
1989-90	0.93	0.31	5.16	6.40
1990-91	1.05	0.56	6.10	7.71
1991-92	1.77	0.98	7.65	10.40
1991-92	1.77	0.98	7.65	10.40
1992-93	2.26	1.29	9.81	13.36
1993-94	1.25	1.50	16.28	19.03
1994-95	1.26	2.40	22.35	26.01
1995-96	1.41	2.90	17.47	21.78
1996-97	1.35	2.53	18.13	22.01
1997-98	1.30	2.18	32.92	36.40

Table 5: Annualised Pollution Abatement Cost in Relation to Annualised Total Cost and Annual Turn Over

Year	Annualised PAC	Annualised TC	Annualised PAC as % of annual TC	Annual turnover	Annualised PAC as % of annual turnover
1989-90	0.34	6.40	5.3	10.6	3.2
1990-91	0.24	7.71	3.1	11.5	2.1
1991-92	0.32	10.40	3.1	15.3	2.1
1992-93	0.42	13.36	3.1	20.5	2.03
1993-94	0.25	19.03	1.3	25.6	0.98
1994-95	0.29	26.01	1.1	30.4	0.96
1995-96	0.29	21.78	1.3	32.5	0.88
1996-97	0.21	22.01	0.95	34.2	0.62
1997-98	0.30	36.40	0.82	45.4	0.67
Mean	–	–	2.23	–	1.5

The annual maintenance cost on pollution control was compared with the annual pollution abatement cost and total cost of the unit; similarly power consumed for pollution abatement was compared with the power consumed for the unit. Maintenance cost on pollution control was high when compared to others. Maintenance cost on pollution control as percentage of total pollution abatement cost was 7.5 (mean) and the average power consumed for pollution abatement in relation to the unit was 5.1; excepting these all others were average values of small proportion ranging from 0.69 to 2.6. The average chemical consumed in relation to the total unit was only 1.2. (Table 6).

Table 6: Operation & Maintenance Cost on Pollution Abatement

Year	Maintenance cost on PA as % of total PAC	Maintenance cost on PA as % TC	Power consumed for PA as %	Chemical consumed for PA as %	Total wage bill paid for PA as %
1989-90	9.4	1.5	5.3	8.7	2.4
1990-91	6.7	0.87	7.6	0.4	2.5
1991-92	7.8	0.86	6.8	0.2	3.0
1992-93	8.1	0.71	5.6	0.06	2.9
1993-94	6.0	0.43	4.1	0.02	3.1
1994-95	8.0	0.54	4.6	0.0012	2.7
1995-96	8.4	0.53	3.7	0.016	2.9
1996-97	6.2	0.38	3.5	0.004	0.3
1997-98	7.1	0.39	4.5	–	3,5
Mean	7.5	0.69	5.1	1.2	2.6

Pollution abatement cost as percentage of total cost of the unit was 16 per cent in the initial years but came down to 5.6 per cent during 1997-98. This proportion is a good indicator that pollution control cost is well within the reach of the unit, if this increases, factory authorities would be reluctant to invest in pollution control, (Table 7). The cost of chemical used in the treatment process was so high that they did not consume any chemical in the treatment process for the year 1997-98.

Table 7: Pollution Abatement Cost & Total Cost

Year	Total PAC	Total cost	PAC as % TC
1989-90	3.47	21.72	16.0
1990-91	3.35	6.3	12.7
1991-92	3.41	31.4	10.9
1992-93	3.52	39.2	8.9
1993-94	3.34	46.1	7.2
1994-95	3.37	50.4	6.7
1995-96	3.34	52.7	6.3
1996-97	3.32	55.6	5.9
1997-98	3.85	68.4	5.6
Mean	–	–	8.9

If the social cost/damage cost is estimated, it would certainly be greater than the cost of pollution control measures. Major problem with studies on pollution control is that polluting units seldom share information with researchers. There is resistance from the units to divulge information regarding pollution, pollution control technology etc. The fact that the study unit shared information on pollution control itself stands as testimony for the unit having adopted pollution control measures. However, the level of water and air pollution is far in excess of permissible limits as even after treatment, the COD and BOD level are much higher than the permissible level.

The upshot is that pollution control in the concerned unit has been unsatisfactory. Many a reason can be attributed to this status. One prime reason is the strategy that is in vogue viz., the regulatory or command and control method. The need of the hour is that India switches over to applying economic incentive/disincentives like pollution tax and marketable pollution permits to tackle environmental problems. Already industrially developed countries have successfully administered a policy mix of both economic instruments and command and control. Use of economic instruments will remove production inefficiencies associated with the regulatory procedures used so far, and facilitate the choice of least-cost pollution abatement technologies by polluting industries. (Murthy M.N., 1999).

The need of the hour is that India switches over to applying economic incentive/disincentives like pollution tax and marketable pollution permits to tackle environmental problems.

Effluents Sources: Treatment & Recycling

The distillation process generates spent wash which is a major source of effluent in distilleries. Pollution control engineers confirm that the effluents contain both organic matter and left over yeast. About one third of pollutants can be treated through primary and secondary methods. Effluents after treatment get discharged on farms, in public sewers, land and in surface water. Generally the discharged effluents go underground or into rivers and degrade groundwater quality and create health hazards to people who live around.

Major pollutants in distilleries comprise fermentation sludge, spent wash and spent lees. Both spent lees and fermentation sludge are recycled by distilleries. The fermentation sludge is generally used as cattle feed or as a fertilizer after processing. It is spent wash which is the major source of pollutant from the analyzer column.

Besides, there is non process waste water being discharged from distilleries such as the cooling water, wash water from fermenter house and bottling plant.

To abate pollution the Central Pollution Control Board (CPCB) prescribes environment related standards. Discharges of effluents and emission of air pollutants vary from industry to industry depending upon the category and nature of products produced. Therefore CPCB has initiated what is called MINAS (minimal national standards) taking into account the 'treatability of the effluent from the technical and economic feasibility' of each category of industry. Waste management in distilleries has always been a complex problem due to large volume of waste. Especially, during rainy season, the level of effluent in solar ponds increases and contaminates the factory and the canals nearby.

The factory is adopting anaerobic digestion and methane generation technology for primary treatment of spent wash; production of methane gas from the spent wash can meet the entire energy requirements of the unit. Modes of disposal are solar evaporation, soil reclamation, ferti-irrigation and bio-composting.

The firm has put up 3 solar evaporation ponds in an area of 5 acres within the factory campus and also 16 solar evaporation ponds in an area of about 40 acres in Mandaiyur village of Pudukkottai District, where the factory has purchased 239 acres of land for creating a green belt using the treated effluent. The treated effluent is transported by tankers, nearly 15 tankers per day, with a cost of Rs. 500 for each trip. The unit has its own farmlands and is using the effluent for irrigating fruit bearing trees, like mango, guava, jack, amla, tamarind and neem, eucalyptus, hawayan giants, teak and other shade giving trees. The unit is partly using the treated effluent for ferti-irrigation of lands and in the manufacture of bio-compost. The company has put up an additional clean water treatment plant for treating chemical plant washings etc. with RBc technology. Treated water is being reused in the plant and also for irrigating plants and trees around the factory area.

The unit is partly using the treated effluent for ferti-irrigation of lands and in the manufacture of bio-compost.

Indian Scenario

A working paper (IEG 1996) on water pollution abatement made certain useful observations about the status of pollution control in Indian distilleries. The team covered about 254 distilleries in the country through mailed questionnaire. According to them, one fourth of the total units were not attached to sugar factories and procured molasses from outside sources, while the majority of the units were self-sufficient. For every litre of alcohol produced, around 25 litres of water was used. The annual output of alcohol remained less than 20,000 kilo litres. Interestingly, all the units were found to have adopted primary treatment process but only half of the total units carried on up to secondary treatment stage. Of the two stages, secondary treatment process is highly capital and energy intensive. Primary treatment brings down BOD level from 35000 ppm to 3000 ppm, while the secondary stage could reduce BOD level further down to 100 ppm. The requirement of total investment on primary treatment plant ranged from Rs. 70 lakhs to Rs. 4 crores, and double the amount is required for installing a secondary treatment plant. Nearly half of the total number of units claimed that the treated waste water is suitable for ferti-irrigation. The growth of polluting categories of industries is faster than the non-polluting industries in India. Distillery is certainly one among the former categories and the total number of distilleries was 254 in 1994, with a total production of 1.3 billion litres of alcohol entailing discharge of effluents, the level of effluent discharge being at 20 billion litres per annum.

Conclusion

As per the information furnished by the unit, based on the analysis made it can be concluded that pollution control measures have not proved to be a burden for the unit excepting on one or two parameters. Besides, the study unit shifted the burden of pollution control cost on the price of alcohol to the extent of Rs. 0.50 per litre. The merit of the unit with respect to pollution control is that the unit has established pollution control technology and has spared adequate space and is also attempting to recycle the waste. But the ugly side of the story is that bad odour continues to be negative externality for the citizens of Tiruchirappalli city.

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Foreign Direct Investment in India: Policy, Trends & Determinants

K.G. Radhakrishnan & Jaya Prakash Pradhan

This paper is an attempt to explain Foreign Direct Investment in India. It is observed that the liberalisation package of 1991 had a significant impact on the FDI flows into the country. The crucial determinants of FDI inflows in the Indian context are the absolute size of the domestic market, the exchange rate, openness of the economy, and a set of sound macroeconomic fundamentals. Therefore, to attract a critical quantum of FDI which can accelerate the growth process of the economy by bringing in more capital, technology, and market access, policy focus should be on the factors as noted above.

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** The views expressed are only of the authors and not of the organisations to which they belong.*

The Government of India attempted a massive Structural Adjustment Programme (SAP) during the year 1991 – a radical break with the past in respect of policy guidelines. This was followed by a series of further liberalisation measures carried out over the subsequent years which, interalia, included opening up areas hitherto barred for FDI, delicensing, removal of 40 percent foreign equity ownership restriction as stipulated under the FERA, withdrawal of PMP requirements, dismantling of the barriers on the use of foreign brand names and trademarks as well as dilution of export obligations and technology transfer requirements. This radical approach towards FDI as an integral part of the reform process of nineties was based, apart from the compulsions and constraints prevailing at that time, on the protagonist approach to FDI which highlighted the 'constraints-relaxing' function of FDI on the growth process of the host economy. The protagonists are emphatic on how FDI relaxes the triad constraints of savings, technology and market on growth dynamics and further how FDI related 'externalities' and 'spill-overs' over the local production chains result in the outward movement of the national production function over time. In short, FDI is a powerful solution to the problem of low level equilibrium trap. The experiences of most of the NIEs evidenced that substantial flow of FDI has played a critical role in expediting their process of economic development.

Seen in this perspective, an adequate flow of FDI can play a vital role in putting India on an accelerated growth path. Here, it is pertinent to examine whether the policy framework brought in during the course of liberalisation has been really a success in attracting an enhanced flow of FDI into the country. If not, what are the inadequacies/constraints in the present set-up? Moreover, what are the factors determining the flow of FDI in the Indian context in the perspective of future prospects? The present paper is an attempt to look into these issues of FDI in India.

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FDI Policy: An Overview

Till seventies, the Government of India's approach towards FDI was based on three principal regulations, viz., the Industrial Development and Regulation Act (IDRA, 1951); the Monopolies and Restrictive Trade Practices Act (MRTPA, 1969), and the Foreign Exchange Regulation Act (FERA, 1973). IDRA provided for an elaborate licensing system for establishment of new industrial units or expansion of existing units. During 1970s the Government gave effect to MRTPA to ensure against concentration of economic power and restrictive trade practices. FERA was designed to control foreign investment and restrict the operation of foreign companies in India like limiting the participation of foreign companies upto 40 per cent of paid-up capital.

However, during the eighties there was increasing disenchantment with the growth of economy marked by inefficiency, low productivity, and technological obsolescence attributed to the dirigistic model of industrialisation pursued till then. This led to policy re-orientations focused on 'growth with productivity' marked by a touch of liberalisation and half-hearted opening up of the economy to the external world. Subsequently, in the early part of 1991, India underwent a major macro-economic crisis characterised by high inflation, large fiscal and current account deficits, and an unsustainable burden of domestic and foreign debt. In fact, there was a steep fall in foreign exchange reserves to about $ 1 billion hardly sufficient to meet two week's imports, and a sharp downgrading of India's credit rating.

The sweeping structural reforms brought in by the government during 1991 were in response to this macroeconomic instability. The reforms were intended to accomplish a fundamental transformation in the Indian economic structure, push up the growth process and to integrate national economy with the global economic system. SAP, among other things, comprised major policy initiatives pertaining to foreign investment as well as foreign technology agreements. This indicated a significant departure with the earlier policy paradigm governing inward FDI. The rationale for such a policy approach was that "we cannot afford to shackle foreign investment without losing the benefits of additional capital, technology, market access and growth that have been so successfully harnessed by our neighbours in East Asia" (Singh, 1994). These liberalisation measures embodied in the New Economic Policy were followed up in later years by a series of policy measures further liberalising the inward FDI policy regime. The policies governing FDI are detailed in Table 1.

Table 1: India's regulatory environment for inward FDI, 1991-2000

Year	Description of Measures adopted/industries liberalized
1991	Abolishment of mandatory licensing system.
	Opening of areas previously closed to foreign investors including power generation.
	Establishment of Foreign Investment Promotion Board.
1992	Movement of partial convertibility of rupee (current account)
	Adoption of Export Import Policy, involving a phased reduction of both tariffs and quotas.
1993	Full ownership allowed in certain industries previously closed to or restricted for foreign investors.
	Adoption of national treatment principle.
	Partial opening of financial industry to FDI.
	Rupee becomes fully convertible (Current Account)
1994	Telecommunications industry opened to FDI.
1995	Cable television networks opened to FDI.
	A Working Group set up for examination of schemes and incentives available to NRIs for investment in India, some of whose recommendations have been implemented subsequently.
1997	Expansion of scope of automatic approval route.
	Increase in foreign equity participation from 51 to 74 per cent under automatic approval (100 per cent in case of NRIs).
1998	100 per cent foreign equity allowed in several infrastructural areas under the automatic route, subject to a ceiling of Rs. 1500 crores.
1999	GDR/ADR guidelines further liberalised.
	Establishment of Foreign Investment Implementation Authority (FIIA) to expedite approvals as well as implementation of foreign investments.
	Opening up of domestic private insurance sector to foreign investment.
2000	Reduction of the negative list to a limited number of industries.
	Permission to 100 per cent foreign investment in film industry.
	Fixation of upper limit for foreign equity participation at 74 per cent in advertising sector.
	Hydrocarbon industry—specifically, refining sector has been allowed for 100 per cent FDI, against existing limit of 49 per cent.
	Adoption of Exim policy 2000-2001 providing for, inter alia, scrapping of quantitative restrictions on import of 714 items, and introduction of a scheme of Special Economic Zones (SEZs).
	Permission of 100 per cent in IT industry.

Note: This table has been adapted from World Investment Report, 1995 and has been updated.

Sap comprised major policy initiatives pertaining to foreign investment as well as foreign technology agreements.

FDI in India: Recent Trends

Actual FDI Stock

The policy pursued by the Government towards FDI for more than two decades since independence was cautious. With the result, FDI stock increased by only Rs. 489 crores from Rs. 386 crores in the year 1955 to Rs. 875 crores in 1979. This is evidenced by table 2, revealing a modest growth rate of 3.5 per cent per annum till 1979.

Table 2: Compound Annual Growth Rate (AGR) of FDI Stock

Period	CAGR(%)
1964-1979	3.455901
1980-1991	12.40533
1992-1999	48.87055
1964-1999	10.74206

Note: The growth rate has been calculated by using semi-log of the form: log Y = $\alpha+\beta t$, where Y denotes the variable of interest and t is trend. Since FDI stock data were not available for the periods 1981-85 and 1996-99, the same have been worked out by adding net inflows to the FDI stock.

This lower growth of inward FDI stock has been attributed, apart from restrictive policy aspects, to the underdeveloped infrastructural base, limitations of human capital resources, underdeveloped indigenous market coupled with lower purchasing power, absence of domestic leadership for creative destruction, etc. During this phase of inward FDI, a major portion had originated from the United Kingdom whereas in terms of rate growth, countries like Germany, Switzerland, and U.S.A. were ahead. During the same period, manufacturing sector was the dominant host of inward FDI stock.

Low growth of inward FDI stock has been attributed to the underdeveloped infrastructural base, limitations of human capital resources, underdeveloped indigenous market coupled with lower purchasing power, and absence of domestic leadership.

The second phase which spanned the decade of eighties was marked by a substantial increase of FDI stock by Rs. 1712 crores, from Rs. 933 crores in 1980 to Rs. 2705 crores in 1990. The period registered a remarkable growth rate of about 12 per cent, nearly quadrupled over that of the preceding period. The partial policy liberalisation effected during this period alongwith the accumulated productive capabilities available in the economy, and further supported by expanding market as well as improved infrastructure, have been identified as the possible factors that gave a push to the propensity of foreign investors to invest in India. This period was also characterised by a relative decline in the share of manufacturing sector in total FDI stock though it continued to be the predominant sector attracting FDI stock. The final stage for inward FDI in India was characterised by a full-fledged liberalisation effected during the 1990s, commencing in the year 1991. During 1991-1999, increase in FDI stock was Rs. 47093.3 crores from Rs. 3213 crores in 1991 to Rs. 50306.3 crores in 1999. In fact, there was a distinct break with the former phases as indicated by the impressive growth rate of 49 per cent during this period vis-a-vis the growth rates for earlier periods as well as for the period as a whole. This has been mainly attributed to the major policy liberalisations and a significant role acquired by financial institutions, trading and other service segments of economy. The relative share of manufacturing sector in FDI stock continued to decline.

Actual Inward FDI Flows

An analysis of the trend in real FDI flows (Table 3), reinforces the findings obtained from table 2. During the partial liberalisation phase (1980-81 to 1990-91) the real

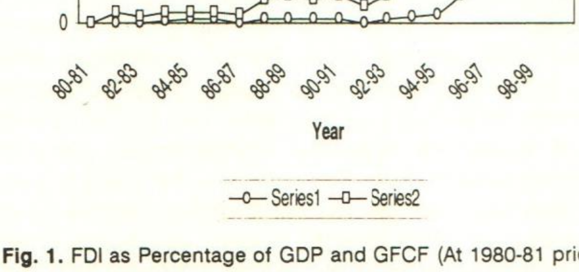


Fig. 1. FDI as Percentage of GDP and GFCF (At 1980-81 prices)

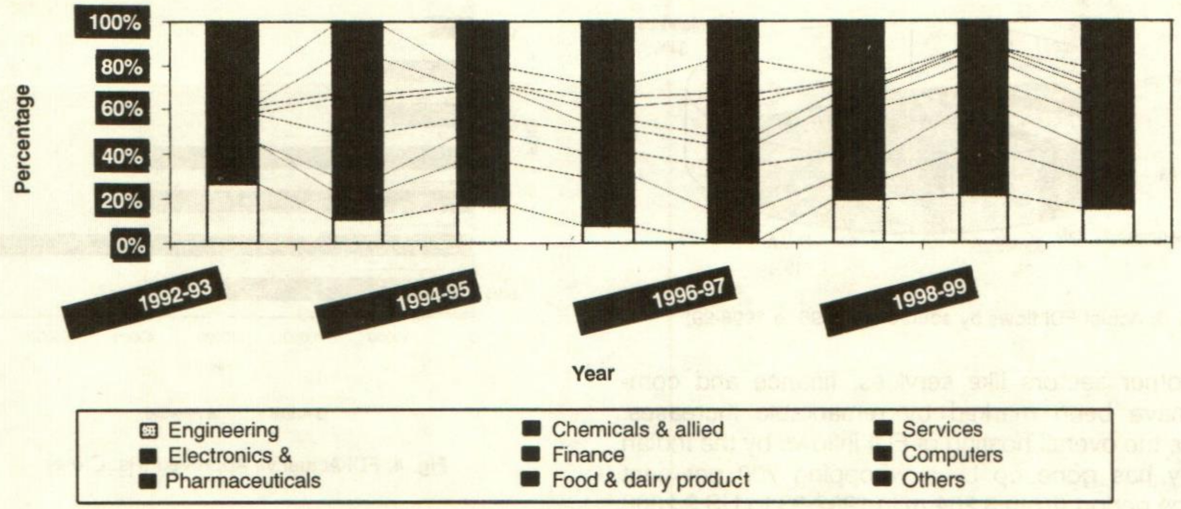


Fig. 2. Actual FDI flows-Sectoral Composition (%)

FDI flows exhibited a remarkable growth rate of 20.72 per cent per annum, which went upto 54.87 per cent in the post-reform phase (1991-92 to 1989-99). This quantum jump in the growth rate during the post-reform phase may be attributed to the contributory factors already mentioned.

The economic significance of FDI may be gauged by visualising its share in the Gross Domestic Product and Gross Fixed Capital Formation as shown in Fig. 1.

Table 3: Annual Compound Growth Rates of Real FDI Inflows in India (at 1980-81 Prices)

Period	CAGR(%)
1980-81 to 1990-91	20.72
1991-92 to 1998-99	54.87
1980-81 to 1998-99	30.92

Note: Calculated from semi-log model

FDI flows in the year 1980-81 as a percentage of real GDP is only 0.01 and that of real Gross Fixed Capital Formation is 0.04, but its real share has risen to 0.03 and 0.14 respectively in the year 1990-91 and further to 0.87 and 2.74 respectively in the year 1997-98, evidencing the increasing economic significance of FDI to Indian economy.

The relative share of FDI in total foreign investment in the Indian economy has been looking up in the post-reform era.

Another significant observation is that the relative share of FDI in total foreign investment in the Indian economy has been looking up in the post-reform era. Whereas this constituted only 14.11 per cent during the year 1993-94, the relative share has gone upto 66.05 per cent in 1997-98 and more than 100 per cent during the year 1998-99 (which signify a negative inflow of portfolio investment). It may appear that there has been a decline in the relative share of FDI after 1992-93; however, a closer examination of table 4 reveals that the absolute quantum of FDI has in fact increased but the massive increase in portfolio investment depressed the relative share of FDI.

Table 4: Relative Share of Direct Investment (%)

(Amount in U.S. $ Million)

Year	Total Inv.	Direct Inv.	% Share
1992-93	559	315	56.35
1993-94	4153	586	14.11
1994-95	5138	1314	25.57
1995-96	4892	2144	43.83
1996-97	6133	2821	46.00
1997-98	5385	3557	66.05
1998-99	2401	2462	102.54

The post reform phase witnessed major inflows of actual FDI (Fig. 2) in the sectors of engineering, chemicals and allied services, electronics and electrical equipment, finance as well as computer. It is also observed that various sectors of engineering, electronics and electrical equipment and food and dairy products registered declines in their relative share of FDI, while

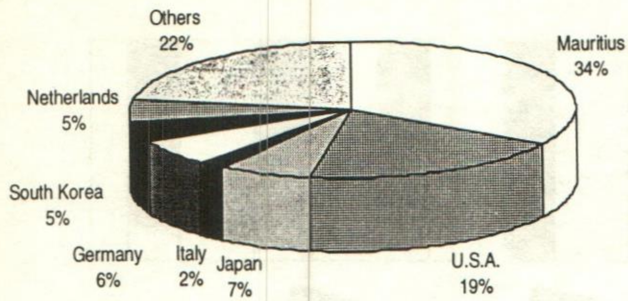


Fig. 3. Actual FDI flows by source (1995-96 to 1998-99)

certain other sectors like services, finance and computers have been marked by remarkable increases. However, the overall hosting of FDI inflows by the Indian economy has gone up by a whopping 700 per cent during the period (from $ 264 m in 1992-93 to US $ 2000 m in 1998-99).

In respect of the source-composition of inward FDI flows since mid-nineties, major investments originated from countries like Mauritius, U.S.A., and Japan. Predominant chunk of FDI has been from Mauritius, even though its relative share has looked down during this time frame (see Fig. 3). The explanation generally provided for this is that it is, in fact, the MNCs of U.S.A. and Germany and various other countries who are investing in India through the tax-haven route of Mauritius. Whereas the relative share of FDI from U.S.A., Japan, Italy and South Korea have registered improvements over this period, that of Mauritius, Netherlands and Germany as well as group of countries classified as 'Others' have recorded declines.

Actual vs. Approved

Another important observation is that the actual inflow of FDI is lagging far behind approvals granted, ranging from 13% to 47% of approvals granted during the period 1991 to 1998 (Fig. 4).

This undesirable facet of the problem may be stemming from a complex interactive process of several factors like lack of a transparent incentive mechanism, administrative hurdles, political inexpediency, etc. But the foremost bottleneck is infrastructure constraints on production process. Hence, several studies have pointed out that to attract and maximise the extent of actualisation of FDI approved, we should make our administrative process even more transparent, reallocate towards infrastructure sector, and build up a political consensus to ensure a stable FDI policy. With a growing indigenous market, availability of cheap and skilled labour, and political stability once attained, as a recent

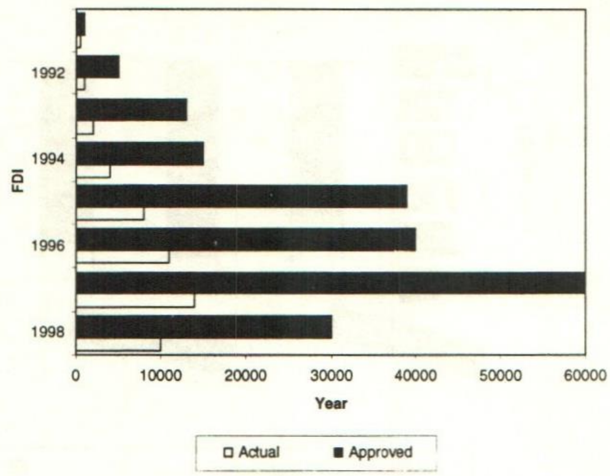


Fig. 4. FDI-Actual vs Approved (Rs. Crore)

IMF report predicts, India may soon emerge as a winner in the game of attracting foreign investment.

To attract and maximise the extent of actualisation of FDI approved, we should make our administrative process transparent, reallocate towards infrastructure sector, and build up a political consensus to ensure a stable FDI policy.

Approved Foreign Collaborations

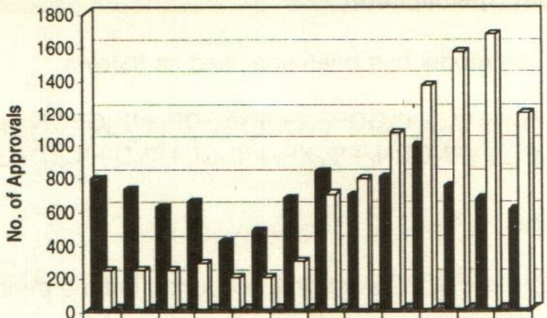
The average number of foreign collaborations approved during the phase of restrictive policy (1951 to 1979) was only 245 whereas the partial liberalised phase (1980 to 1991) witnessed two times increase in the corresponding figure to 743. However, the real boom in foreign collaborations came in post-liberalisation phase (1992 to 1998), recording an impressive average number of 1943 approvals. During these periods, the average approved foreign investments also showed similar trends (Table 5).

Table 5: Foreign Collaboration Approvals – Selected Averages

Period	Total	Technical	Financial	% share of financial	Foreign inv. (Rs. Crores)
1951-1979	245.24138	237.73684**	60.736842**	19.713435**	NA
1980-1991	742.58333	559.08333	183.5	23.807699	151.14417
1992-1998	1943	756	1187	59.995002	24736.25
1951-1998	617.1667	434.68421**	306.97368**	28.426649**	9614.4068*

Note: * over the period 1977-1998, ** over the period 1961-1998

Further, a break-up of the approved foreign col-



	1985	1986	1987	1989	1990	1991	1992	1993	1994	1996	1997	1998
■ Technical	786	717	611	411	472	661	828	691	792	744	660	595
□ Financial	238	240	242	194	194	289	692	785	106	155	166	119

Fig. 5. Foreign Collaboration Approvals (No.)

laborations during the partial and full-scale libearlisations brings out that the average number of technical collaborations was increasingly relatively at a slower pace vis-a-vis the financial collaborations. This position is further clarified by figure 5. This may have implications for the process of 'technology transfers' so vital for the development of the Indian economy. As the new FDI policy regime does not require investments to be necessarily accompanied by technology contents, this flexibility may be one possible explanation for this phenomenon.

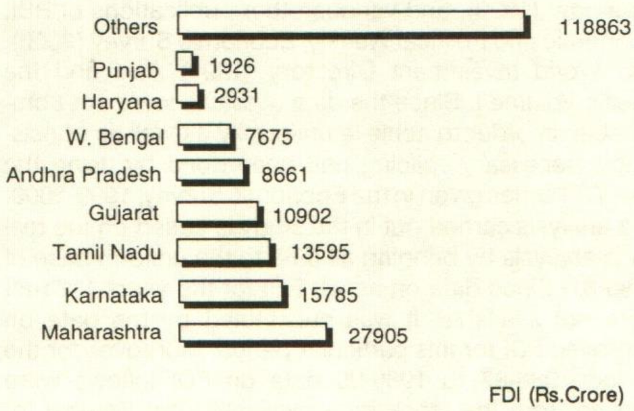


Fig. 6. State-wise Distribution of FDI (From April 1991 to November 1999)

Regional Destination of Approved FDI

From the geographical distribution of FDI it is evidenced that these investments have been concentrated in a few developed regions of India (observe Fig. 6).

The state of Maharashtra stood as the most dominant destination for FDI followed by Karnataka, Tamil Nadu and Gujarat during the period April 1991 to November 1999. Possible reasons for this concentration of FDI could be the FDI-friendly image of the respective state, level of infrastructural developments as well as prevalence of other factors conducive to investments. Another possible reason could be the emergence of IT industry in most of the dominating states which is presently the happening industry.

Determinants of FDI in India

In the context of India it is hypothesized that FDI flows into the country are determined by the following set of factors: the size of the market, the rate at which the market is growing, infrastructure development, domestic investment position, the extent of openness of economy, the rate of foreign exchange as well as the cluster of factors comprising inflation rate, gross fiscal deficit, and debt-service ratio which together impart the requisite confidence to the prospective foreign investors.

Domestic Market Size: Most of the empirical studies have identified the domestic market size to have a critical impact on the inward flow of FDI into the country (Bandera & White, 1968; Scaperlanda & Mauer, 1969, 1973; Schmitz & Bieri, 1972; Lumn, 1980; Bucklet & Casson, 1981; Scaperlanda & Balough, 1983; Petrochilas, 1984, 1989; Torrisi, 1985; Hultman & Mchee, 1988; Dunning, 1993; Aristotelous & Fountas, 1996; Gopinath, 1997; Goldar & Ishigami, 1999). This is of particular relevance for the Indian economy. The huge domestic market of India acts as a positive incentive for foreign investments in India. The market size has been proxies by the gross domestic product (GDP lagged one period).

Change in Market Size: In addition to the market size, the change in market size is a significant consideration entering into the choice-function of foreign investors to invest in any economy (Scaperlanda & Mauer, 1969; Schmitz & Bieri, 1972; Lunn, 1980; Petrochilas, 1984, 1989; Torrisi, 1985; Goldar & Ishigami, 1999). A stagnant domestic market size, inter alia, may work out as a disincentive to the foreign investor. Theoretically, it is expected that expansion of domestic market would have a positive impact on FDI inflows. This variable is measured as:

$$\Delta GDPt(=GDPt\text{-}GDPt\text{-}1)$$

Infrastructure: A critical mass of infrastructural development is imperative for foreign investors to realize ownership advantage in an alien market (Root & Ahmet, 1979; UNCTAD, 1992; Healy & Palepu, 1992; OECD, 1989). Quite often in academic discussions, it has been held that infrastructural bottlenecks in our economy have slowed down the actual FDI flows as well as widened the gap between the actual and approved FDI inflows. For our study the addition to the stock of infrastructural base has been structured as the combined expenditure of the Centre and State Govts. on economic services which include expenditure on energy, transport and communication services, technology and environment, electricity, gas and water and other economic services. Growth and development of the infrastructural base is expected to encourage the inflow of FDI.

Domestic Investment: Another major factor attracting FDI inflows is the extent of domestic capital formation. Economies with higher capital formation are expected to be fertile grounds for attracting FDI. For our instant study, this variable has been taken as gross fixed capital formation (GFCF lagged one period).

Exchange Rate: Existing literature on the subject evidences a strong relation between FDI inflows and the foreign exchange (Cushman, 1985; Hultman & Mcgec, 1988; Froot & Stein , 1991; UNCTAD, 1993; Aristotelous & Fountas, 1996; Goldar & Ishigami, 1999). A continued devaluation/depreciation of domestic currency is a priori expected to depress the profitability position of foreign investors. First, this may curtail the quantum of dividends, royalty, technical fees, etc. repatriated by them. Secondly, most of the FDI companies have high import-elasticity of sales (RBI, 1999). Hence, erosion of the value of domestic currency leads to high cost of production. Accordingly, this variable is expected to have a negative sign. For our analysis, the exchange rate has been taken as number of rupees per unit of US dollar.

Openness of Economy: The degree of openness of economy is one more factor that is supposed to impact positively on the FDI inflows into a country (UNCTAD, 1993; Goldar & Ishigami, 1999). The conventional measure of openness is the percentage ratio of export plus imports to GDP.

Apart from these variable, in the context of India, the following variables are also expected to influence the inflows of FDI; namely, the rate of inflation (measured by WPI series), the gross fiscal deficit (as a percentage of GDP), and the debt-service ratio. Theoretically, these individual indicators are expected to have a negative impact on FDI. Accordingly, a composite indicator has been arrived at by giving weight to each indicator inverse to its mean, and the resultant indicator is expected to retain the negative impact. Further, to incorporate the fundamental shift in economic policy effected during 1991, dummy variable has been used in the analysis, by giving the value of 1 till 1990-91 and zero for the period thereafter.

Model Specification

The model has been specified as follows:

$$FDI_t=\Psi_0+\Psi_1 GDP_{t-1}+\Psi_2 \Delta GDP_t+\Psi_3 GFCF_{t-1}+ Y_4 INF_{t-1}+\Psi_5 OPN_t+\Psi_6 XR_t+\Psi_7 CI_t+\Psi_8 D+\Psi_9 (D*OPN)$$

Where

FDI_t = FDI inflows into the country in time period t

GDP_{t-1} = Last Year GDP level

$DGDP_t$ = Change in the GDP level between Years t and (t-1).

$GFCF_{t-1}$ = Gross Fixed Capital Formation in period t

INF_{t-1} = Incurrence on infrastructure in (t-1) period.

XR_t = Exchange rate in time period t.

OPN_t = Degree of openness in economy in period t.

CI_t = Composite Indicator.

D = Dummy variable taking value of 1 for period 1981-82 to 1990-91 and 0 for the period 1991-92 to 1998-99

Data pertaining to this study have been obtained from the following sources: Handbook of Statistics on Indian Economy (1999), and various other publications of RBI, Economic and Political Weekly, Economic Survey (2000), and World Investment Directory (1992) Asia and the Pacific Volume I. Since the data available were not comparable, in order to achieve uniformity as well as consistency, necessary splicing has been done by using the new WPI series given in the Economic Survey, 1999-2000. The analysis carried out in the study is based on the real price analysis by bringing all data to the uniform base of 1980-81. Since data on actual FDI for the years 1981-85 were not available, it was substituted by the data on approved FDI for this particular period. Moreover, for the period 1986-87 to 1980-90 data on FDI inflows were derived from the stock data available from Foreign Investment Surveys and Census conducted by the RBI.

Empirical Findings

The results of econometric analysis are furnished in Table 6.

From the results it is evident that as expected, the size of the domestic market (GDP_{t-1}) has a highly significant and positive impact on FDI inflows into the country. But change in the market size does not influence FDI to any significant extent. These findings are in accord with the findings arrived at by a few other

Table 6: Regression Statistics

Variable	Coefficients	Standard Error	t Stat	P-value
Constant	−10032.178	4733.384	−2.11945	0.066882
GDP_{t-1}	0.0389616	0.011293	3.450038	0.008694
DGDP	0.0104831	0.013078	0.801602	0.4445938
OPN_t	684.9019	311.889	2.19598	0.059365
$GFCF_{t-1}$	−0.0936535	0.068718	−1.36287	0.210045
INF_{t-1}	0.0376495	0.092318	0.407826	0.694098
CI_t	−464.61637	197.6862	−2.35027	0.046661
XR_t	−167.0234	55.91032	−2.98734	0.017404
D	9001.341	3303.1	2.725119	0.026042
$D*OPN_t$	−644.42482	221.0761	−2.91495	0.019441

Adjusted R Square = 0.9796932 d = 2.079596 F = 92.128853

earlier empirical studies (Toreros, 1985; UNCTAD, 1993; Goldar & Ishigami, 1999). However, the extent of capital formation in the country is observed to be not significant and is wrongly signed. It is also observed that the infrastructure availability in the economy has a positive impact on FDI, but not to any significant extent. In accordance with a priori expectation, the variable exchange rate comes out with a negative sign. The variable of openness has got a very significant and positive impact on FDI inflows. This has to be seen in the backdrop of the journey of economy from the halting reform phase of 1980s culminating in the progressive reforms of the 1990s. The findings are in harmony with the results of many other earlier studies (Ex: UNCTAD, 1993; Goldar & Ishigami, 1999). As anticipated, the composite indicators comprising inflation rate, gross fiscal deficit, and the debt-service ratio, has come out with significant negative impacts. This is quite revealing as it indicates how macroeconomic fundamentals can influence inflows of FDI. Finally, it is interesting to observe that the differential intercept (which is the coefficient of D) and the differential partial slope coefficient with respect to openness (which is the coefficient of D*OPN) are statistically significant, strongly indicating that the regression for the pre- and post-liberalisation phases are distinctly different. This brings out that the response of FDI towards the policy change of 1991 has been substantial.

Elasticity of FDI

The average response of real FDI inflows with respect to its different determinants, namely, market size, change in market size, openness, infrastructure, composite indicator as well as the exchange rate is shown in Table 7.

Table 7: Elasticity of FDI Inflows with respect to different variables

Variable	Elasticity	t-statistics
GDP	11.65	3.45
DGDP	0.223	0.802
INF	1.0334	0.408
OPN	12.068	2.196
CI	−1.6633	−2.35
XR	−4.3625	−2.987

The GDP elasticity co-efficient is statistically significant at 11.65, indicating that for a one per cent increase in the real GDP this year, the real FDI inflows, on the average, increase by 11.65 per cent in the following year. The magnitude of the response of real FDI inflows to the openness is also as high as that with respect to GDP at around 12 per cent and this instantaneous response is also statistically significant indicating the crucial importance of the policy variable in influencing FDI inflows into the country. This table also suggests that other significant determinants of FDI inflows are exchange rate and composite indicator.

Conclusions

The policy liberalisation of 1991 had a distinct impact in boosting up the flow of FDI into the country. There has also been a structural shift in FDI flows from natural resource seeking (ex. Plantations, mining, and petroleum) towards created assets seeking (i.e. Manufacturing activities) and lately towards the services sector. Secondly, there has been a continuous source diversification of FDI inflows indicating the expedited globalisation of Indian economy. Thirdly, among the approved foreign collaborations, the relative share of financial collaboration is on the increase, with its implications for 'technology transfer' to India. Fourthly, there has been a definite regional concentration of FDI flows into India to a few developed states which contain the potential for accentuating regional divergences in the development process. Fifthly, the gap between the actual and approved FDI still remains wide as compared to many other developing countries, necessitating appropriate policy initiatives to bridge the gap. Finally, among the various determinants of FDI, the most predominant factors are GDP, openness, and the rate of exchange. Another observation is that the composite

The gap between the actual and approved FDI still remains wide necessitating appropriate policy initiatives.

indicator comprising rate of inflation, fiscal deficit and the debt-service ratio, has got a significant impact on FDI inflows, whereas infrastructure as well as the variation in GDP do not impact on FDI inflows to any significant extent.

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"Every organisation—not just business—needs are core competence: innovation and every organisation needs a way to record and appraise its innovative performance".

— Peter F. Drucker

Trends in Fertiliser Consumption in Punjab

Kamal Vatta & K.C. Dhawan

The paper attempts to highlight the trends and changes in fertiliser consumption and the factors affecting fertiliser use in Punjab. Although fertiliser use has increased over time its growth has almost stagnated during the nineties. The NPK ratio is highly imbalanced. There is a need to develop new crops and varieties which are more responsive to fertilisers. Proper and extensive extension efforts, effective pricing of fertilisers (not biased towards a single nutrient) will help in achieving the objective of balanced fertiliser use.

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The total foodgrain production in the country has increased from 50.8 million tonnes in 1950-51 to 194.1 million tonnes in 1997-98 (Economic Survey of India). Still, we have a daunting task to produce 240 million tonnes of foodgrains to feed the projected population of one billion and more in the new century. The cultivable land has already approached its physical limit. So the only option left is to increase the productivity of the land and fertiliser is one of the crucial inputs to increase productivity (Subramaniyan & Nirmala, 1991). Punjab stands first in consuming fertilisers (per hectare), followed by Andhra Pradesh and Haryana, respectively (Statistical Abstract of India). Despite this, the per hectare consumption of nutrients in Punjab is far behind the level of consumption of some of the agriculturally-well-developed countries of the world. Keeping in view the significant and positive marginal productivity of fertilisers in these countries, there is a large scope to increase the total consumption as well as per hectare consumption in the state, thereby increasing production and productivity.

Trend in Fertiliser Use

The total fertiliser consumption in Punjab registered more than six times increase from 213 thousand nutrient tonnes in 1970-71 to 1314 thousand nutrient tonnes in 1997-98. Fertiliser use per hectare increased from 37.51 Kg to 166.94 Kg over the same period (more than four times increase). However, the gross cropped area in the state experienced a relatively small increase from 5678 thousand hectare to 7871 thousand hectare i.e. by 38.62 per cent (Table 1). It means that the increase in total foodgrain production in the state was largely due to increase in per hectare consumption of fertilisers.

The compound growth rates for both the total as well as per hectare fertiliser consumption were calculated for three periods, viz., 1970-71 to 1997-98 (Overall). The compound growth rates of total fertiliser use were 12.72 and 1.47 per cent for period-I and period-II, respectively. Likewise, the compound growth rates for per hectare fertiliser use were 10.84 and 0.66 per cent for the respective periods (Table 2). However, the overall growth rate (per annum) for the total and per hectare fertiliser use turned out to be 7.00 and 5.73 per cent, respectively. It becomes clear that fertiliser consumption in the state (both total and per hectare) increased significantly over the study period. The increase was very rapid during the first period which might be due to fast adoption of improved technology by the farmers during this period.

Table 1: Fertiliser use in relation to growth in area, Punjab, 1970-71 to 1997-98

Year	Fertiliser Use ('000 Nutrient Tonnes)	Gross Cropped Area ('000 Ha)	Fertiliser Use Per Hectare (kg)
1970-71	213	5678	37.51
1971-72	290	5724	50.66
1972-73	325	5931	54.80
1973-74	307	6037	50.85
1974-75	244	5894	41.40
1975-76	295	6267	47.07
1976-77	373	6285	59.35
1977-78	465	6391	72.76
1978-79	603	6629	90.96
1979-80	686	6536	104.96
1980-81	762	6763	112.67
1981-82	813	6929	117.33
1982-83	892	6915	128.99
1983-84	991	6978	142.02
1984-85	1048	7013	149.44
1985-86	1098	7158	153.39
1986-87	1116	7217	154.63
1987-88	1112	7326	151.79
1988-89	1117	7387	151.21
1989-90	1145	7394	154.86
1990-91	1221	7501	162.78
1991-92	1262	7518	167.86
1992-93	1199	7552	158.77
1993-94	1199	7552	158.77
1994-95	1285	7693	167.03
1995-96	1263	7712	163.7
1996-97	1208	7818	154.52
1997-98	1314	7871	166.94

Source: Statistical Abstract of Punjab (various issues)

Graphical representation of the data reveals that fertiliser use (per hectare) in the state, increased fast till 1984-85, remained more or less stagnant upto 1988-89 and then reached its maximum in 1991-92 (Fig. 1). Afterwards it did not show any specific direction. It indicates that the intensity of fertiliser use has stagnated during the nineties and has touched the plateau. However the other side of the picture is that, we have failed to develop new high-yielding varieties along with introduction of new crops in cropping pattern, which could be more responsive to fertilisers as compared to already existing crops and varieties. Thus, the increase in total consumption of fertilisers in the state was largely attributed to the intensive use of fertilisers instead of an increase in total cropped area. Very slow changes during the nineties reflect the necessity to put greater efforts in the research and development of high-yielding varieties and crops which are more responsive to the fertiliser use.

Table 2: Compound Growth Rate of fertiliser Use, Punjab, 1970-71 to 1997-98

(Per cent per annum)

Particulars	Period-I 1970-71 to 1983-84	Period-II 1984-85 to 1997-98	Overall 1970-71 to 1997-98
Total Fertiliser Use	12.7238* (1.1992)	1.4705* (0.2080)	7.0038* (0.6169)
Fertiliser Use Per hectare	10.8432* (1.1514)	0.6636* (0.2014)	5.7306* (0.5661)

Note: Figures in parentheses represent the standard error
* Significant at 5 % level.

Changes in Fertiliser Consumption Pattern

Use of fertilisers in the state had been imbalanced, with a large tilt towards consumption of nitrates. However, with passage of time, the share of Nitrates in total fertiliser consumption declined from 82 to 76 per cent and that of Phosphates increased from 15 to 22 per cent from 1970-71 to 1997-98 (Table 3). The share of Potashic fertilisers remained almost negligible throughout the study period because the Punjab soils are not deficient in Potash. The NPK ratio changed from 25.0:4.4:1 in 1970-71 to 45.7:13.0:1 in 1997-98. This ratio is totally imbalanced because the most favourable ratio under Indian conditions is 4:2:1 (Indian Economy). An imbalanced use of fertilisers may in itself be the reason for slowing down the improvement of productivity in the state, as imbalanced application of different types of fertilisers does not result in maximum productivity especially on marginal lands. Probably, the imbalanced use is due to lack of awareness amongst farmers in the state. Further, the prices of fertilisers are also responsible for the present situation in the state because the prices of phosphates and potash were decontrolled during the nineties and consequently their prices jumped too high. To sum up, although Punjab is one of the agriculturally-most-developed states of the country

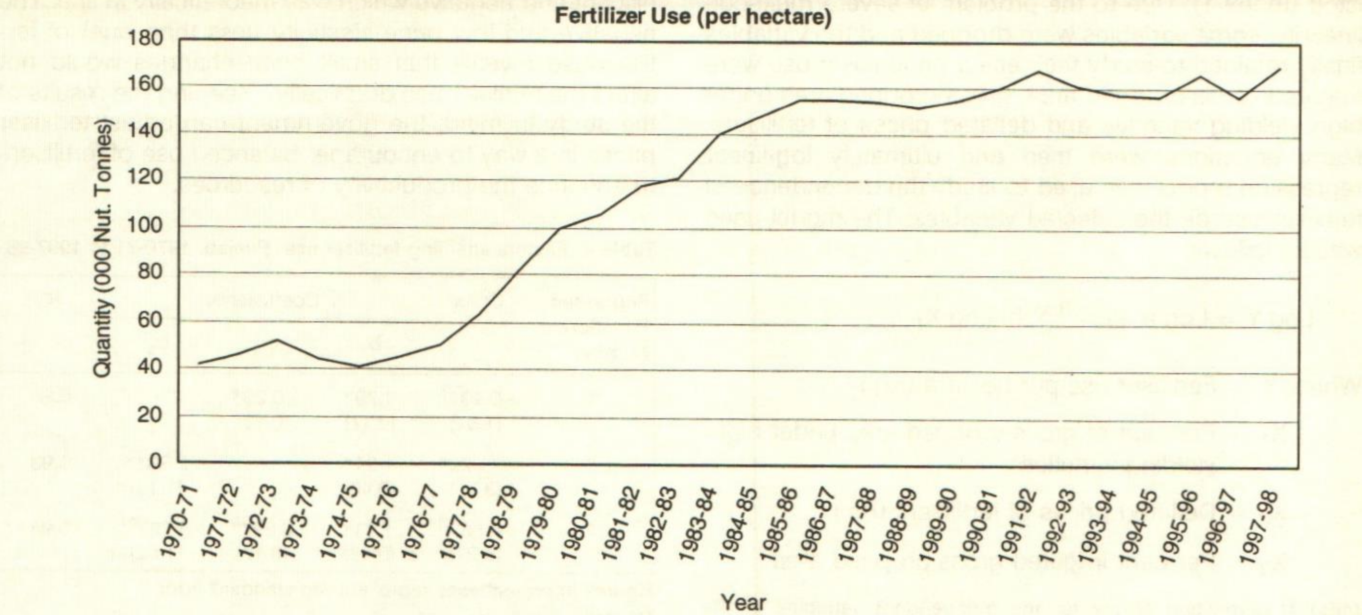

Fig. 1. Fertiliser use (per hectare) in Punjab, 1970-71 to 1997-98

leading in fertiliser consumption and agricultural production, there is a large scope to improve productivity through balanced use of fertilisers. It is the sole responsibility of extension specialists to create awareness amongst farmers. An effective price policy from the government, facilitating the balanced use of nutrients, will also play an important role.

An effective price policy from the government, facilitating the balanced use of nutrients, will also play an important role.

Factors affecting fertiliser use

In an attempt to identify some of the most important determinants of fertiliser use (per ha) in the state, state level data on different variables, supposed to affect the intensity of fertiliser use, over the period 1970-71 to 1997-98 was collected. The data pertained to deflated prices of nutrients, index of yield, per cent of irrigated gross cropped area and area under high-yielding varieties and index of agricultural prices deflated by the wholesale prices. The prices of the nutrients were calculated using the formula:

$$P = \frac{\sum P_i Q_i}{\sum Q_i}$$

Where P = Average price of nutrients (Rs./Tonne)

P_i = Price of i-th nutrient (Rs./Tonne)

Q_i = Quantity of i-th nutrient during the given period (Tonne)

Table 3: Changes in the NPK ratio, Punjab 1970-71 to 1997-98

Year	NPK-Ratio (N:P:K)	Total Fertiliser Use (thousand nutrient tonnes)			
		N	P	K	Total
1970-71	25.0:4.4:1	175 (82)	31 (15)	7 (3)	213 (100)
1975-76	23.2:5.3:1	232 (79)	53 (18)	10 (3)	295 (100)
1980-81	18.1:7.1:1	526 (69)	207 (27)	29 (4)	762 (100)
1985-86	32.8:11.9:1	787 (72)	287 (26)	24 (2)	1098 (100)
1990-91	58.5:22.0:1	877 (72)	330 (27)	15 (1)	1221 (100)
1995-96	63.7:14.3:1	1020 (81)	227 (18)	16 (1)	1263 (100)
1997-98	45.7:13.0:1	1005 (76)	287 (22)	22 (2)	1314 (100)

Source: Statistical Abstract of Punjab (various issues)

Figures in parentheses represent the percentage to total fertiliser-use

The average prices were then deflated by the wholesale price index for the previous year. The index of agricultural prices was deflated by the wholesale price index of the current year. Zero order correlation matrix was obtained and it was found that a serious problem of high correlation amongst the explanatory variables existed (Index 1). Due to the problem of severe multi-collinearity, some variables were dropped and the variables finally retained to study their effect on fertiliser use were irrigated gross cropped area, gross cropped area under high yielding varieties and deflated prices of fertilisers. Many equations were tried and ultimately log-linear regression model was used to study the dependence of fertiliser use on the selected variables. The model used was as follows:

$$\text{Log } Y = \text{Log } a +_{I=1}{}^{3} \sum \text{bi Log } X_1$$

Where Y = Fertiliser use per hectare (Kg.)

X_1 = Per cent of gross cropped area under high-yielding varieties

X_2 = Deflated prices of fertilisers (Rs.)

X_3 = Per cent irrigated gross cropped area

Index 1: Correlation Matrix for the Independent variables of the study

	Per cent of Gross Cropped Area under HYVs	Index of Agricultural Production	Deflated Fertiliser Prices	Per cent of Gross Cropped Area (Irrigated)	Deflated Index of Crop Returns
Index of Agricultural Production	0.92	–	–	–	–
Deflated Fertiliser Prices	0.84	0.88	–	–	–
Per cent of Gross Cropped Area Irrigated	0.98	0.97	0.86	–	–
Deflated Index of Crop Returns	0.70	0.60	0.42	0.71	–
Index of Yield	0.93	0.99	0.87	0.97	0.64

Note: Calculated from the data collected from Statistical Abstracts of Punjab (various issues)

To identify the significant variables affecting the fertiliser use, a number of log-linear equations were estimated using various combinations of the selected variables (Table 4). The regression analysis revealed that the coefficient of irrigated gross cropped area was 2.38 which was significant and affected the use of fertilisers positively. Further the area under high-yielding varieties had also positive coefficient in all the fitted equations. However, the coefficient of price of fertilisers was significant and negative which was theoretically in line. The negative and low price elasticity (less than one) of fertiliser-use reveals that small price changes would not affect the fertiliser use drastically . Keeping the results of the study in mind, the government can adjust fertiliser prices in a way to encourage balanced use of fertilisers to enhance the productivity of resources.

Table 4: Factors affecting fertiliser use, Punjab, 1970-71 to 1997-98

Regressed Equation Number	Constant	Coefficients b_1	b_2	b_3	R^2
1	-0.49^{NS} (1.54)	1.79* (0.17)	–0.29* (0.13)	–	0.95
2	–11.22* (3.71)	1.34* (0.40)	–	2.33** (1.18)	0.93
3	-4.58^{NS} (6.21)	1.53* (0.42)	0.22^{NS} (0.17)	1.03^{NS} (1.52)	0.95

Figures in parentheses represent the standard error

NS: Non-significant

*, ** represent significance at 5 & 10 % levels, respectively

Conclusions & Policy Implications

Fertiliser use has increased rapidly both in terms of total as well as per hectare in the state. However, increase in fertiliser use per hectare of cropped area almost stagnated during the nineties and present growth is almost negligible as compared to earlier growth. It necessitates a greater attention towards research and development of high-yielding varieties and new crops. The consumption of fertilisers in the state has been highly imbalanced. Proper and extensive extension efforts, effective pricing of fertilisers (not biased towards a single nutrient) will help in achieving the objective of balanced fertiliser use.

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Financial Structure for Backward Area Development

P. R. Kulkarni

The development of backward areas is no longer a question of choice left either to the policy makers or to the entrepreneurs of the country. With the necessity of spreading out benefits of economic growth in general and industrialisation in particular to all segments of Indian society it is inevitable that industrialisation particularly in the backward areas should take place as part of the programme of balanced development. The present article throws light on policy initiatives taken by Government of India for the development and promotion of industries in backward regions.

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Balanced regional development is the basic objective of economic planning in India. In recent years, therefore, a variety of measures have been implemented by the central and state governments and central and state level financial and promotional institutions for relieving and alleviating backwardness. The development of the industrial sector, comprising large/medium, small scale industries, ancillary units and agro-processing industries plays an important part in any strategy for industrialisation of backward or industrially lagging areas. The policy framework for small scale industries has to be to some extent different from other industrial sectors. The credit flow of financial institutions, including the banking sector, to the backward areas for the development of large scale industries in general and the SSI sector in particular merits study for achieving the goals of regional development.

Policy Initiatives

In consonance with the government's policy towards balanced regional development, various financial and fiscal incentives such as capital subsidy by state governments, transport subsidy in hilly areas by the central government and assistance on concessional terms in the form of lower promoters' contribution by Financial Institutions are being offered to industrial units coming up in backward areas. In addition to these, central government also gives fiscal incentives in the form of rebate in income tax to units set up in specified hilly and backward areas of the

The Government of India had identified 301 districts as 'Specified Backward Areas' (SBAs) and classified them into 3 categories, *viz.* A, B and C, based on the degree of backwardness.

country. The Government of India had identified 301 districts as 'Specified Backward Areas' (SBAs) and classified them into 3 categories, *viz.* A, B and C, based on the degree of backwardness. Category A districts – 134 in all – include 93 "No Industry Districts" (NIDs) which have no medium or large scale industrial units. B category includes 54 districts and in C category there are 113 districts.

Besides, with a view to promoting industrialisation of the backward areas the Government of India, in June 1988, announced the 'growth centre' scheme. The growth centres, each of which would be developed in an area of 400-800 hectares, would be endowed with basic infrastructural facilities like power, telecommunication, water and banking, enabling them to attract industries. Each growth centre would be developed at the cost of Rs. 25-30 crores, and would be jointly funded by the centre, state and financial institutions. The allocation of growth centres to the states has been made on a combined criteria of population, area and extent of industrial backwardness. It was proposed to develop 71 growth centres during the Eighth Five Year Plan, out of which 70 growth centres have been selected, of which 50 centres have so far been approved. In addition to this, the scheme of Integrated Infrastructure Development (IID) for small scale industries to facilitate location of industries in rural and backward areas in order to promote stronger linkages between agriculture and industry was launched in 1994. So far 66 centres have been sanctioned in the rural/backward areas. In these centres facilities such as power distribution network, water, telecommunication, drainage and pollution control facilities, roads, banks, raw material depots, storage and marketing outlets, common facilities and technological back-up services are expected to be developed. The project size of each of the centres would be around 15 to 20 hectares which is expected to accommodate 400 to 450 SSI and tiny units. Four years have passed since the implementation of the scheme. The objective of the growth centres and IIDs is to concentrate all efforts for the development of backward areas by utilising the locally available, but scare resources. It is only by properly coordinating and co-relating the essential social infrastructure with physical infrastructure that we can hope to catalyse industrial development in the large, medium and small sectors at the well-selected growth centres. All efforts should be concentrated in these areas for promoting industries so that within a time-frame of five years, concrete results can be achieved. Through the forward and backward linkages as also sustained efforts by the various institutions involved, the spread and multiplier, the spread and multiplier effects are likely to be noticeable. Therefore, there is now a need to review the progress of implementation of these schemes to make them more effective.

It is only by properly coordinating and co-relating the essential social infrastructure with physical infrastructure that we can hope to catalyse industrial development.

Flow of Assistance

At the time of independence, the Indian economy had already established a modest industrial base. Whatever industrial development had taken place, however, was in response to the emerging market conditions and not as a result of planned efforts. After independence, evolving and promoting a balanced regional growth became the major goal of economic policy. Financial institutions have been ensuring flow of assistance to industrially backward areas by offering liberalised financial terms such as lower promoters' contribution, higher debt-equity ratio, longer moratorium and amortisation period. The three major financial development institutions, *viz.* the Industrial Development Bank of India (IDBI), the Industrial Finance Corporation of India (IFCI) and the Industrial Credit and Investment Corporation of India Ltd. (ICICI) provide the major share of assistance for promotion and development of large and medium industries in SBA. The Small Industries Development Bank of India (SIDBI) was set up in 1990 to boost the development of medium/small industries in specified backward areas. Besides, All India Financial Institutions (AIFI) at the national level, the development banks operating in the states specifically for the development of backward areas include 18 State Financial Corporations (SFCs) and 25 Small Industries Development Corporations (SIDCs). Most of the SFCs were set up during the fifties and early sixties. In particular, these corporations cater to the requirements of small scale industries. The SIDCs were set up during the sixties to promote industrialisation in their respective regions by extending financial assistance especially to small and medium enterprises. Both the organisations have played a vital role in the dispersal of industries for removing disparities in regional development within their

Financial institutions have been ensuring flow of assistance to industrially backward areas by offering liberalised financial terms such as lower promoters' contribution, higher debt-equity ratio, longer moratorium and amortisation period.

Table 1: Flow of Assistance to SBA

Year	IDBI			IFCI			ICICI			AIFI**		
	B	T	%	B	T	%	B	T	%	B	T	%
1993-94	3121.0	11801.9	26.44	949.4	2163.1	43.89	1428.5	4413.3	32.36	5249.4	16865.9	31.12
1994-95	6504.1	18059.9	36.01	1179.8	2938.7	41.56	2374.9	6879.3	34.52	7708.2	23386.3	32.96
1995-96	5855.6	16376.9	35.75	2026.9	4563.3	44.41	2034.8	7120.4	28.57	8656.7	26837.1	32.25
1996-97	5780.4	15589.9	37.07	2609.5	5157.1	50.60	2114.8	11180.9	18.91	10021.5	31872.1	31.44
1997-98	9247.9	24139.5	38.31	2677.6	5650.1	47.39	2356.6	15806.9	14.90	11708.2	42062.0	27.83
Cumulative*	52507.4	144949.2	36.22	14527.1	30756.8	47.23	16216.5	68400.0	23.70	73821.1	225224.2	32.77

**IDBI, ICICI, IFCI, SIDBI and IIBI B = Backward Area T = Total Disbursement, % = Share of 'B' in total disbursement

*As on March 1998

respective states. Over the years the total financial assistance given by the national/state-level institutions to industrial units in the backward areas has been substantially increased.

Assistance to Large/Medium Units

The large and medium industries in the private, public and cooperative sectors, located in backward areas, have played very important roles in boosting the backward-area economy. Industry provides linkages and if these linkages are used and exploited for the betterment of economy, the industry could act as a leader. There is a need for integration of various sectors, i.e. large, medium, small and tiny into one coordination chain as an answer for the development of backward areas. During the last fifty years their efforts have resulted in creation of additional employment opportunities also through ancillary and subcontracting units. Besides they have contributed to the development of an industrial environment and culture in the surrounding backward areas. These industries have no doubt, helped in promoting local entrepreneurs who have taken to small and village industries, utilising local resources in the backward areas. The assistance disbursed by AIFI will work as catalystic for further investments in SBA.

Table 1 shows that as on March 1998, a cumulative assistance of Rs. 73,821 crores or 32.7 per cent of total assistance was disbursed by the All India Financial Institutions (AIFIs) to specified backward areas in the country. Out of the total assistance, the IDBI has provided Rs. 52507.4 crores to SBA which worked out to 71.12 per cent of the total assistance provided by AIFI. The average annual assistance disbursed to backward areas increased from Rs. 3176 crores during 1980-90 and further to Rs. 4575 crores during 1990-98. However, the share of SBA's assistance the total has remained more or less constant at 33 per cent during the years 1980-98.

Region-wise Disbursement

Fifty-two per cent of the assistance given by the AIFI has gone to the backward areas of industrially developed states, as against 48 per cent to the developing states. This is mainly because of the infrastructural facilities available in the backward districts of the better developed states, *viz.* Haryana, Punjab, Gujarat, Maharashtra, Karnataka, Kerala, Tamil Nadu and West Bengal. It also indicates that many more large and medium industries have been set up in the less developed areas of developed states rather than in the developed districts of the developing states like Rajasthan, Uttar Pradesh, Andhra Pradesh, Madhya Pradesh, Bihar and Orissa. Table 2 indicates region-wise cumulative assistance disbursed by AIFI to industrially backward areas of developed and developing states.

Many industries have been set up in the less developed areas of developed states rather than in the developed districts of the developing states.

The aggregate assistance disbursed to backward areas upto 1998 in the western states was 38.72 per cent, followed by 26.80 per cent to backward areas of the northern states. During 1990-98, the assistance disbursed to backward areas of both the regions has increased by an average compound growth rate of 22 per cent and 18 per cent respectively as against 11.34 per cent and 14 per cent of the backward areas of the Eastern and North-Eastern regions. The share of assistance to backward areas of western region has increased from 31.4 per cent in 1990 to 38.7 per cent in 1998. As against this, share of Northern, Southern, Eastern and North-Eastern regions has declined state-wise. This brings out that the development of the backward areas

Table 2: Region-wise Assistance Disbursed to Backward Areas

(Rs. crores)

Region	1989-90*			1997-98*			CAGR (1990-98)	
	B	T	%	B	T	%	B	T
Northern Region	5237	9433	55.51	19788	49474	39.99	18.08	23.02
Western Region	5899	18801	31.37	28587	97165	29.42	21.81	22.79
Southern Region	5106	13110	38.94	17807	58005	30.69	16.90	20.43
North-Eastern	550	550	100.0	1568	1571	100.0	14.00	14.02
Eastern Region	1679	5152	32.58	3965	16731	23.69	11.34	15.86
Union Territories	274	1237	22.15	2106	2278	92.44	29.03	7.93
Total	18745	48283	38.82	73721	225224	32.77	18.64	21.23

Cumulative Disbursement as on March 1990 and 1998

CAGR: Compound Average Growth Rate

in states like Maharashtra, Gujarat, Rajasthan and Madhya Pradesh is going on at faster pace where an industrial culture on the part of promoters, administrators as well as labour has been built up over a longer period of time. State-wise disbursement of assistance by the AIFI to industries in the backward regions is shown in table 3. The backward areas of under-developed states of Northern region, *viz.* Himachal Pradesh, Rajasthan and Uttar Pradesh, have benefited more comparatively by the assistance disbursed by the AIFI upto 1998 than the Eastern and North-Eastern states. About one-third (Rs. 25,551 crore) of the total assistance for setting- up industrial units in backward areas has gone to three states, *viz.* Maharashtra, Gujarat and Tamil Nadu, while the highly populated states of Bihar and Uttar Pradesh have received only 1.50 per cent and 8.0 per cent of total assistance respectively. This indicates that the developing states will have to concentrate more on providing better infrastructural facilities and creating a conducive industrial environment to attract industrial ventures in their backward areas.

The developing states will have to concentrate more on providing better infrastructural facilities and creating a conducive industrial environment to attract industrial ventures.

It is also revealed from the analysis that some of the backward areas, specifically of industrially developed states, have drawn the lion's share of assistance, while the other backward areas have remained untouched. The concerned financial institutions will have to actively help identify such backward areas which to date remain outside the ambit of the present schemes for industrial development so as to ensure equitable share of development funds. There is a need for better allocation and re-alignment of schemes so that desired results are achieved more quickly. With the growing emphasis on balanced regional development, the need for establishing an effective institutional framework for promotion of large scale industries is well recognised. State governments have set-up SIDCs as catalytic agents for the industrialisation of states. Wholly owned by respective state governments, there are at present 25 SIDCs operating as limited liability companies under the Indian Companies Act. There are some differences in the functions of different SIDCs, and the level of emphasis on different activities by various SIDCs also differs depending primarily on the degree of industrialisation and institutional network already developed in the states. The functions of SIDCs cover: industrial promotion activities, such as project identification, preparation of feasibility reports, identifying entrepreneurs and assisting them in project implementation, setting-up of industrial projects in medium and large sectors in partnership with private entrepreneurs, and provision of infrastructural facilities and market intelligence services.

Out of the 25 SIDCs, 13 are functioning in those states which are totally backward. As on March 1998 (Table 3), out of the cumulative assistance, 45.5 per cent has gone to such backward areas. In less industrially developed states, the aggregate assistance disbursed by SIDCs to backward areas worked out to 41.34 per cent. However, it is a matter of concern to note that over the years the assistance sanctioned to the backward areas has declined from 41 per cent in 1993-94 to 32.71 per cent in 1997-98.

Small Scale Sector

Speedy development of industries in backward

Table 3: Cumulative Assistance Disbursed to Backward Areas by AIFIs*

State/Region	1989-90				1997-98				Compound Growth Rate	
	B	%	T	%	B	%	T	%	B	T
Northern Region										
Haryana	382	2.04	312	0.65	1276.5	1.73	6383.9	2.86	16.28	45.84
Himachal Pradesh	463	2.47	463	0.96	2526.2	3.42	2526.2	1.13	23.63	23.63
Jammu & Kashmir	335	1.79	335	0.69	470.1	0.64	470.1	0.21	4.33	4.33
Punjab	676	3.61	1656	3.43	2365.4	3.20	5877.7	2.64	16.95	17.16
Rajasthan	1071	5.71	1921	3.98	5194.5	7.04	10349.2	4.64	21.82	23.43
Uttar Pradesh	2310	12.32	4746	9.83	7955.7	10.78	18014.7	8.08	16.72	18.14
Delhi	–	–	–	–	–	–	5852.2	2.60	–	–
Total	5237	27.94	9433	19.54	19788.4	26.81	49474.0	22.19	18.08	23.02
Western Region										
Goa	427	2.28	427	0.88	1404.7	1.90	1404.7	0.63	16.05	16.05
Gujarat	2274	12.13	6188	12.82	9464.9	12.82	36048.6	16.01	19.51	24.64
Madhya Pradesh	1378	7.35	2493	5.16	6677.1	9.04	11952.2	5.31	21.8	21.64
Maharashtra	1820	9.71	9693	20.08	11040.2	14.96	47759.2	21.42	25.27	22.06
Total	5899	31.47	18801	38.94	28586.9	38.72	97164.7	43.14	21.81	22.79
Southern Region										
Andhra Pradesh	1810	9.66	3931	8.14	6127.7	8.30	17758.6	7.97	16.47	20.74
Karnataka	1368	7.30	3184	6.59	5336.2	7.23	15226.2	6.83	18.55	21.61
Kerala	452	2.41	1137	2.35	1295.1	1.75	4020.1	1.78	14.06	17.10
Tamil Nadu	1476	7.87	4858	10.06	5047.9	6.84	21000.7	9.32	16.61	20.08
Total	5106	27.24	13110	27.15	17806.9	24.12	58005.6	25.75	16.90	20.43
North-Eastern Region										
Arunachal Pradesh	12	0.06	12	0.02	28.7	0.04	28.7	0.01	11.52	11.52
Assam	356	1.90	356	0.74	1212.1	1.64	1212.1	1.64	1212.1	0.54
Manipur	25	0.13	25	0.05	63.7	0.09	63.7	0.03	12.40	12.40
Meghalaya	64	0.34	64	0.13	97.2	0.13	97.2	0.04	5.36	5.36
Mizoram	23	0.12	23	0.05	31.2	0.04	31.2	0.01	3.89	3.89
Nagaland	28	0.15	28	0.06	59.1	0.08	59.1	0.03	9.79	9.79
Sikkim	20	0.11	20	0.04	34.9	0.05	37.1	0.02	7.21	8.03
Tripura	22	0.12	22	0.05	41.6	0.06	41.6	0.02	8.29	8.29
Total	550	2.93	550	1.14	1568.5	2.12	1570.7	0.70	14.00	14.02
Eastern Region										
Bihar	253	1.35	1217	2.52	438.8	0.59	3372.0	1.50	7.13	13.59
Orissa	525	2.80	1353	2.80	1338.8	1.81	3888.4	1.73	12.41	14.11
West Bengal	901	4.81	2582	5.35	2187.2	2.96	9471.0	4.25	11.72	17.64
Total	1679	8.96	5152	10.67	3964.8	5.37	16731.4	7.43	11.34	15.86
Union Territories	274	1.46	1237	2.56	2105.6	2.85	2277.8	1.01	29.03	7.93
Total	18745	100.00	48283	100.00	73821.1	100.00	225224.2	100.00	18.69	1.23

As on March 1990 and 1998 B = Backward Areas T = Total Disbursement

*IDBI, IFCI, ICICI, SIDBI and IIBI

Table 4: SFCs/SIDCs Assistance to Backward Areas

(Rs. Crores)

Year	SFCs			SIDCs			Total		
	B	T	%	B	T	%	B	T	%
1993-94	742.5	1908.8	38.89	380.1	917.9	41.40	1122.6	1826.7	39.71
1994-95	1106.6	2702.4	40.94	596.0	1588.6	37.51	1702.6	4291.0	39.61
1995-96	1501.2	4188.5	35.84	730.7	1951.2	37.44	2231.9	6139.7	36.35
1996-97	1534.3	3544.8	43.28	667.7	1811.7	36.85	2202.0	5356.5	41.10
1997-98	1082.6	2628.6	41.18	595.3	1819.6	32.71	1677.9	4448.2	37.72
Cumulative	12327.1	29138.0	42.30	7082.5	15565.8	45.50	19409.6	44704.1	43.41

*As on March 1998

Table 5: Financial Assistance to Units in Backward Areas

(Rs. Crores)

Year	NABARD			SIDBI			CB		RRB			KVIC
	B	T	%	B	T	%	B(E)	T	B	T	%	
1993-94	323	2745	11.76	570.6	2314	24.65	8456	21561	418	4682	8.92	172.2
1994-95	411	3011	13.64	486.3	2729	17.81	10135	25843	585	6226	9.39	217.9
1995-96	460	3064	15.01	874.0	4029	21.69	12370	31542	589	7546	7.80	200.6
1996-97	645	3523	18.30	703.0	3561	19.74	14946	38109	218	4016	5.42	330.8
1997-98	617	3922	15.73	1046.8	4345.5	24.08	19015	48483	356	4634	7.68	348.1

E = Estimates

areas can be achieved by rapid promotion of small scale industries. Such a programme of SSI development should be conceived as an instrument of social change and not merely as a welfare programme. It is the small scale industry sector which can have a tremendous impact on our economy by diversification of production through ancillarisation, diffusion of

Speedy development of industries in backward areas can be achieved by rapid promotion of small scale industries.

ownership through promotion of local entrepreneurship and geographical dispersal of industrial activity by basing industries on local resources. The backward areas of the country are rich in resources, both mineral and agricultural. They have remained industrially backward because we have located industries based on these raw materials near the cities which provide the markets. Now the time has come to locate the industries in the backward areas where the raw materials are available. One very fruitful area of research and development in India is to find the industrial usages for agricultural raw materials. In this context, the strategic role that small scale sector has to play in the economic development of the country needs no emphasis. The rapid growth of small scale industries could promote economic federalism. The small scale sector has shown phenomenal growth during the last five decades. At present, over 7500 items are being produced by about 31 lakh small scale units in the country. This sector provides employment to nearly 170 lakh persons and is next only to the agricultural sector. Production at current prices has multiplied almost by 20-fold from Rs. 28.060 crores in 1980-81 to Rs. 538,357 crores in 1998-99. The share of the small scale sector is about 56 per cent of the total industrial production. All this has been possible because of the bold initiatives taken by entrepreneurs on the one hand and centre/state governments and financial institutions

SSI development should be conceived as an instrument of social change and not merely as a welfare programme.

including the banking sector on the other. Back-up support and escort services to small enterprises are provided right from the choice of production line upto the marketing stage. The SSI sector is amenable to structural diversification and regional dispersal of industries in rural and semi-urban areas.

National level institutions such as NSIC, KVIC, NABARD, SIDBI were set up to promote and assist the small scale industries in backward/rural areas in the country. The quantum of financial assistance provided by NSIC to the backward area is not readily available. Table 5 shows the assistance provided by these organisations to industrial enterprises in the backward areas.

NABARD and KVIC promote village and small scale industries in rural villages and in areas outside municipal limits, the population of which does not exceed 20,000. The NABARD operates the following schemes, viz. District Rural Industries Project (DRIP). Area Plan for rural Industrialisation (APRI), mother-unit's scheme for promotion of sub-contracting and ancillaries industries, scheme for intensive development of rural industries and Rural Entrepreneurship Development Programmes, etc., for promotion of village and small scale industries. The Government of India has created the Rural Infrastructure Development Fund (RIDF) in NABARD in 1995-96 to create infrastructure such as irrigation, roads, bridges, market yards, etc., in rural areas. By considering forward linkages of the rural economy, the scope of RIDF should be expanded and fund should also be made available for setting up industry-related infrastructure such as mini-industrial estates, common service facilities and market centres, etc., to boost utilisation and processing of agricultural resources. Considering the vast potential for employment offered by the village and cottage industries and given the inability of the organised industry to absorb the bulk of the labour force, the role played by various institutions is laudable. The Government of India had set up in 1953 the All India Khadi and Village Industries Board to plan and organise the development of khadi and village industries in the country. The state governments were also requested to set up similar bodies at the state level. From two state-level KVIBs, 242 registered institutions and 60 cooperative societies in 1957, the numbers have now reached impressive totals of 30 State Khadi and Village Industries Boards, 4969 registered institutions and, 30129 co-operative societies. The khadi and village industries have taken roots and spread out into 2.50 lakh Indian villages. The KVIC is responsible for giving attention to the production of khadi and processing of specified products, such as cereals and pulses, ghani oil, forest based products, hand-made paper, bee keeping, village pottery, village labour, non-edible oils, soaps, etc. The production which was at the level of Rs. 8.23 crores under khadi and Rs. 12.72 crores for other village industrial products in 1956-57 has risen to Rs. 624.10 crores under khadi and Rs. 3895.21 crores under village industries in 1997-98. Employment level increased from Rs. 15.58 lakhs in 1956-57 to Rs. 56.50 lakhs in 1997-98. It is the cottage industry where all the ingredients for success such as men, material, machinery and method are already available. It is also one of the few industries in the decentralised sector which has high investment return ratio. The Commission is also operating a number of schemes such as margin money scheme, marketing, training schemes for the healthy and orderly growth of village industries. The scope of village industries has also widened. In the near future the Commission will have to pay more attention to the quality and cost of products. In addition to this Institute, Regional Rural Banks (RRBs) have been set up in 1976 to mitigate the credit requirements of rural industries. They are expected to supplement and supplant the other agencies for institutional credit for these clients groups. RRBs have been allotted compact homogeneous areas of 1 to 5 districts with same agro-climatic conditions for their operation. RRBs grant composite loans to cottage and village industries and artisan units for meeting both their capital investment and working capital needs. As on March 1998, they had granted Rs. 356 crores (by way of short term as well as medium term advances) to rural artisans and non-agricultural activities.

RRBs grant composite loans to cottage and village industries and artisan units for meeting both their capital investment and working capital needs.

SIDBI and commercial banks are also playing a crucial role in development and promotion of small scale sector in backward areas. SIDBI also operates schemes such as Micro-credit, Mahila Vikas Nidhi, Rural Industries Programme, Adoption of Clusters for Technology Upgradation, National Equity Fund (NEF), and Single Window Scheme and has undertaken extensive human resources development programmes in backward areas. In the new millennium, the bank will have to change the strategy for the development of backward areas. Because of the development of software and IT industry, there will be a greater tendency by the medium and small ancillary and sub-contracting industries to locate centres where infrastructure is available in order to minimise overhead costs. SIDBI will have to pay more attention to provide training to the rural youth to make them more productive and emphasise on the creation of more extension and support facilities. By considering

Table 6: Statewise and Regionwise Cumulative SSI units and Employment

State	1990-91		1995-96		1997-98				CAGR 1990-98	
	No. of Units	Employ-ment	No. of Units	Employ-ment	No. of Units	% Share in total Units	Employ-ment	% Share in total Employ-ment	Units	Employ-ment
Northern Region										
Haryana	42657	221342	76661	427136	87251	3.30	490430	3.42	10.76	12.04
Himachal Pradesh	20545	91506	24845	103269	26378	1.00	110112	0.77	3.63	2.68
Jammu & Kashmir	15121	66677	21979	95022	24688	0.93	107313	0.75	7.25	7.25
Punjab	160368	668845	191025	802329	195400	7.39	834187	5.82	2.86	3.21
Rajasthan	44691	184293	69238	299993	85451	3.23	334322	2.33	9.70	8.88
Uttar Pradesh	132719	742476	267042	1219697	327827	12.41	1394830	9.74	13.79	9.43
Delhi	85050	765450	126218	1135962	130218	4.93	1171962	8.18	6.27	6.27
Total	51151	2740589	777008	4083408	877177	33.19	4443156	31.01	8.33	7.15
Western Region										
Goa	4120	27328	5118	33136	5488	0.21	36734	0.26	4.18	4.32
Gujarat	62609	443076	128037	771485	156731	5.93	862929	6.02	14.01	9.99
Madhya Pradesh	107657	243220	222740	521715	266994	10.10	629633	4.39	13.85	14.55
Maharashtra	54610	360426	180401	1196817	234943	8.89	1562595	10.91	23.18	23.31
Total	228996	1074050	536296	2523153	664156	25.13	3091891	21.58	16.43	16.31
Southern Region										
Andhra Pradesh	63848	471541	91909	701512	101814	3.85	789421	5.51	6.89	7.64
Karnataka	65920	399576	125849	738829	173753	6.58	939438	6.56	14.85	12.99
Kerala	51071	302990	10672	612731	157640	5.97	747654	5.22	17.47	13.77
Tamil Nadu	127202	1373782	234400	2323000	295004	11.16	2802538	1956	12.77	10.72
Total	308041	2547889	462830	4376072	728211	27.56	5279051	36.85	13.08	10.97
North-Eastern Region										
Arunachal Pradesh	–	–	–	–	–	–	–	–	–	–
Assam	10265	58746	23131	117913	27742	1.05	136401	0.95	15.26	12.79
Manipur	4413	21950	5576	27880	5958	0.23	29880	0.21	4.38	4.50
Meghalaya	1558	9248	2533	14791	3008	0.11	17259	0.12	9.85	9.32
Mizoram	1762	8604	2687	14321	3427	0.13	19758	0.14	9.97	12.61
Nagaland	–	–	–	–	780	0.03	3900	0.03	–	–
Sikkim	140	1857	261	2698	297	0.01	2895	0.02	11.34	6.55
Tripura	–	–	–	–	1700	0.06	8500	0.06	–	–
Total	18138	100405	34188	177603	42912	1.62	218593	1.53	13.09	11.76
Eastern Region										
Bihar	60077	274562	112499	424147	131794	4.99	473633	3.31	11.88	8.10
Orissa	14657	112928	26152	181739	32436	1.23	214074	1.49	12.02	9.57
West Bengal	96702	438446	137624	545860	165934	6.28	606383	4.23	8.02	4.74
Total	171436	825936	276275	1151746	330164	12.49	1294090	9.03	9.81	6.63
Grand Total	1227762	7288869	2086597	12311982	2642620	100.00	14326781	100.00	11.57	10.14

@ Compound Average Growth Rate

the size of regional spread of SSI units (table 6) and potential for growth and their requirement in terms of finance, technical, extension and support services, SIDBI may restructure its operation by setting up one zonal office (instead of regional offices) for a set of two states, viz. Andhra Pradesh and Karnataka, Tamil Nadu and Kerala, Maharashtra and Goa, Uttar Pradesh and Bihar, west Bengal and Orissa, Rajasthan and Himachal Pradesh, Punjab and Haryana, etc.[1] This will help to closely monitor the orderly growth of SSI units in

1. Centres for marketing, transfer of technology and liaison office for coordinating various activities may be set up at Delhi under a single roof.

Total 7: Distribution of Cumulative SSI Units in Backward Areas: 1997-98

Totally Backward States	1990-91		1997-98		CAGR		Partially Backward States	1990-91		1997-98		CAGR		Backward Area@	
	U	E	U	E	U	E		U	E	U	E	U	E	U	E
Assam	10265	58746	27742	136401	15.26	12.79	Uttar Pradesh	132719	742476	327827	1394830	13.79	9.43	197608	810480
HP	20545	91508	26378	110112	3.63	2.68	Andhra Pradesh	63848	471541	101814	789421	6.89	7.64	57620	44370
J&K	15121	66677	24688	107313	7.25	7.03	Gujarat	62609	443076	156731	862929	14.01	9.99	52660	284370
Manipur	4413	21950	5958	29880	4.38	4.50	Haryana	42657	221342	87215	490430	10.76	12.04	42210	227940
Meghalaya	1558	9248	3008	17259	9.85	9.32	Kerala	51071	302990	157640	747654	17.47	13.77	7850	368970
Nagaland	–	–	780	3900	–	–	Karnataka	65920	399576	173753	939438	14.85	12.99	137790	744040
Sikkim	140	1857	297	2895	11.34	6.55	Madhya Pradesh	107657	243220	266994	629633	13.85	14.55	227210	522590
Tripura	–	–	1700	8500	–	–	Maha-rashtra	54610	360426	234943	1562595	23.18	23.31	105720	697780
Arunachal Pradesh	–	–	–	–	–	–	Orissa	14657	112928	32436	214074	12.02	9.57	1290	8520.00
Goa	4120	27328	5488	36734	4.18	4.32	Punjab	160368	668845	195400	834187	2.86	3.21	107470	462120
Mizoram	1762	8604	3427	19758	9.97	12.61	Rajasthan	44691	184293	85451	334322	9.70	8.88	48280	20760
Andaman & Nicobar	–	–	1005	4321	–	–	Tamil Nadu	127202	1373782	295004	2802538	12.77	10.72	140790	1295280
Bihar	60077	274562	131794	437633	11.88	7.82	West Bengal	96702	438446	165934	606383	8.02	4.74	94910	351180
Union Territories*	–	–	8520	63330	–	–	Delhi	85050	765450	130218	1171962	6.27	6.27	–	–
Total	118001	560480	240785	1014036	10.77	8.75	Total	1109761	6728391	2411360	13380396	11.72	10.32	1303740	6101920

*Includes Pondicherry, Daman & Diu, Dadra & Nagar Haveli, Lakshdweep, Chandigarh; U = Units; E = Employment; Compound Growth

general and in the backward areas in particular. Commercial banks will also have to gear up themselves to meet the new credit requirements of small scale units in backward areas and also think about fee-based activities.

> **In the new millennium, the bank will have to change the strategy for the development of backward areas.**

During the last three decades, SFCs have contributed substantially to investment activity in the industrial sector, especially the small scale sector. The success of their efforts at dispersal of ownership of means of production is reflected in the increased number of units assisted annually, from 17, 962 in 1979-80 to 31,498 in 1984-85, 38040 in 1992-93 and further to 43,069 in 1997-98. By 1997-98, over 39 lakh units have benefited through their assistance – the average cumulative per unit assistance being Rs. 2.6 lakhs.

Looking at the growth, the manifold activities, share of investment in small scale sector, generation of new projects in backward areas, their all round assistance to development of SSIs and the resultant balanced regional growth, the proactive role played by SFCs cannot be underscored. SFCs have emerged as the single largest source of term finance to units in the small and small-medium sectors. With the recent redefinitions of SSI, the share of small scale sector in the backward regions in SFCs' operations is expected to increase substantially from the present level of 42 per cent. In line with the national priority, SFCs have contributed significantly to the industrial development of specified backward areas/districts. It could be seen from Table 2 that the share of assistance to backward areas during 1993 to 1998 varied between 39 to 45 per cent.

Regionwise SSI Units

The SSI sector levels itself to the structural diversification and regional dispersal of industries in rural and semi-urban areas. The compound growth in the number of registered small scale sector units between 1990 to

1998 was 11.57 per cent, while in employment generation it was 10.14 per cent during the same period. Table 6 indicates the state and region-wise distribution of the SSI units set up and employment generation. The data shows that in 1998 the industrially developed states (as defined by NCDBA) accounted for nearly 60 per cent of the number of units and 65 per cent of employment.

During 1990-98, the western region registered a 16.43 per cent compound average growth in setting up small scale units followed by North-Eastern Region which was 13.09 per cent where the infrastructure facilities are not comparatively so well developed. North-Eastern Development Finance Corporation Limited (NEDFCL), set up in August 1995, aims at providing finance and other facilities for promotion and expansion and modernisation of industrial and infrastructural projects in the region as against 16401 units set up during 1990-95. The corporation has not made any significant impact on stimulating and promoting small enterprises considering the potential available in the region. There is a need for further providing proper facilities and encouragement for making the small scale sector an important tool for the development of the North-Eastern Region and due publicity should be given to various facilities and investment opportunities. There is also a need for proper guidance to entrepreneurs in identifying the viable industries. The states which have shown higher growth for setting up SSI units are Maharashtra (23.18 per cent), Gujarat (14.01 per cent), Madhya Pradesh (13.85 per cent), Karnataka (14.85 per cent), Kerala (17.47 per cent) and Uttar Pradesh (13.79 per cent). These states have also shown a higher increase in the creation of employment opportunities in the SSI sector. Table 7 indicates the distribution of SSI units in totally backward states and specified backward areas of partially backward states.

There is a need for further providing proper facilities and encouragement for making the small scale sector an important tool for the development of the North-Eastern Region.

Assam, Himachal Pradesh, Jammu & Kashmir, Meghalaya, Nagaland, Sikkim, Tripura, Goa, Mizoram and Andaman & Nicobar Islands have been declared as industrially backward states. It is estimated that 15.44 lakh units (58.23 per cent) are set up in backward areas as against 11.07 lakh units (41.77 per cent) set up in the industrially advanced areas. The units set up in the industrially lagging areas have created 49.43 per cent of the total employment opportunities in the country. The promotion of SSI units in the partially backward (developed) states *viz.* Maharashtra, Gujarat, Tamil Nadu, West Bengal, Karnataka, Kerala and, Haryana is higher because most of the organisational framework for supporting small industries are situated in these states and also they are better placed in terms of infrastructure including the network of banking and financial intermediaries. Access to these services is very poor in the backward states. The analysis reveals that the SSI sector has achieved the major goal of regional development or dispersal of industries in the backward areas.

Conclusions

In the last five years, on an average, annually, Rs. 25.276 crores comprising Rs. 8,669 crores to large scale units and Rs. 3,622 crores to SSI units as term loans and Rs. 12,985 crores as working capital were disbursed to set up industries in the backward areas in the country. The flow of assistance by national and state level financial institutions has helped to set up industries of various categories; large, medium and small scale in the industrially backward areas. However, the challenges of the large, small and medium industries in backward areas in the years to come will be in the field of technology which will cater to the needs of the new markets. Too much support in the form of subsidies and protection could jeopardise the healthy functioning of any enterprise, irrespective of its size. Global integration and cooperation of the large, and small scale sectors are urgently required for units working in the backward areas. Entrepreneurship development training programmes for ingraining the concept of quality standardisation and customer service are required to be conducted in order to keep the enterprises competitive in the liberalised environment.

New strategies and programmes are required for backward areas following the liberalisation of economies and rapid technological developments. The role of Government in the SBA would be significant in creating a conducive environment for the private sector to grow and prosper. The creation of such an environment would include appropriate micro-policies, laws and regulations to encourage marketisation and competition, provision of infrastructure, transport, health and educational facilities. Since upgradation of skills is a paramount need of the backward areas, training programmes should be undertaken not only through formal educational institutions but also through associations of enterprises and NGOs. The self-help institutions formed by entrepreneurs themselves should be encouraged. Programmes specifically oriented towards the establishment and development of industries by women entrepreneurs also ought to receive special consideration.

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The small scale industry sector is an integral part of the industry and economy. The restructuring processes will equally affect the small units in backward areas which have experienced temporary difficulties. These units should be restructured and assisted through technology and financial support to turn into profitable enterprises. Coordination at the working level, cooperation and collaboration among the various agencies are crucial to avoid overlapping and to enable optimum use of scare resources. The importance of mutually beneficial intra-regional and inter-regional cooperation between small and medium scale enterprises in SBA, specifically in technology transfer cannot be underestimated. The role of the tertiary sector in the development of backward areas is also missing in the official policies. NGOs also should be encouraged to build up the capacity to form appropriate linkages between one another.

Within the small and medium scale enterprises sector, micro-enterprises and rural industries have not received adequate attention. Recent experiences in many backward areas have revealed that a flexible response to informal enterprises is needed under the changing circumstances. In the case of tiny or micro enterprises, delivery of both financial and technical assistance has to be decentralised and carried to the enterprises. Specific attention is required to link such enterprises to the needs of the community around them and to provide them the required infrastructure and services.

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"The ability to learn faster than your competitors may be the only sustainable competitive advantage".

– Arie P. de Geus

Consumer Behaviour: Reference Group As A Determinant

R.P. Saxena, Naseem Abidi & Ashraf Malik

To understand the buyer and to create a customer through this understanding, is the main purpose of buyer behaviour study. Business firms and researchers have studied the subject extensively, contributing a large assortment of information on buyer behaviour. However, a universally accepted theory of the subject is yet to emerge. The present study is an attempt to understand the reference group influence on the buying decision of car and scooter and is of exploratory nature where a large sample has been used to be representative of the universe.

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The aim of marketing is to meet and satisfy the target customers' needs and wants. Everyone in the market has only one desire—to attract, satisfy and retain customers. To understand the buyer, and to create a customer through this understanding, is the main goal of marketers. Today, the market is evolving, so are the consumers. What was considered unique yesterday is expected today. It becomes most essential for the firms to understand the buyer and accordingly evolve marketing strategies. Specifically, it must understand how the buyer decides in favour of one brand or product, what motivates him or her to select an alternative.

Purchase Behaviour

The consumer continues to be an enigma—sometimes responding the way the marketer wants and on other occasions just refusing to buy the product from the same marketer. For this reason, the buyers' mind has been termed as a black box (Fig. 1).

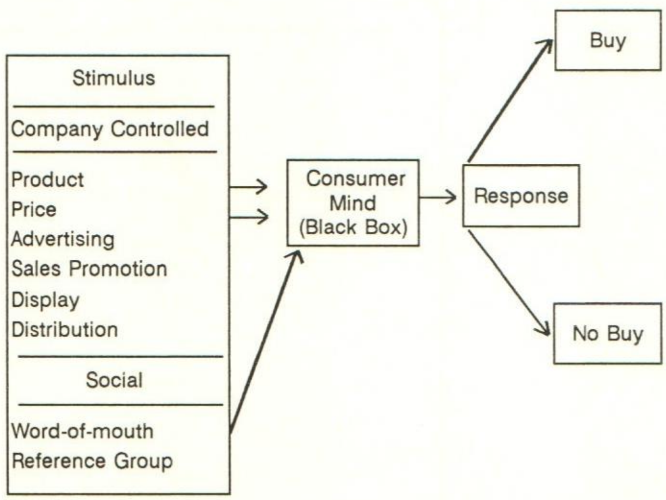

Fig. 1. Buyer Behaviour

The marketer provides stimulus but he is uncertain of the buyer responses. This stimulus is a combination of product, brand name, colour, style, packaging, intangible services, merchandising, shelf display, advertising, distribution, publicity etc. Marketing and environment stimuli enter the buyer's consciousness. The buyer's characteristics and decision process lead to certain purchase decisions. The marketer's task is to understand what happens in the buyer's consciousness between the arrival of outside stimuli and purchase decisions. A consumer's buying behaviour is influenced by cultural, social, personal and psychological factors. Cultural factors exert the broadest and deepest influence. The marketing stimuli aimed towards consumers are varied in nature. His/her decision to buy depends on the trust worthiness of particular stimuli. Marketers should aim to place their message as trustworthy and for this, reference group plays an important part. This concept can help in determining the advertising strategy to be followed in promoting the product.

Reference Groups

Although cultural factors have the greatest influence on consumers, culture may not be a determining factor in making a choice of one brand as opposed to another. The influence of culture and sub-culture is over many years. The effect of marketing variables and situations might occur during a very short time and has little lasting impact. A consumer's behaviour is much influenced by social factors, such as reference groups, family and social roles and status. Reference groups have great influence on brand purchase decisions, however its degree differs with the product categories and the buying situations. A person's reference groups consist of all the groups that have a direct (face-to-face) or indirect influence on the person's attitudes or behaviour. Groups having a direct influence on a person are called membership groups. Some membership groups are primary groups, such as family, friends, neighbors, and co-workers, with whom the person interacts fairly continuously and informally. People also belong to secondary groups, such as religious, professional, and trade-union groups, which tend to be more formal and require less continuous interaction. People are significantly influenced by their reference groups in at least three ways. Reference groups expose an individual to new behaviours and lifestyles. They influence attitudes and self-concept. And they create pressures for conformity that may affect actual product and brand choices. From marketing prospective, reference groups are groups that serve as frames of reference for individuals in their purchase or consumption decisions.

Reference groups have great influence on brand purchase decisions, however its degree differs with the product categories and the buying situations.

Marketers try to identify their target customer's reference groups. However the level of reference-group influence varies among products and brands. Reference groups appear to influence both product and brand choice strongly, mainly in the case of automobiles and colour televisions; mainly brand choice in such items as furniture and clothing; and mainly product choice in such items as beer and cigarettes (Kotler, 1997). When choosing products or services, consumers are often influenced by advice from other people. One reason for this is that consumers generally can not process all the information that is available for purchase decisions. They apply various decisions heuristics in their information processing tasks. Therefore, the manufacturers of products and brands where reference group influence is strong must determine how to reach and influence the opinion leaders in these reference groups. Customers often use information to reduce the number of alternatives in their mind and the views of their opinion leader help them in taking the final decision. Marketers have realized the fact that a strong positive word-of-mouth publicity will invariably lead a brand to higher market shares. A new product's chances of success get substantially improved when it has the support of buyers, who are perceived as opinion leaders by the target market. Diffusion of an innovation or a new product idea in a society is essentially a trickle down phenomena i.e. from opinion leaders to others who may be perceived as opinion leaders by the next group of customers. Today, people are very much concerned about their image and status in society. Their concept of status decides what material possessions they should have. The influence of reference group tends to be strongest when the product is visible to others whom the buyer respects. Products that are especially conspicuous and status revealing are most likely to be purchased with an eye to the reactions of relevant others like automobiles, fashion products etc. Whereas purchase of products, which are bought and used privately are not much affected by reference group influences because neither the product nor the brand will be noticed by others.

Manufacturers must determine how to reach and influence the opinion leaders in reference groups.

Types of Influence

Hawkins, Best and Coney (1995) have classified reference group influence into three components, viz. Informational influence, Normative influence and Identification influence (also called value expressive influence). Informational influence occurs when an individual uses the behaviours and opinion of reference group members as potentially useful lists of information. Thus a person may notice several members of a given group using a particular brand of coffee or cosmetics. He or she may then decide to try that brand simply because there is evidence (its being used by friends) that it may be a good brand. Conformity is simply the result of information shared by group members. Normative influence referred to as utilitarian influence occurs when an individual fulfills group's expectations to gain a direct reward or to avoid a sanction. Identification influence occurs when individuals uses the perceived group norms and values as a guide to their own attitudes or values. Thus the individual is using the group as a reference point for his or her own self image.

An interesting research by William D. Breaden & Michael J. Etzel, titled "Reference group influence on product and brand purchase decision", published in the "Journal of Consumer Research", in September 1982, was on how products differ in their susceptibility to reference group influences. This research reveals that reference group influence depends on two characteristics of a product; how visible it is to other persons and how exclusively it is owned (if everyone already own a product, it is much less exclusive than if only a few persons own it). Findings of this research are as follows:

Reference group influence depends on two characteristics of a product; how visible it is and how exclusively it is owned.

	LOW EXCLUSIVITY	HIGH EXCLUSIVITY
LOW VISIBILITY	"Private Necessities" Reference group influence weak for product ownership and weak for brand choices.	"Private Business" Reference group influence strong for product ownership but weak for brand choice.
HIGH VISIBILITY	"Public Necessities" Reference group influence weak for product ownership but strong for brand choices.	"Public Luxuries" Reference group influence strong for product ownership and strong for brand choice.

The reference group influence is defined as the influence from an actual or imaginary individual or group conceived of having significant relevance upon an individual's evaluations, aspirations, or behaviour. Furthermore, reference group influence has three motivational components—Information, Utilitarian and value expressive (Park & Lessig, 1977, p. 102).

Informational: Influence accepted from others for its informational content because it enhances the individual's knowledge of his/her environment or his/her ability to cope with some aspect of the environment.

Utilitarian: Influence based on compliance with others. An individual complies because he/she perceives that significant others can mediate rewards or punishments, because the individual's behaviour is known or visible to others or because the individual is motivated to realize a reward or avoid punishment.

Value Expressive: Influence relating to the individual's desire to enhance his/her self concept in the eyes of others (i.e. the individual identifies with positive referents and dissociates him/her self with negative referents).

The reference group scale used in the study by Park and Lessig (1977) is composed of 14 statements each measured along 4 point scales (i.e. highly relevant = 4, medium relevance = 3, low relevance = 2, and not relevant = 1 to one's consumer behaviour). There are 5 items each for the informational and value expressive dimensions and four items for the utilitarian dimension. Item scores are summed within dimensions and then divided by the number of items within each dimension to form indices for each dimension. A number of mean scores are reported by Park and Lessig (1977, Tables 1, 2, 3 and 4 pp. 106-108). Across the 20 products studied, mean scores ranged from 2.46 to 4.00 for informational influence, 2.33 to 3.95 for utilitarian influence and 1.93 to 3.97 for value expressive influence. Based on this scale the present study was undertaken to measure the reference group influence on purchase of car and scooter, to determine if there is any significant difference between the two categories and to determine item total correlation for car and scooter.

Methodology

The study was exploratory in nature with survey being the research approach. The survey was done on car owners and scooter owners. Keeping in mind the objective of the study, non-probability sampling was found more appropriate and the method used to select the subjects for the survey was purposive sampling.

Subjects were chosen from Indore. The sample size in the research was 200 comprising 100 car owners and 100 scooter owners.

For Data Collection: A questionnaire developed by Park & Lessing (1977) was used to collect the data from subjects. Two sets of questionnaires (Table 1) were developed for collecting the primary data from car owners and scooter owners, consisting fourteen statements on three components viz. Informational, Utilitarian and Value expressive for measuring reference group influence on buying behaviour of customers for the purchase of car and scooter. First five statements in the questionnaire measured the informational dimension. To form an index of utilitarian dimension next four statements were used and last five statements were used to measure the value expressive dimension. The respondents were asked to answer each statement on a Likert scale of 1 to 4 (minimum and maximum as 1 and 4 respectively) i.e. 4, 3, 2, 1 points for high, medium, law and no relevance respectively.

Table 1: Questionnaire (Reference Group Influence)

Q.1.	When you purchased your car, did you try gathering information about various cars from an independent group of experts?
Q.2.	Did you seek information about different cars from people who are associated with the product as profession? (Mechanics/Dealers)
Q.3.	Did you seek brand related knowledge & experience (i.e. how brand A's performance is compared to brand B's) from those friends, neighbours, relatives who have reliable information?
Q.4.	Is your choice influenced by independent testing agency?
Q.5.	Were you influenced by what experts buy (i.e. car, which is purchased by employees working in that particular industry)?
Q.6.	Were you influenced by fellow work associate?
Q.7.	Were you influenced by the preferences of people with whom you had social interaction (i.e. friends, peer groups, etc.)?
Q.8.	Was your choice of the car depending on the preferences of your family members?
Q.9.	Did you choose that particular car because you wanted to satisfy the expectations of others on you?
Q.10.	Did you choose that particular car keeping in mind that it would enhance your image in the society?
Q.11.	Did you purchase that particular car because you felt that it possesses the characteristics which you would like your ideal car to have?
Q.12.	Did you feel that it would be nice to be like the type of the person which advertisements show using a particular car?
Q.13.	Did you buy the particular car because you felt that people who purchase a particular car are admired by others?
Q.14.	Did you purchase the particular car because you felt that it would help you show others what you are/want to be?

Note: The same questionnaire was executed among scooter owners, after changing the word car by scooter in all the above statements.

For Data Analysis: Mean and standard deviations were calculated for all the three components and the total group influence. Z-test was performed to know the significance between car and scooter. Correlation coefficients were calculated between various components and also between components and total of all these components.

Results & Discussion

The objectives of this study were to measure the reference group influence in the case of car and scooter purchase and to check if there is any significant difference between the two; and to know the contribution of different dimensions viz. Informational, Utilitarian, Value expressiveness in the buying decision of car and scooter.

Study shows that average of overall reference group influence is greater in case of car (mean = 2.834) as compared to scooter (mean = 2.382). It was observed that variability was low in car purchase (S.D. = 1.074) as compared to scooter (S.D. = 1.157). Study also shows that means of information, utilitarian and value expressive dimensions of car (mean = 2.774, 3.0675, 2.663) are greater as compared to scooter (mean 2.354, 2.6025, 2.190) respectively. Variability for car for three dimension (S.D. = 1.144, 0.9748, 1.044) is less than scooter (S.D. = 1.211, 1.064, 1.143). This shows that reference group exerts greater influence in case of car purchase as compared to scooter purchase. Utilitarian dimension of reference group influence is shown to have higher influence as compared to other two dimensions. Averages for all the three dimensions in case of car are greater than scooter.

Z-test was performed to check whether the difference between car and scooter is significant, Z-statistic was calculated. Z-statistic for Informational, Utilitarian and Value expressive dimensions are 2.52, 3.23 and 3.13 which are greater than 1.96 (at 5% significance level). Z-statistic of the means of all the three dimensions viz. Informational, Utilitarian, Value expressiveness was found to be greater than 1.96 (at 5% significance level). Z-statistic for overall reference group influence is 2.87 which is greater than 1.96 (at 5% significance level). Study shows that there is significant difference in case of car as compared to scooter for all the three dimensions of reference group influence. Car purchase is more susceptible to reference group influence as compared to scooter, (Table 2).

Table 2: Results: Test of Significance (Z-Test)

Hypothesis 1 "There is no significant difference between the information dimension of car and scooter".

Mean (car) = 2.774 S.D. (car) = 1.144

Mean (scooter) = 2.354 S.D. (scooter) = 1.211

Difference = 0.42

$$\text{Standard Error} = \sqrt{\frac{(1.144)2}{100} + \frac{(1.211)2}{100}}$$

Z-statistic = 0.42/0.166 = 2.52

Z-statistic is greater than the standard 1.96 (At 5% significance level). The hypothesis is rejected. Hence, there is a significant difference between the means of information dimension of car & scooter.

Hypothesis 2 "There is no significant difference between the utilitarian dimension of car and scooter".

Mean (car) = 3.0675 S.D. (car) = 0.9748

Mean (scooter) = 2.6025 S.D. (scooter) = 1.064

Difference = 0.465

$$\text{Standard Error} = \sqrt{\frac{(0.9748)2}{100} + \frac{(1.064)2}{100}}$$

Z-statistic = 3.23

The hypothesis is rejected. Hence, there is a significant difference between the means of utilitarian dimension of car & scooter.

Hypothesis 3 "There is no significant difference between the value expressive dimension of car and scooter".

Mean (car) = 2.663 S.D. (car) = 1.044

Mean (scooter) = 2.190 S.D. (scooter) = 1.143

Difference = 0.473

$$\text{Standard Error} = \sqrt{\frac{(1.044)2}{100} + \frac{(1.143)2}{100}}$$

Z-statistic = 3.13

The hypothesis is rejected. Hence, there is a significant difference between the means of value expressive dimension of car & scooter.

Hypothesis 4 "There is no significant difference between the reference group influence on consumer behaviour for purchase of car and scooter".

Mean (car) = 2.834 S.D. (car) = 1.074

Mean (scooter) = 2.382 S.D. (scooter) = 1.157

Difference = 0.452

$$\text{Standard Error} = \sqrt{\frac{(1.074)2}{100} + \frac{(1.157)2}{100}}$$

Z-statistic = 2.87

The hypothesis is rejected. Hence, there is a significant difference between the means of reference group influence on consumer behaviour for purchase of car & scooter.

Correlation coefficient between dimensions and item total correlation was calculated. In case of car, correlation between informational and utilitarian, informational and value expressiveness and utilitarian and value expressiveness were found to be 0.4208, 0.4591 and 0.5372 respectively. In case of scooter, correlation between informational and utilitarian, informational and value expressiveness and utilitarian and value expressiveness were found to be 0.3404, 0.5281 and 0.6237 respectively. The correlation coefficients between each dimension were observed to be high, (Table 3).

In case of car, correlation between informational dimension and total, utilitarian dimension and total and value expressiveness and total were found to be 0.8112, 0.796, 0.8287. This shows that each dimension is contributing in the overall reference group influence. In case of scooter, correlation between informational dimension and total, utilitarian dimension and total and value expressiveness and total were found to be 0.7703, 0.7817, 0.8923. It is observed that item total correlation is high and it shows that all the three dimensions are contributing in the overall reference group influence. Study shows that all the three dimensions exert greater influence in car purchase as compared to scooter purchase. In both cases utilitarian dimension of reference group influence is shown to have higher influence as compared to other two dimensions. Therefore, marketers should focus more on utilitarian dimension while making marketing strategy for car and scooter.

Table 3: Correlation Coefficients

For Car Owners

	Informational	Utilitarian	Value	Total
Informational	–	0.4208	0.4591	0.8112
Utilitarian	–	–	0.5372	0.796
Value expressive	–	–	–	0.8287

For Scooter Owners

	Informational	Utilitarian	Value	Total
Informational	–	0.3404	0.5281	0.7703
Utilitarian	–	–	0.6237	0.78179
Value expressive	–	–	–	0.8923

Implications

The findings of the present study have significant implications for marketers and advertisers, especially those operating in automobiles. Results of this study clearly indicate that reference groups have great influence on buyer behaviour in purchase of both car and scooter. From researcher's perspective, the study needs to be replicated on a large sample. In addition researchers can measure reference group influence on other products, which may include both durables and non-durables. Further they can form a continuum of reference group influence across product categories.

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"Excellent firms don't believe in excellence – only in constant improvement and constant change".

– Tom Peters

Feature

Management of Customer Defection – An Integrated Strategy of Four C's

M.A. Sahaf

Firms spend time and effort on acquiring customers. It is perhaps even more important, to devote effort to customer retention. Customer retention helps a firm to increase its profitability and understand consumer preferences and needs. The present paper describes the special features and elements of an effective customer retention strategy that a firm requires to achieve success.

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An organisation cannot survive in an ivory tower, it should gain customer support to continue operating. This support is offered by loyal customers–supporters and advocates–through repeated sales. Loyal customers even become business builders as they buy more, pay premium prices, and bring in new customers through referrals (O'Brien & Jone 1995). Thus, the basic purpose of any business should be 'to create and keep customers'. But unfortunately the practice has been quite reverse as marketers focus solely on winning customers and no serious attention is paid to retain them. It is believed that keeping them will happen automatically. Some managers do not consider consumer defection a serious problem as they believe that a good business will always find customers to replace the defecting ones (Kotler & Armstrong, 1995). Such an attitude is dangerous for the survival and growth of business.

Marketers not only have to change this tendency of finding new customers at the cost of old ones but also have to realize that cutting defections in half doubles the average company's growth rate (Bateson, 1995). Moreover, reducing the defection rate by five per cent can boost profits from 25 per cent to 80 per cent, depending on the industry (Reichheld & Sasser, 1990). The fundamental task of marketing function should be to minimize customer defection.

Management of Defection

Management of defection is a systematic process consisting of all such efforts of a marketer that ensure customer retention before he will defect. Therefore, the process begins with identification and analysis of reasons for customer defection that enables a marketer to improve his market offering continuously. As a consequence customers find the improved offer more suitable for them which would bring a considerable reduction in future defections. Merely satisfying the customer is rarely enough to give him a reason for staying with a company (Sellers, 1993). Customer defection is bound to take place as and when the customer finds the offering of another firm innovative in its outlook as he gets a better value for his investment from the said offer. As long as a firm succeeds in meeting customer needs better than its competitors, defection is relatively impossible. Such an approach keeps customers delighted and therefore, switching to a substitute brand is unthinkable. To keep customers delighted, marketers in future have to replace traditional marketing by a differentiated marketing formed by integrating four C's – cooperation, customization, customer service and customer value.

Management of defection begins with identification and analysis of reasons for customer defection.

Co-operative Spirit

To manage customer defection, a co-operative spirit among the marketer and customer is essential. The traditional marketing system i.e., transaction marketing, has failed to develop a meaningful and workable relationship – an essential prerequisite for customer retention – between them. To ensure such a relationship both parties should consider each other wedded partners who can think of progress and prosperity through joint efforts. The findings of various research studies clearly reveal that concern for one's partner, fairness, honesty and shared values expand the scope for long term cooperation (Robert & Hunt, 1994). But such a feeling is not observed in the current business scenario. In fact, these partners find themselves estranged if not enemies. At present, customers feel that marketers concentrate more on the objectives that suit them better and less on consumer needs. To remove this feeling and make customers comfortable and responsive towards his programme, a marketer has to work continuously with the customers. The whole process should be based on a reciprocal interaction that would bind the marketer and consumer together and would enable them to meet each other's needs. The spirit of such a prospective interaction can be captured in the term – "Co-destiny" – each party's destiny will be dependent on the other (Sahaf, 1998). This strong interaction and relationship to prosper would require far more trust than before, because both parties would be more reliant on each other than they are when under transaction marketing. This trust shall be the critical determinant of long-term sales opportunities in the future (Crosby, et al, 1990).

Further, such an interaction would provide a marketer an opportunity to have accurate first-hand information about customer preferences and needs which would enable him to meet the demands effectively. Such an information would provide a marketer an immense competitive advantage. At present, few small business firms take advantage of this interaction by using first-hand information. Executives of business firms in general and large firms in particular cannot take advantage of this interaction as they often learn about the customer needs, through marketing reports. Consequently, there is a wide gap between what customers actually need and what the high-level executives, who are not in contact with customers, learn about such needs through reports. To bridge this gap, firms should make adequate arrangements to encourage sales people who are in regular contact with customers to communicate their experiences to the concerned executives. Further, by observing service delivery, executives should gain insights into customer expectations and perceptions. Executives can also reduce the knowledge gap by meeting panels of customers at regular intervals and thereby sharing views about their interaction with the firm. These interactions would encourage frank feedback. Such an approach would not only create a favourable impression in the mind of customers but at the same time provide an opportunity to a marketer to come closer to a customer – a prerequisite for successful cooperation. The marketer has to avoid a generalised approach in the selection of target customers and has to direct his value-oriented programme only to such customers who ensure maximum cooperation to him. (O'Brien and Jones, 1995).

Customization

As the consumer becomes conscious of his position in the market, his preferences and needs become more complicated and demanding. A firm would not achieve much success as long as it continues to approach the market with a mass market strategy – turning out a huge quantity of goods. Such a strategy fails to offer additional satisfaction that differentiates a firm's offering from its competitors. Essentially, the only way to replace customer satisfaction with customer delight is to tailor one's offer to the individualized needs of each customer. This would demand a shift from standardization to customization – a strategy in which a firm tailors its

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product and marketing efforts for a single individual customer, in order to match his individual preferences. The customized strategy on the one hand would help a firm develop a sustainable competitive advantage and on the other hand it might result in inconsistency in a firm's marketing offer as it would depend more on the firm's judgement and capabilities and less on the firm's set of rules and procedures. In addition, such a strategy is costly as it fails to maintain cost efficiencies of conventional mass production strategy. As a consequence, a firm has to pursue either differentiation strategy by employing customization approach or low cost strategy by using standardization approach in order to maintain a competitive advantage. To meet the growing demands of a competitive market, a firm would desire to make possible simultaneously the effective use of both low cost and differentiation strategies. Against this backdrop, a firm can standardize some aspects of its product and market strategy which are not of strategic importance for a consumer while leaving remaining aspects of the strategy for customization. For example a firm may take products of standardized manufacture and locate a few processes of their manufacturing that would be tailored to individual needs. In the same way some aspects of the marketing strategy like packaging, promotions, position etc. can be standardized to achieve the benefits of economies of scale. This blend of standardization and customization called mass customization would help a firm achieve dual goals of cost-reduction and differentiation. At the same time, an organisation would reach the same large number of customers as in the mass-market and simultaneously would treat them individually as in the customized market without sacrificing the speed or cost efficiencies of mass production. Although apparently it seems a simple process it calls for total transformation of the organisation.

Blend of standardization and customization called mass customization would help a firm to achieve dual goals of cost-reduction and differentiation.

Customer Service

Customer service is one of the key factors that keeps customers delighted. Quick order handling, training on how to use the product effectively, answering buyers' questions fully, accurately and promptly, and speedy and satisfactory handling of complaints have consistently given the competitive edge to a marketer. A study conducted by Forum Corporation, a Boston Consulting Firm, reveals that service-related issues were the main cause for forfeiture of relations between firms. Customer service adds value to the basic product and therefore, can be used as a main weapon against competitors. Despite strategic importance, customer service is the most neglected area of marketing in India. Whatever attempt has been made in this direction by Indian firms has been a half-hearted one (Saxena, 1997). Marketers in India still perceive customer service as a small component of logistics management that is concerned with the delivery of the product to the customer. However, to meet the growing demands of competitive market, this perception of marketers about customer service has to be changed and replaced by a wider view which considers it a strategic tool for differentiation. Customer service as a differentiating tool must constitute 'three 'S's of service'—system, strategy and staff.

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There is a need to devise a customer-friendly system. For this purpose, marketers have to ensure a continuous interface between their system and customers. They have to seek maximum cooperation and help from customers. Where complex or difficult systems are unavoidable, customers may need help by training which should be imparted to them by the marketer as and when they desire it. Firms can offer suggestion schemes to their customers for making the system more friendly. The various components of customer service system—ordering, logistics, payment, after sale and contingency—should be coordinated in such a way so as to operate as an integrated system. Further, with the advancement in technology, firms should use varied and different systems in combination to meet the expectation of customers. Every effort must be made to make it responsive to the changing environment. To keep customer service system (CSS) effective, the marketer should review the performance of the system regularly and changes required in the system should be incorporated as and when needed. Such an approach would not only improve internal efficiency of the system but would also help reduce operational cost.

A carefully thought out strategy is the best foundation for effective managerial actions. A formally expressed service strategy helps organisation's members understand their role clearly in achieving customer service objectives. The strategy needs to demonstrate the organisation's commitment to customer service and its role in overall corporate strategy. Against this backdrop, it is essential for the organisations to express their philosophy vis-a-vis customer service in their corporate mission statement. In the light of customer service objectives, management has to develop an appropriate service packages for the target market. Different service packages need to be developed for different market segments. Thus each market segment has to be properly studied in order to assess the relative significance of each element of customer service in it. After devising a service package for a target market, it shall become an essential component of the marketing mix that has been designed for it.

No matter how well a customer service system and strategy may be devised, they cannot be functional unless they are equipped with professional and dedicated staff to support them. Person-to-person relationship between service providers and customers plays an important role in the success of a business. Therefore, staff for front line needs more human skills than technical skills to perform its job efficiently. But the selection procedure of firms for such jobs often fails to recognise this fact. Most firms select their front line staff on the basis of technical competence without paying attention to human skills. Consequently, the staff thus appointed may feel exposed and insecure when in contact with customers and, therefore, take refuge in the technical nature of its work, consciously or unconsciously ignoring the significance of the inter-personal relations—an essential ingredient of customer service.

Staff for front line needs more human skills than technical skills.

Firms need to thoroughly examine their selection criteria to ensure the staff appointed for this purpose possess both human and technical skills. The problem is further aggravated in the absence of proper and adequate training. Usually firms organise training programmes for their front line staff that cover only conceptual and technical aspects of their jobs. Training to improve interpersonal skills for front line staff is as necessary as for any other skill. There are many group training techniques, of which the best known and for customer service, probably, the most useful is role playing (Peel, 1987). Such an approach to training not only provides an insight into the perception of the staff members involved in customer service but also motivates them to perform their job to the best of their capabilities.

Customer Value

Customers in future are expected to be more rational in their buying decisions and therefore, strongly value-oriented. Customer expression about value can be summed into four forms: (i) value is low price, (ii) value is whatever a customer wants in a product or service, (iii) value is the quality a consumer gets for the price he pays, and (iv) value is what a customer gets for what he pays (Zeithaml, 1988). However, in a broader perspective, value can be thought of in terms of the perceived worth in monetary units of the technical, economic and psychological benefits a customer would receive in exchange for the price he pays for a product (Anderson & Narus, 1998). As long as the perceived worth of the market offering is higher than the customer's investment in terms of price and efforts to realize the offering, he would consider the offering valuable. In competitive terms, the market offering that carries the highest value among the available alternatives would be considered by the customer. Alternatively, unless a firm's market offering looks superior in some way than its competitors, it may not gain customer acceptance. Consequently, every firm desires to find new ways of providing meaningful differentiation through value enhancement. This would be one of the main challenges to marketers in the future.

As long as the perceived worth of the market offering is higher than the customer's investment in terms of price and efforts to realize the offering, he would consider the offering valuable.

One of the popular techniques which can be used to ensure superior delivered value is the value chain—a systematic means of displaying and categorizing activities (Porter, 1985). The value chain provides a systematic means of analysing the contribution of individual activities in a business to the overall level of customer value the firm produces. Such an assessment enables a firm to enhance the value of its market offering by reviewing the activities which add little value to the offering and identifying the possibilities to add more value at each stage. Although individual roles of process activities within a value chain to improve the firm's overall ability to create value cannot be underestimated, this role becomes even more significant when played in combination. This is because the value chain is not a collection of independent activities but a system of interdependent activities. Overall value for customers is created not by individual activities but by groups of activities that come together to form what are known as core processes and systems. While studying a value chain, marketers should not consider activities in isolation and should manage the chain as a whole system despite the varying importance of individual activities.

In the past few years, some attempts have been made to consider the value chain as part of larger core processes with a purpose to maximise the overall value the business provides to customer rather than maximising individual activities (Miller & Dess, 1996). Efforts are on to "reengineer" core processes and systems to ensure better value to customers for their investment. In this direction, over the last decade, core process reengineering has been widely used by the managers. Core Process Reengineering (CPR) begins with what could be and works backward to rethink aims to bring radical improvements in the existing processes through reengineering. It involves organisational efforts related to improving the process of doing things. Since core process reengineering concentrates simultaneously on quality, cost and speed, there is enough scope for making an organisation capable of meeting customer needs.

Conclusion

Organisations often pay more attention to gain new customers than to keep old ones but research into the profitability of old and new customers indicates that customer retention rate can have a dramatic impact on boosting the profits of organisations. Marketers have to recognise sooner or later that a loyal customer is worth in rupees. Accordingly, they have to seriously rethink their priority of winning a customer in favour of retaining him. Consequently, marketers have to strive hard to achieve this goal. Against this backdrop, the integrated strategy of four C's has been recommended to help organisations in fulfilling this goal. The integrated strategy sounds academically simple and straight forward. But a firm has to be careful in its implementation which demands intelligence, maturity and experience on the part of marketers. They have to understand the critical dimensions of each component of the strategy and the relationship that exists between the components in order to ensure their integration. Integration of the components is the key to using this strategy as a competitive weapon. Therefore, a marketer has to ensure closer alignment of crucial elements of the strategy and where each element should be focussed on towards meeting customer requirements.

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Equity Considerations of Regional Rural Banks in Punjab

Sajla Kalra & Karam Singh

Regional Rural Banks (RRBs) established in 1975 as a new set of state sponsored, region based, rural oriented and low cost banks, were mandated to purvey credit in rural areas, especially to the weaker sections of society and industry. Keeping this aspect in mind, an attempt has been made to study as to how far the RRBs have carried out institutional reforms in the field of rural credit, and in what way their policies have been effective in reaching out to the relatively weaker sections of the rural society.

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Parity in distribution of income and wealth has been a major concern in India since independence because of the great contrast prevailing between the grinding poverty of masses and growing affluence of a few at the top. Therefore, greater equality of income and wealth through accrual of more benefits of development to relatively less privileged classes and a progressive reduction in the concentration of income, wealth and economic power have been the focus of our national policy.

Institutional Assistance for Rural poor

In order to improve the access of institutional assistance to all sections of population, there has been continuum of measures and reforms in the banking sector such as mandating funding to the priority sector, agriculture and linking with development programmes for weaker sections. In spite of these efforts, benefits of institutional credit expansion have largely accrued to the well-off farmers and a majority of the rural poor have remained outside the institutional network (Adams & Vogel, 1986; Egger, 1986; Ghatak, 1983; Sarap, 1990). Institutional leaders prefer to lend against immovable and tangible collaterals and consequently labourers, artisans and small landholders who own little of such collateral assets generally get screened out. Thus, reforms are warranted in the institutional credit system for rural areas. One such step which was expected to bring about reduction in rural poverty and inequality, was improving the access of rural poor to institutional credit. It was against this background that the Government of India approved a working group on rural banks under the chairmanship of Shri M. Narasimham "to examine in depth the setting up of new rural banks as subsidiaries of public sector banks to cater to the credit requirements of the rural people" (Govt. of India, 1975). It was on the recommendation of this Committee that regional rural banks (RRBs), as a new arrangement, were established in 1975 to overcome the ethos, attitudes and high cost profile of commercial banks which were not conducive to meet the credit needs of the rural population, especially the weaker sections, to the required extent.

RRBs were established to overcome the high cost profile of commercial banks not conducive to meet the credit needs of rural population.

Credit is a lubricant that keeps the wheels of development moving. "In Indian agriculture with 74.5 per cent of operational holdings falling in the category of small and marginal, the primary responsibility of development rests with the government because it needs colossal public expenditure and strong policy intervention" (Dantwala 1988). Agricultural credit policy of the Government since its inception stressed upon equitable distribution of institutional credit among all the regions of the country, among all the areas within the state and among all the farm size classes. The supply of institutional credit to small and marginal farmers always remains of special significance because of their very low capacity of generating economic surpluses as such and consequently their inability to make productive investments on their farms and/or to meet the operating cash requirements of modern production technology.

Keeping this aspect in mind, an attempt has been made to study as to how far the RRBs have carried out institutional reforms in the field of rural credit, and in what way their policies have been effective in reaching out to the relatively weaker sections of the rural society. These objectives have been examined with reference to the functioning and performance of a RRB in Punjab namely Malwa Gramin Bank (MGB). Malwa Gramin Bank (MGB) sponsored by State Bank of Patiala was established in 1986 and serves the districts of Sagrur, Patiala and Fatehgarh Sahib with a network of 41 branches. Since its establishment, MGB has played an important role in enhancing rural credit system and is one of the best RRBs as far as recovery performance (94.67 per cent in 1996- 97) is concerned. The functioning and performance of the two branches of Malwa Gramin Bank, selected randomly, namely Thulliwal and Ghanaur, was analysed in detail. This is based on the data of all the 817 borrower households of these two branches. To delineate the rural poor or weaker sections, the households were classified into different groups on the basis of their socio-economic characteristics like caste/religion, occupation, land ownership and value of assets owned. The distribution pattern of loans was analysed by contrasting the percentage share of each group under different socio-economic categories in the total loans disbursed as compared to percentage share of each group in the total sample. The average loan per unit obtained by a household under each group was also studied. Further, more analytically, the equity was measured through Lorenz curves and Gini concentration ratios for various parameters taking data or cumulative per cent of farmers across farm size groups and corresponding cumulative percentage of bank advances, outstandings, recovery and interest burden shared by them.

Distribution Pattern by Social Groups

The sample households based on caste and religion were classified into three broad social groups, namely, upper caste, backward caste and schedule caste including schedule tribe (SC and ST). The grouping was done in such a way as to represent the status of a household under social hierarchy.

Distribution of loans advanced during 1996-97 agricultural year (AGY) according to social groups showed that upper caste group received more than its proportionate share in the total loan advanced to sample households (Table 1). Thus, households in upper caste group who constituted about 75 per cent of sample households received as much as 98 per cent of total loans advanced. For all other groups the share in total loan amount was less than their proportion in the total number of households. The average amount of loan received by upper caste groups was Rs. 22, 554, which was far higher than the loan per household in other groups. SC and ST households who were at the bottom of the social hierarchy received an average loan of Rs. 704 and backward caste households received an average loan of Rs. 1,822.

Upper caste group who constituted about 75 per cent received as much as 98 per cent of total loans advanced.

Distribution of outstanding loans as on 1.7.96 according to social groups shows even further inequitable distribution. Thus out of the total loans outstanding on 1.7.96, share of upper caste household was as high as 93.27 per cent. The average amount of loan outstanding of upper caste group comes out to Rs. 18,201 which was also the highest among all households.

Distribution of loans recovered during 1996-97 AGY showed that share of recovery from upper caste groups was also higher at 97.25 per cent against the share in advances of 92 per cent which may also be partly due to better services provided by banks to this group and partly due to better economic viability.

Share of recovery from upper caste groups was also higher at 97.25 per cent partly due to better services provided and partly due to better economic viability.

Table 1: Relative Share of MGB Assistance According to Social Groups, 1996-97 (per cent)

Social Groups	House-holds	Advan-ces	Outstandings as on 1.7.96	Outstandings as on 30.6.97	Re-covery	Interest burden borne
Upper caste	74.91	98.41	93.27	94.51	97.25	93.74
Backward caste	8.57	0.91	2.62	2.47	0.99	2.24
SC and ST	16.52	0.68	4.11	3.02	1.76	4.02

Source: Malwa Gramin Bank

Distribution of outstanding loans as on 30.6.97 according to social group showed that share of upper caste groups in the loans portfolio increased over time. Thus, their share in total loan outstandings at the beginning of AGY (as on 1.7.96) was 93.27 per cent, advances during the AGY (1996-97) were 91.41 per cent; with recovery share at 97.25 per cent outstandings by the close of the year (as on 30.6.97) increased to 94.51 per cent.

The interest burden borne was worked out as follows:

$$I = (O_e - O_b) + (R_d - La)$$

where,

I = Interest burden borne during the year.

O_e = Loans outstandings at the end of the year.

O_b = Loans outstandings at the beginning of the year.

R_d = Loans recovered during the year.

L_a = Loans advanced during the year.

The average amount of interest borne by upper caste, backward caste and SC and ST borrower was Rs. 3223, Rs. 672 and Rs. 626, respectively, the overall average being Rs. 2575 per borrower (Table 2).

Table 2: Average Share of MGB Assistance According to Social Groups, 1996-97 (Rs.)

Social Groups	No of House-holds	Average loan Advan-ced per borrow-er	Average loan Outstandings per Borrower as on 1.7.96	Average loan Outstandings per Borrower as on 30.6.97	Average loan recover-ed per borrow-er	Average interest burden borne per borrow-er
Upper caste	74.91	22554	18201	21665	22313	3223
Backward caste	8.57	1822	4462	4957	2000	672
SC and ST	16.52	704	3639	3135	1835	626

Source: Malwa Gramin Bank

To sum up the relative share (%) according to social groups, the analysis shows that 98 per cent of advances of MGB have gone to upper caste group which constituted about 75 per cent of sample households. For all other social groups, the share in total loan advanced was far less than their respective proportion in total number of households. Even for outstandings at the beginning and end of agricultural year 1996-97, the loan outstanding was the highest for upper cast group. It is also important to note that the amount of loan recovered during the year was less than the amount of loan advanced to upper caste group only because of asset-building with the help of institutional loans by this group. In case of lower caste groups, loan recovered was more than loan advanced during the year thereby indicating little assistance in strengthening their income earning capacity for the long run.

Distribution Pattern by Occupational Groups

Based on the main occupation of borrowers, the sample households were classified into four groups namely, agricultural labour, rural artisan/service, trade and business and cultivator.

Distribution of loans advanced according to occupational groups during 1996-97 AGY showed that cultivator households received more than their proportionate share in the total loan advanced to sample households. Thus, whereas cultivator households constituted 72.34 per cent, they received 97.58 per cent of the total loans. Households having trade and business as main occupation obtained about 0.78 per cent of loans (Table 3). In the case of other two occupational groups, agricultural labour and rural artisan/service, share of loan received was 0.97 per cent and 0.67 per cent whereas they formed 13.93 per cent and 9.06 per cent of total sample households, respectively. Even average loan obtained showed that it was the households in cultivator groups who got a higher average loan amount when compared to other occupational groups. Cultivator household received a far higher average loan of Rs. 23, 158. Trade and business households got an average loan of Rs. 2808 whereas agricultural labour and rural artisan group got Rs. 1199 and Rs. 1278, respectively (Table 4).

Table 3: Relative Share of MGB Assistance According to Occupational Groups, 1996-97 AGY (per cent)

Occupational Groups	Households	Advances	Outstandings as on		Recovery	Interest burden borne
			1.7.96	30.6.97		
Agricultural labour	13.83	0.97	3.29	2.88	1.39	3.45
Rural artisan	9.06	0.67	1.89	1.67	0.87	1.71
Trade/ business	4.77	0.78	1.86	1.83	0.83	1.96
Cultivator	72.34	97.58	92.96	93.62	96.91	92.88

Distribution of outstanding loans as on 1.7.96 according to occupational groups showed that the total loan outstanding was the highest in case of cultivator household group (92.96%) followed by agricultural labour (3.29%), rural artisan (1.89%) and finally the trade and business group (1.86%). The average loan outstanding per cultivator group stood at Rs. 18,785, followed by the business group at Rs. 5686, agricultural labour at Rs. 3477 and rural artisan group at Rs. 3053 (Table 4).

Table 4: Average Share per borrower of MGB Assistance According to Occupational Groups, 1996-97 AGY (Rs.)

Occupational Groups	No.of Households	Average loan advanced per Borrower	Average loan Outstandings per borrower as on		Average loan recovered per borrower	Average interest burden borne per borrower
			1.7.96	30.6.97		
Agricultural labour	13.83	1199	3477	3579	1739	642
Rural artisan	9.06	1278	3053	3171	1645	486
Trade/ business	4.77	2808	5686	6565	2983	1055
Cultivator	72.34	23158	18785	22223	23026	3307

Source: Same as Table 1

Distribution of loans recovered according to occupational groups during 1996-97 AGY showed that the total estimated amount of loan recovered was the highest for cultivator group household, which was 97 per cent of the total amount recovered. Recovery from agricultural labour household group was 1.39 per cent and from rural artisan and trade/business household group recovery was 0.87 and 0.83 per cent, respectively.

Distribution of outstanding loans as on 30.6.97 according to occupational groups showed that share of cultivator group in the loan portfolio of RRBs increased over time. Thus, their share in total loan outstandings at the beginning of AGY (as on 1.7.96) was 92.96 per cent (Table 3) and advances during AGY (1996-97) were 97.58 per cent with recovery share at 96.91 per cent; the outstandings by the close of the year (as on 30.6.97) increased to 93.62 per cent.

Average interest burden borne during the AGY 1996-97 by the agricultural labour, rural artisan, trade/business and cultivator household was Rs. 624, Rs. 486, Rs. 1055 and Rs. 3307, respectively (Table 4), the overall average being Rs. 2575 per borrower.

Equity aspects of MGB loans showing the relative share (%) according to occupational groups showed that cultivator households received more than their proportionate share in total loans advanced by MGB. The other three occupational groups received less advances than their proportionate share in total sample households. Since the cultivator group received the maximum advances, this group had major share in loan outstanding both at beginning and at the end of agricultural year. But the share in advances to each of the three lower social groups was less than their respective share in outstandings, which shows that flow of credit to the weaker sections is not that smooth.

Cultivator households received more than their proportionate share in total loans advanced.

Distribution Pattern by Farm Size Groups

Land is the basic asset which determines the economic status of a rural household and hence credit-worthiness to a great extent. The sample households were classified into seven farm size groups on the basis of the extent of their land ownership. For the lower three farm size groups, including the landless (upto 4 acres), share of loan obtained was about 22 per cent of the total loan advanced which was far lower when compared to their share in total number which was 57 per cent of all households (Table 5). Even amongst agricultural households share of this stratum was 20.6 per cent in all loans, 25 per cent in crop loans and as dismal as

1.4 per cent in term loans compared to their being 40.4 per cent in numbers. As one moved up from lower to higher farm size groups, proportion of loans received by different groups became more or less equal to and finally becoming much higher than their respective share in the total sample. Households in the highest farm size groups alone constituting only about 8 per cent of all households obtained nearly 22 per cent of total loans. The term loans were appropriated to the extent of 84 per cent by households of above 8 acres who constituted only 25 per cent of all households.

Average loan obtained by a household in different farm size groups increased with increase in size of land ownership. While for the landless category average loan obtained was Rs. 1470, for the largest farm size group, it was as high as Rs. 48,391 i.e., a difference of nearly forty times (Table 6). In other words, the pattern is, the larger the ownership of land, the higher the loan obtained from the MGB. As demand for agricultural loans basically depends upon size of land holdings, loans advanced per acre would better reflect the inequality. It was found that average loan obtained per acre decreased as farm size increased. Average loan per acre was the highest for the smallest farm size category of upto 2 acres which was Rs. 5021 per acre. It was Rs. 4513 and Rs. 4466 per acre for the next two categories of 2-4 and 4-6 acres respectively, but declined sharply to Rs. 3975 for the farm size category of 6-8 acres. Since the term loan advanced increased sharply for the farm size categories of above 8 acres, the per acre loans advanced again increased to Rs. 4435 and Rs. 4331 for farm size categories of 8-10 and above 10 acres, respectively. Thus there was not much inequality in loans advanced per acre on different farm size holdings.

The larger the ownership of land, the higher the loan obtained.

Distribution of outstanding loans on 1.7.96 according to farm size groups showed that the lower farm size groups (upto four acres) forming 57 per cent of total sample household had about 18 per cent of total loan outstandings (Table 5). The higher farm size groups which formed 43 per cent of total sample households had about 82 per cent of total loan outstandings. Households in the highest farm size group alone constituting only about 8 per cent had nearly 40 per cent of total loan outstandings. Average loan outstandings per borrower goes on increasing for owners of large farm size groups. Again, average loan outstandings per acre increased upto 2-4 acres farm size category, were the lowest at Rs. 1726 per acre for 4-6 acres farm size category but increased sharply after that to touch Rs. 6664 per acre for the largest farm size groups. It was because of term loans which are mainly obtained by farm size categories of above 6 acres.

Distribution of loans recovered according to farm size group during 1996-97 AGY showed that the lower two farm size groups alongwith the landless had share of about 23 per cent in total loans recovered, whereas they formed nearly 57 per cent of total sample households (Table 5). Repayments by the higher land size groups forming 43 per cent of total sample households contributed for about 77 per cent. Average loan recovered per borrower increased with increase in farm size. Average loan recovered per acre varied between Rs. 4653 for the smallest farm size category and Rs. 4133 for 8-10 acres farm size category (Table 6). There was an indicative negative association of loans recovered per acre with farm size.

Table 5: Relative Share According to Farm Size Groups, Various Financial Indicators, 1996-97 (per cent)

Farm Size group (acres)	House-holds	Advan-ces	Out-standings as on 1.7.96	Out-standings as on 30.6.97	Re-covery	Interest burden borne
Landless	28.26	2.42	7.32	6.57	3.18	7.37
Up to 2	6.23	2.73	1.26	1.38	2.53	0.51
2-4	22.73	17.96	9.49	8.68	17.99	4.27
4-6	18.21	23.69	10.76	12.31	12.01	9.67
6-8	10.76	17.46	14.48	12.77	19.53	10.99
8-10	5.87	13.66	17.41	18.99	12.72	20.67
10 and above	7.94	22.08	39.28	39.30	22.04	46.52

Source: Same as Table 1

Distribution of loan outstandings as on 30.6.97 according to farm size groups showed that the lower farm size groups which got relatively less advances in proportion to their share in total sample households (57%), had only 16 per cent of total loan outstandings (Table 5). The highest farm size group which formed only about 8 per cent of total sample households got the major chunk of loan advances and had as high as 39 per cent of total loans outstandings. Loan outstandings per acre increased with increase in farm size and were distinctively higher for farm size categories of above 8 acres.

Distribution of interest burden borne according to farm size groups for the agricultural year 1996-97 was also studied. The average interest burden borne per borrower for the landless category worked out to Rs. 3036 (Table 6). It increased with increase in farm size;

from Rs. 212 per borrower for the smallest farm size category to Rs. 15059 per borrower of the largest farm size group.

Table 6: Average Share per borrower According to Farm Size Groups, Various Financial Indicators, 1996-97 (Rs.)

Farm Size Group (acres)	No.of House-holds (%)	Average loan advan-ced per Borrow-er	Average loan Outstandings per borrower as on 1.7.96	Average loan Outstandings per borrower as on 30.6.97	Average loan recover-ed per borrow-er	Average interest burden borne per borrow-er
Landless	28.26	1470	3784	3992	1933	671
Up to 2	6.23	7531	2924	3765	6979	212
2-4	22.73	13538	6093	6551	13584	482
4-6	18.21	22300	8628	11581	20745	1366
6-8	10.76	27822	19653	20366	31162	2627
8-10	5.87	39917	43326	55515	37193	9061
10 and above	7.94	48391	73300	84832	47624	15059

Source: Same as Table 1

Relative access of different farm size groups to the MGB finances in terms of various financial parameters shows that the lower farm size groups (upto 4 acres) which constituted about 57 per cent of total sample households received about 22 per cent of the total loan advanced during the agricultural year which was far lower than their share in total number. As one moved up from lower to higher farm size groups, the proportion of loans received by different groups became more or less equal to or higher than their respective share in total sample. The lower farm size groups share in total outstandings and recovery was also far lower than their share in total sample households. In other words, the pattern was that the larger the ownership of land, the higher the loan advances, outstandings and recovery. Thus inequality in land ownership which is the basic resource that determines the use of capital results in inequality in access to financial institutions.

Lower farm size groups (upto 4 acres) which constituted about 57 per cent received about 22 per cent of the total loan advanced.

Distribution Pattern by Asset Groups

Besides land, there are also other assets like buildings, livestock, financial assets etc. which determine a household's economic status, demand for credit and capacity to borrow. The sample households were classified into seven asset groups on the basis of value of various assets they owned. The distribution pattern of MGB's loans across these asset groups was also studied in detail as follows.

Distribution of loans advanced according to asset groups during 1996-97 AGY showed that the top three asset groups constituting 18 per cent of the total households received nearly 41 per cent of the total loans (Table 7). The largest asset group alone, with 6.24 per cent share in total sample, received nearly 18 per cent of the total loans. The four lower asset groups accounting for 82 per cent of total households put together obtained only 59 per cent of the total loans. The average loan received by a household in different asset groups showed a strong positive association with increase in the value of assets owned. The households in the lowest asset group on an average received a loan of Rs. 1344 each, those in the largest asset group received Rs. 48,843 each (Table 8).

Table 7: Relative Share of MGB Assistance According to Asset Groups, 1996-97 AGY (per cent)

Asset Groups (Rs.)	House-holds	Advances	Outstandings as on 1.7.96	Outstandings as on 30.6.97	Re-covery	Interest burden borne
Upto a lakh	26.19	2.05	6.99	6.08	2.94	6.87
1-4 lakhs	16.65	8.30	4.46	4.45	8.09	3.09
4-8 lakhs	23.74	24.67	12.76	12.62	24.02	7.55
8-12 lakhs	14.81	22.78	19.07	16.42	24.74	14.54
12-16 lakhs	7.95	12.00	14.97	12.60	14.69	13.04
16-20 lakhs	4.42	12.44	10.57	13.76	10.29	17.47
More than 20 lakhs	6.24	17.76	31.18	34.07	15.83	37.44

Distribution of loan outstanding as on 1.7.96 according to asset group, as can be seen from Table 7, showed that four lower asset groups (upto Rs. 12 lakhs) forming 82 per cent of total sample households had about 43 per cent of total loan outstandings. The higher three asset groups which formed 18 per cent of total sample households had about 57 per cent of total loan outstandings. Households in the largest asset group alone constituting only about 7 per cent had nearly 32 per cent of total loan outstandings of MGB in the study area.

Distribution of loans recovered according to asset group during 1996-97 AGY showed that the share of the lower four asset groups in total loan recovered was 60 per cent whereas they formed nearly 82 per cent of total sample. The higher three asset groups forming 18 per cent returned 40 per cent of total loan recovered.

Table 8: Average Share per Borrower of MGB Assistance According to Asset Groups, 1996-97 AGY (per cent)

Asset Groups (Rs.)	No.of Households (%)	Average loans advanced per borrower	Average loan Outstandings per borrower as on		Average loans recovered per borrower	Average interest burden borne per borrower
			1.7.96	30.6.97		
Upto 1 lakh	26.19	1344	3899	3988	1930	675
1-4 lakhs	16.65	8556	3915	4593	8355	478
4-8 lakhs	23.74	17834	7858	9126	17384	819
8-12 lakhs	14.81	26405	18112	1928	28709	2528
12-16 lakhs	7.95	25903	27519	27194	30452	4723
16-20 lakhs	4.42	48472	35033	53606	40048	10490
More than 20 lakhs	6.24	48843	73024	93720	43595	15448

Source: Same as Table 1

Distribution of loan outstandings as on 30.6.97 according to asset groups showed that lower four asset groups which got less advances in proportion to their share in total sample households, had only about 39 per cent of total outstandings. The largest three asset groups which formed 18 per cent of total sample households and got the major chunk of loan advances, had 61 per cent of total loan outstandings.

Distribution of interest burden borne according to asset group during 1996-97 agricultural year showed that the average interest burden borne by the upto 1 lakh asset group was Rs. 675 and it increased with upgradation of asset group. It was Rs. 15448 per borrower in the largest asset group category.

To sum up the relative share according to asset groups, it was found that the lower four asset groups (upto Rs. 12 lakhs) constituting 82 per cent of the total households received nearly 59 per cent of total loans which was far lower than their proportion in total sample. The top three asset groups constituting 18 per cent of total households received nearly 41 per cent of total loans of MGB. Total loan outstandings and recovery were also the highest in case of top three asset groups. So a direct association was noticeable between asset ownership and the amount of loan received, outstandings and recovery.

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Distribution of Farm Credit – Analysis of Equity Issues

Equity issues were more analytically studied by drawing the Lorenz curves and estimating the Gini Ratios. The Lorenz curves and Gini Ratios under alternative allocations contrast the data on cumulative percentage of farmers across farm size groups with the corresponding cumulative percentage of advances, outstandings, recovery and interest burden shared by them. The farther the Lorenz curve from the diagonal line (egalitarian line), greater is the inequality. Likewise, higher the Gini Ratio, higher is the inequality. The shares of different deciles of all households including landless in the total farm size area, total loan advanced, total cumulative outstanding, total cumulative recovery and total interest burden are given in Table 9. These shares based on cultivator households only i.e. excluding the landless group, are given in Table 10.

Table 9: Cumulative Per cent Distribution of Important Financial Indicators of MGB (All Households)

Deciles	Cumulative percentages					
	Farm Size Area	Advances	Outstandings as on 1.7.96	Outstandings as on 30.6.97	Recovery borne	Interest burden
Bottom	0	0.25	1.46	0.94	0.77	1.53
Second	0	1.27	5.05	3.88	2.37	4.73
Third	0.44	3.19	7.58	6.98	3.80	7.60
Fourth	5.32	8.65	10.53	9.79	9.26	9.62
Fifth	12.13	15.99	14.25	13.20	16.54	10.89
Sixth	21.51	26.36	19.83	18.47	26.81	14.17
Seventh	32.98	38.81	25.06	24.58	38.10	17.18
Eighth	47.31	54.73	33.63	32.90	53.95	23.73
Ninth	66.46	73.49	57.13	55.75	73.42	47.55
Top	100.00	100.00	100.00	100.00	100.00	100.00

The cumulative share of the lowest three deciles including the landless households accounted for 0.44 per cent of the total farm area, 3.19 per cent of the total loan advances during 1996-97, 7.58 per cent of the total outstanding as on 1.7.96, 6.98 per cent of the total outstandings as on 30.6.97, 3.80 per cent of cumulative recovery and 7.60 per cent of the total cumulative interest burden. The highest three deciles (eighth, ninth and top) accounted for major share (almost more than 60%) in total loan advances, cumulative outstandings, cumulative recovery and cumulative interest burden. The fact that the lowest 30 per cent of all households had less share in advances and more share in outstandings, recovery and interest burden indicates not only their weak financial base but also their relatively more exploitation.

Table 10: Cumulative Per cent Distribution of Important Financial Indicators of MGB (Excluding Landless Households)

Deciles	Cumulative percentages					
	Farm Size Area	Advances	Outstanding as on 1.7.96	Outstanding as on 30.6.97	Recovery borne	Interest burden
Bottom	2.75	3.50	1.24	1.89	3.28	0.63
Second	6.94	8.04	4.49	4.30	8.05	3.14
Third	11.93	13.71	7.35	6.99	13.58	3.71
Fourth	18.42	20.89	11.58	10.54	21.04	5.20
Fifth	25.96	29.50	15.18	15.48	28.29	8.11
Sixth	34.66	39.19	20.07	20.48	37.88	12.84
Seventh	44.93	50.92	26.82	26.76	49.65	16.38
Eighth	57.43	63.37	34.46	33.79	62.46	22.24
Ninth	73.17	79.70	62.78	62.03	79.31	54.22
Top	100.00	100.00	100.00	100.00	100.00	100.00

Again, when the landless households were excluded to study the inequality in institutional finance amongst the cultivator households only, it was found that the top three deciles (eighth, ninth and top) accounted for major share in total loans advances, outstandings, recovery and interest burden indicating inequalities in farm credit distribution (Table 10). The cumulative share of the lowest three deciles increased only marginally and still accounted for 11.93 per cent of the total farm area and 13.71 per cent of the total advances but less than this, at 7.35 per cent of the total outstandings as on 1.7.96, 6.99 per cent of the total outstandings as on 30.6.97, 13.58 per cent of the total recovery and 3.71 per cent of the total interest burden. This is in contrast to the earlier finding including the landless households. This shows that in order to improve the economic status and bankability of landless households, programmes for this group need to be production oriented rather than simply financial assistance-oriented ones.

In order to improve the economic status and bankability of landless households, programmes for need to be production oriented rather than financial assistance-oriented.

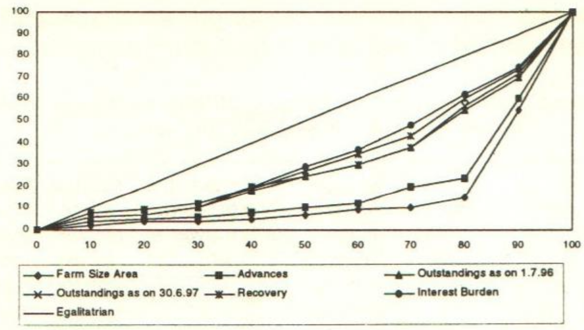

Fig. 1. Lorenz Curves: All Households

Figure 1 indicates Lorenz curves for comparison of inequalities between cumulative percentage of farm size area groups and corresponding cumulative percentage of advances, outstandings, recovery and interest burden shared by them. Lorenz curves lie farther away from the egalitarian line indicating inequalities in farm credit distribution. The curve was the farthest for the interest burden parameter.

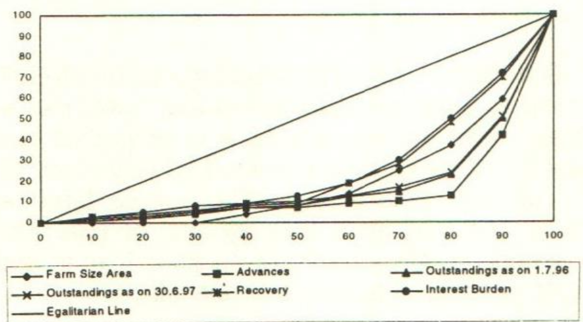

Fig. 2. Lorenz Curves: Excluding Landless Households

Figure 2 indicates Lorenz curves for comparison of inequalities between cumulative percentage of farm size area excluding landless and corresponding cumulative percentage of bank advances, outstandings, recovery and interest burden shared by them. Lorenz curves lie farther away from the egalitarian line indicating inequalities in farm credit distribution. Even in this case the Lorenz curve for the parameter interest burden was the farthest.

The Gini Ratios give more precise estimate of the in equality in various indicators of institutional finance. These are given in Table 11. The inequality in loans advanced and loans recovered during AGY 1996-97 was higher when all households were considered than amongst cultivator households only, the Gini Ratio being 0.45 and 0.45 for all households and 0.28 and 0.29 for cultivator households, respectively. The Gini Ratio, and hence inequality increased over time in terms of outstandings for all households being 0.55 as on 1.7.96 and 0.57 as on 30.6.97 but that among cultivator households declined from 0.61 to 0.53 during the same period i.e. the beginning and end of AGY 1996-97. This indicated that MGB during 1996-97 financed more to the small cultivators also. Interestingly, the Gini Ratio was the highest in both the situations i.e. 0.63. This vindicates that the bank earnings from the larger farmers, who are economically more viable, are better. Conversely, the statement that "weak clientele does not make an institution strong" stands vindicated.

Table 11: Gini Concentration Ratios of Various Parameters of Institutional Finance

Parameter	Gini Concentration Ratio	
	All households	Cultivator households
Farm size area	0.53	0.21
Advances	0.45	0.28
Outstandings as on 1.7.96	0.55	0.61
Outstandings as on 30.6.97	0.57	0.53
Recovery	0.45	0.29
Interest burden	0.63	0.63

To sum up, the RRB meant basically for the poorer sections was found to have benefitted mainly households belonging to the better-off segments of rural society. Upper caste groups still dominate in using institutional finance; so do cultivators in rural areas. The average loan advanced and other related financial parameters per borrower increased with farm size but not so distinctly on per acre basis. However, flow of credit to the weaker sections was not found to be that smooth in proportionate terms. This shows that in order to improve the economic status and bankability of landless households, the programmes for this group need to be production oriented.

It is important to mention that Gini Ratio of important parameters need to be discussed simultaneously in order to have better diagnosis of equity aspects served by the RRBs. Given the inequitable distribution in land holdings, the basic resource that determines the credit requirements of individual cultivators, the Gini Ratios of different financial parameters in relation to Gini Ratio of farm size distribution would show the operation of equity aspects. In case, the Gini Ratio of advances is higher than that of farm size distribution it would mean that large farmers are being advanced loans more than proportionately. Although, when all households were considered the trend was otherwise, amongst cultivator households the Gini Ratio of farm size (0.21) was lower than that of advances (0.28). The Gini Ratio of outstandings was much higher than the farm size, being 0.61 as on 1.7.96 compared to 0.21 of farm size distribution. This was due to the term loans advanced in much greater proportion to the larger farms. However, there was a decline in this Gini Ratio to 0.53 by the end of AGY 1996-97. In case of recovery the Gini Ratio was again higher than farm size distribution which indicates small farmers are better pay masters.

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Feature

Agricultural Research Investment in Southern India

T.R. Shanmugam & C. Ramasamy

This article addresses the constraints in rice production and analyses the research methods currently available to tackle the problem. The economic as well as ecological feasibility are considered to provide future policy direction.

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Several methods have been tried for research evaluation in the past. These range from simple congruence or parity model to highly sophisticated mathematical programming or simulation model. Herdt and Riely (1987) classified the operational methods to allocate research resources as follows in the order of increasing complexity:

- Rules of thumb
- Congruence
- Scoring
- Cost-Benefit analysis
- Consumer surplus-Producer surplus
- Optimization
- Net Present Value (NPV)

The more complex approaches have the advantage of including several factors as decision criteria but have the disadvantage of requiring a great deal of data that are only obtainable from subjective judgements. NPV approach may be preferred over other methods because it is flexible enough to incorporate the dimensions of uncertainty and equity as well as productivity. In this method, part of data requirements is met from subjective estimates but it is enough of an advance over less complex approaches. For the present study, economic analysis of rice research projects is considered. Rice is the staple food for most of Southern Indian population. Rice research has been given top priority among food grains, with emphasis on development of high yielding and pest resistant plants. Four research methods viz., Biotechnology, Conventional breeding, Wide hybridization and Chemical methods are evaluated, in this context.

Methodology

Herdt and Riely (1987) proposed a modified Net

Present Value approach. Its major steps are:

- Define the research challenge/constraints to higher yield.
- Estimate the intensity of each challenge.
- Determine the expected productivity or output gain associated with solving each challenge, evaluated at the expected product price.
- Determine whether environmental benefits or costs are entailed in each potential solution to each challenge and if so, adjust expected net benefits.
- Determine equity implications associated with each challenge and each potential solution and weigh expected net benefits in accordance with equity judgements.
- Use steps 2 and 5 to determine the net present value of equity weighed expected benefits for each potential solution.
- Estimate the potential for addressing the challenge through the application of biotechnology.
- Combine steps 6 and 7 to determine the desired allocation of resources among challenges.

The present study broadly adopted the procedure suggested by Herdt and Riely. The steps as implemented are as follows.

Step 1: Defining challenge/constraints

An exhaustive list containing all possible constraints to higher yield of rice in different production environments with special reference to Southern India (Andhra Pradesh, Karnataka, Kerala and Tamil Nadu) was prepared by perusing literature and making use of the knowledge and experience of scientists involved in rice research projects. The list was again short listed after consulting leading scientists and managers of agricultural extension activities (Table 1). The constraints include biotic and abiotic factors that limit rice yields. They are distinct from socio-economic constraints in that many are potentially solvable through biotechnology or enhanced genetic improvement of rice varieties.

Technical constraints were:

- Insects and pests
- Diseases
- Adverse soils
- Agronomy
- Genetic/Physiology
- Adverse climatic and environment

The description of technical constraints given by Widawsky and O'Toole (1990) with reference to rice production environment of Eastern India is very much applicable to Southern India also. So the same description is adopted here. The first among biotic constraints are insect pests which cause most severe yield losses. Severity of incidence is more in favourable rice production environments where rice canopy is dense. In irrigated and rainfed lowland areas of Southern India, most of the major pests of rice are found to cause some level of damage to rice crops. As these are the potential areas for rice production and set the trend of country's annual rice production, use of pesticides is encouraged to control pests. Pests also cause a perceptible damage to rice crop in terms of yield reduction in upland and deep water rice environments. Nevertheless, the range of pests is narrower and two or three species are usually responsible for most of the damage. The use of pesticides, apart from creating severe economic loss to the farmer, also leads to drastic ecological degradation. This reflects upon the quality of human life itself. However varietal improvement through biotechnology offers critical alternative to use of insecticides.

Another important biotic constraint which affects the yield of rice crop is diseases. Like insects, for diseases there are few effective, simple prophylatic measures available. Diseases vary according to the nature of production environments. Some diseases are linked to soil moisture status and plant health. Diseases that are endemic in dry upland areas may not be prevalent in low land areas. Development of varieties with resistance to specific diseases should be the future focus in research.

The third category of biotic stress is related to genetic and physiological factors, which cause substantial yield loss especially in lowland irrigated areas. Presently, it is increasingly felt that genetic improvement of rice varieties is crucial to get better yields in areas with special problems like upland rainfed condition and deep water localities. Biotechnology has the scope to make a break-through in solving the constraints of these production environments. Any pro-

Genetic improvement of rice varieties is crucial to get better yields in areas with special problems like upland rainfed condition and deep water localities.

gram for genetic improvement and increasing physiological efficiency in rice varieties should have twin objectives: increasing yield, and tolerance of biotic and abiotic stresses.

'Adverse soils' is an abiotic constraint to rice yields. The alluvial soils in low land environments in Southern India are more favourable to rice production whereas red, black and laterite soils are less favourable. There is a wide range of soil types in between these extremes with varying degree of favourableness. In addition, problem soils such as saline, alkaline and micronutrient deficient soils also pose major problems to achieve higher yields in rice. Coupled with adverse soils, some agronomical problems with reference to cultural practices, input use, water management and weed management cause yield reduction in rice. The intensity of damage caused by agronomical problems exist in all rice production environments. The constraints related to 'adverse climate' describe weather related factors, important ones being drought and floods. They are the results of erratic monsoon behaviour and its ill-distribution. In such contexts, achieving yield stability, especially in rainfed areas, is a major constraint to be encountered.

Step 2: Estimation of Intensity/Severity of Constraints

Severity of each constraint was estimated through quantification of yield loss. Effects of constraints account for the gap between potential farm yield and actual farm yield. Herdt and Riley (1987) in their bench mark study for the Rockfeller Foundation program identified the constraints and analysed yield loss estimates for each major environment in Asia and explored the scope for solving constraints through rice biotechnology program. The first stage of the process involved conducting a survey to determine the amount of crop loss attributable to each biotic or abiotic technical constraint. The losses were then weighed on the basis of equity considerations. They refined the constraint list by the weighing priorities with respect to chance of success using biotechnology and degree of difficulty associated with evolution of biotechnological solution.

Research priorities could further be adjusted by incorporating factors like equity, probability of success, cost of research, potential benefits and a host of other adjustments. In the present study, for each agroclimatic region–rice production environment–absolute quantity of yield loss attributed to each constraint was estimated by knowledgeable scientists. They were also required to estimate the proportion of area affected by each constraint to total rice areas of the region. While identifying constraints in the region, scientists were reminded to be specific to sub-production environments within the region. To be precise and authentic in estimation of yield loss, scientists were sought to estimate yield loss due to the constraints which were relevant to their area of specialization. For instance, an entomologist was asked to estimate yield loss due to insects and pests above economic threshold level. The total area affected by each constraint in each region was arrived at by summing up areas affected in different sub-production environments within a region. The scientists were asked to indicate average yield loss due to a particular constraint over the last five years. The average value was considered as the loss due to the constraint. Sum of losses across the regions gave the total production foregone to each constraint in each state. Production foregone was then multiplied by price of current year prevailing in the state to obtain value of foregone production due to each challenge in the state.

Research priorities could be adjusted by incorporating factors like equity, probability of success, cost of research, potential benefits and a host of other adjustments.

Step 3: Estimation of Productivity Gain

Resolving a particular production constraint through the research initiative is expected to result in productivity gain. Gain in productivity reflects regaining of value of production foregone due to each constraint, resolved by research. The productivity gain may be arrived at by multiplying incremental output by price of output. the market price of rice in any country is affected by changes in domestic demand and supply and by external (world) market forces. The increased output due to the productivity gains realized by solving constraints through research interventions can cause, depending upon the nature of the elasticities of demand and supply inside the country, reduction in market prices. Herdt (1987) points out that the impact of rice market price via demand elasticity is the same for all sources of productivity gains. Therefore, he suggested that the impact of the successful solution to individual constraint need not be reflected in a demand elasticity in the analysis concerned only with rice, whereas, it is most likely that the supply side is affected by the constraints solved by research. There will be larger supply due to substantial increase in productivity by solving major constraint or the effect on current supply will be small if a minor constraint is solved. The differential effect is reflected in the change in productivity as measured by unit production costs and quantity of output affected. In the present study, past prices as recommended by the Commission of Agricultural Cost and Prices (CACP) for rice were used to forecast prices for the next five years. Forecasted prices were used to derive the future stream of benefits which will accrue by solving the constraint.

Step 4: Estimating Costs

Cost estimation can be accomplished in three ways: Each constraint is associated with a cost of research and extension required to solve the problem. The stream of annual expenditures required for research and extension to solve the constraint assuming given probability of success in a given time involving several years were elicited from senior scientists and extension specialists who have a fair idea of costs incurred in research and extension activities. If a given problem can be addressed by alternative research approaches, the alternative which has the lowest externality is considered in the decision process. Conventional NPV methods are used to evaluate each problem. The second method assumes constant cost to each problem. Since, the main purpose of the exercise is to prioritise the researchable areas in rice, it can be assumed that a constant amount per year would be spent on each problem for five years. Problems that have greater NPV are selected and prioritised. In this method, the expected benefits over five years is the critical parameter in determining researchable constraint since costs are constant. The third method attempts to derive the breakeven cost to each problem. Given the benefits foregone over five years, assuming a discount factor, this method derives the annual cost of investment on each problem. This derived cost becomes the upper limit for investment on each constraint. The first of the three approaches was considered most relevant and adopted in this analysis.

Step 5: Assessing Environmental Effects

Alternative technologies which are environmentally less damaging are preferred to replace certain rice production technologies having potential to damage the environment—for example using bio- control agents in place of chemicals to control pests. Such approaches generate benefits beyond those realized in the farms. The alternative technology (environment friendly) may entail external costs that would not appear in the computation of private benefits and costs. The research solution suggesting use of a pesticide to control the pest may involve the environmental or external cost. This external cost varies widely among technical constraints, production environments and agroclimatic regions. Hence, in this exercise, scientists are asked to add 10 per cent of total research costs as environmental cost wherever it is applicable to the cost of solving each technical constraint so as to reflect economic costs or returns to the society.

Step 6: Equity Considerations

Herdt suggests that rice farmers in unfavourable rice ecology like upland are poorer than farmers in favourable rice ecology. Poor rice farmers sometimes fail to use technologies requiring cash inputs. Technologies that replace cash with genetic characters may have higher equity enhancing effects than cash using inputs. Likewise introducing machineries would have higher equity benefits in a labour scarce region. This implies that increase in rice productivity due to research intervention has differential social value in favourable and unfavourable production ecologies and therefore equity weights specific to each production ecology need to be provided to assess the relative values of research that solves the constraints in the given ecology. In the present study, we did not consider the equity issues in the analysis.

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Step 7: Estimation of Net Present Value (NPV)

Present worth of net benefits of a research project is obtained by deducting present worth of research costs from the present worth of research benefits. It may be interpreted as the present worth of net benefit stream generated by the research investment. Mathematically,

$$NPV = \sum_{t=1}^{t=n} \frac{B_t}{(1+i)^t} - \sum_{t=1}^{t=n} \frac{C_t}{(1+i)^t}$$

Where,

B_t = benefit obtained by solving each constraint in years 't'. This is calculated by multiplying annual production loss due to each constraint in the zone by price of rice in years 't'. It is a proxy measure for the productivity gain.

C_t = Research and extension cost allocated for undertaking research project to solve each constraint and extension cost allocated for dissemination of technology that emerged out of research efforts in year 't'.

n = number of years, research expenses were incurred to solve each constraint and number of years in which benefit would flow due to solving constraints. Research costs are incurred for the first 5-6 years. During that period, benefits are assumed to be zero. Benefits may accrue for infinite number of years after research accomplishment. But it is limited to 5-6 years here considering it as a reasonable period of time. During the period of benefit flow, extension costs are incurred for transmitting technologies.

i = discount rate or the opportunity cost of capital. The discount rate chosen for this economic analysis is 15 per cent.

Research projects which have positive NPV can be identified and prioritized. Possibly a given production constraint can be addressed by many research alternatives with different NPVs. Also the same research alternatives may have differential impact across rice production ecologies. In situations where resources are scarce and projects are mutually exclusive, the NPV will be a more appropriate measure.

Step 8: Addressing Challenges through Biotechnological Initiatives

The potential of biotechnology to solve rice production constraints is still under test. Nevertheless its cost-effectiveness at the farm point, after establishing its potential through onfarm trials, is beyond doubt. This is the fundamental reason we seek to explore possibilities of introducing some biotechnological initiatives to solve rice production constraints. Judgements of knowledgeable scientists were sought to determine rate of success of technological alternatives to solve a given constraint. Based on this, NPV was worked out for solving each of the constraints through biotechnological alternatives and other approaches for biotic, abiotic and socio-economic constraints.

Research Methods: Economic Analysis

Biological and social scientists involved in rice research assessed yield losses due to various ccnstraints in their respective states. As indicated, (Table 1) totally there were 34 constraints listed and yield losses were estimated for all these constraints. Scientists were asked to suggest alternative research methodologies and costs involved in solving these constraints. It is evidenced from the results that there are 15 important constraints identified for the whole of Southern India which need immediate attention for policy makers and agricultural research managers. Scientists were asked to assess the cost of research for four research alternatives viz. biotechnology, conventional breeding, wide hybridization and chemical and cultural methods. These costs and marginal productivity gains estimated formed the basis to evaluate each problem by each research alternative by computing Net Present Value (NPV). Since rice research is decentralised at state level, we considered only top 15 constraints to prioritize rice research in each state.

Table 1: Major Rice Yield Constraints

Technical Constraints
Pests
Yellow stem borer, Brown plant hopper, Green leaf hopper, Thrips, Gall midge, Leaf folder, Ear head bug, Rodents, Cut worm, Case worm, Coorg caterpillar, Rice hispa.
Diseases
Rice blast, Sheath blight, Brown spot, Sheath rot, RTV- Rice Tungro Virus, Grain discoloration, Bacterial leaf blight.
Agronomical and others
Imbalance use of fertilizers, Weeds, Aged seedlings, Lodging, Drought, Cold at anthesis, Low light intensity, Varietal problem.
Adverse soils
Low fertility, Acid soils, Salinity, Alkalinity, Iron deficiency, Zinc deficiency, Iron toxicity.

Andhra Pradesh

Rice production in Andhra Pradesh is constrained by insects, diseases, adverse soils, and agronomic problems. In this state, leaf folder is the number one constraint causing a production loss of 1,59,130 tonnes. Net present values (NPV) were worked out for all the constraints for different research alternatives and are presented in Table 2. The NPV for leaf folder worked out to Rs. 313.62 million and Rs. 236.19 million respectively for biotechnology and wide hybridization indicating the urgency for accelerating biotechnology research to contain the damage. Its control would bring out economic benefits to rice farmers in a big way as the NPV indicates. There is a greater scope for biotechnological research alternative to tackle this problem.

Ear head bug is a common pest in all production environments of Andhra Pradesh causing major losses followed by leaf folder. It causes 1,30,520 tonnes of production loss in the state and NPV worked out to Rs. 190.93 million and Rs. 126.13 million for biotechnology and conventional breeding respectively. Higher NPV indicates the need for investing in biotechnology research aimed to solve the problem concerned. Yellow stem borer is third important pest in Andhra Pradesh causing 1,20,180 tonnes production loss. As suggested by scientists, NPV was worked out for biotechnology, conventional breeding and widehybridization research alternatives and worked out to Rs. 420 million, 361.53 million and 299.55 million respectively. Economic analysis clearly shows that biotechnology research would be more appropriate to contain this pest.

Table 2: Net present Value of Research Methods (Andhra Pradesh)

(Rs. million)

Constraints	Bio-techno-logy	Conven-tional Breeding	Wide Hybridi-zation	Chemical & Cultural
Leaf folder	313.62	..	236.19	..
Ear head bug	190.93	126.13	..	..
Yellow stem borer	420.00	290.55	361.53	..
Lodging	372.86	320.12	320.95	..
Rice Blast	420.89	262.09	..	..
Weeds	..	..	..	467.68
Brown plant hopper	334.36	267.61	290.96	..
Salinity	..	176.31	312.38	..
Water management	..	..	..	437.07
Gall midge	..	252.25	..	..
Green leaf hopper	222.49	147.83	..	..
Imb. use of fert	..	..	..	369.88
Bact. leaf blight	280.19	174.48	210.58	..
Drought	169.93	..	136.57	..
Sheath blight	253.98	167.98	..	..

.. Not Available

The state is also characterised by coastal climate, cyclone and high rainfall during north east monsoon. Scientists feel that inundation of water in rice fields during cyclone and high rainfall results in lower yields mainly because of lodging. In addition to rainfall during harvesting period, soil texture also induces lodging. Excess use of nitrogenous fertilizers aggravates the problem. Hence lodging is fourth major problem perceived by the scientists and it causes 1,06,690 tonnes production losses in the state. The viable technology for containing this problem appears to be biotechnology research as evidenced from NPV analysis. Rice blast causes heavy damage to rice in Andhra Pradesh and ranks fifth in the order of importance. Production losses due to blast are estimated at 1,05,150 tonnes in Andhra Pradesh. Subhumid climate prevailing during monsoon season activates blast. NPV worked out to Rs. 420.89 million and Rs. 262.09 million respectively for biotechnology and conventional breeding.

Among the listed constraints, weeds ranked sixth and cause 93,920 tonne of production loss. Drought aggravates weed problem. NPV for investment in weed research worked out to Rs. 467.68 million. In the state, Brown Plant Hopper (BPH) ranked seventh in the list of constraints. In kharif, which is the main season for rice, low light intensity and cloudy weather favour the incidence of this pest. Production loss due to this pest is 89,190 tonnes. NPV was worked out for biotechnology, widehybridization and conventional breeding and biotechnology research seems to be more favourable to contain this pest. Salinity is a major problem in coastal areas of the state due to poor drainage and water logging. It is one of the major constraints (eighth) causing production loss of 88,840 tonnes in the state. Due to salinity many farmers in these environments have converted their rice farming into 'prawn bank' as it earns huge profits. Economic analysis shows that research through widehybridization could minimise loss significantly.

Water management is a major problem and ranked ninth in the list of constraints. Poor drainage system and frequent cyclones have made farmers unable to follow proper management practices. For example, in Krishna Godavari and North Coastal zones, water logging coupled with salinity has aggravated yield losses. Deep water rice is also practiced in the above said zones. Nearly, 1 lakh hectare in 'Kolleru lake' region is under deep water rice. Farmers still cultivate traditional varieties following traditional water management practices. According to scientists, cultural methods would reduce loss due to this problem. Gall midge ranked tenth based on the production loss given by scientists. It causes production loss of 84,070 tonnes in the state. Scientists suggested that production loss due to this pest could be significantly reduced by conventional breeding and NPV was worked out at Rs. 252.25 million. The other important rice production constraints in Andhra Pradesh in the order of priority are green leafhopper, imbalanced use of fertilizers, bacterial leafblight, drought and sheath blight. NPV analysis was carried out and results are presented (Table 2).

Karnataka

Rice production is concentrated in almost all the production environments. Rice blast is the most important constraint to be given top priority (Table 3). Total production loss due to blast is estimated at 40770 tonnes annually. NPV analysis for biotechnology and conventional breeding was carried out and worked out to Rs. 162.26 million and Rs. 100.36 million respectively. Blast is a common phenomenon in the whole of Karnataka and requires biotechnological research intervention.

Yellow stem borer is the second major constraint causing a production loss of 39,390 tonnes annually. NPV analysis shows that research intervention through biotechnology could yield a maximum NPV of Rs. 136.76 million. At present there are no varieties which are resistant to stem borer in Southern India, making this constraint a pressing and persistent one. Biotechnology

Table 3: Net Present Value of Research Methods (Karnataka)

(Rs. million)

Constraints	Bio-technology	Conventional Breeding	Wide Hybridization	Chemical & Cultural
Rice blast	162.26	100.36	..	..
Yellow stem borer	136.76	96.96	116.67	..
Leaf folder	72.93	..	53.84	..
Imb. use of fert	..	..	..	177.54
Varietal problems	86.77	51.07	..	..
Ear head bug	49.02	31.91	..	..
Weeds	..	..	..	168.32
Water management	..	..	..	163.36
Zn deficiency	..	..	..	154.92
Brown plant hopper	111.74	38.26	96.45	..
Gall midge	..	88.19	..	..
Salinity	..	57.94	102.92	..
Brown spot	105.39	65.18	..	..
Grain discolor	..	..	99.34	..
Thrips	87.25	61.86	..	..

.. Not Available

would be the best solution to control stem borer. Leaf folder is the third important problem in Karnataka in the order of priority. NPV analysis reveals a value of Rs. 72.93 million for biotechnology research and it is relatively higher than other research methods indicating priority for biotechnological intervention to contain the damage. The other important constraints in Karnataka in the order of priority are imbalanced use of fertilizers, varietal problems, ear head bug, weeds, water management, zinc deficiency, brown plant hopper, gall midge, salinity, brown spot, grain discoloration and thrips. NPV analysis was carried out for all these constraints (Table 3). Most of the constraints are prevalent in the entire state and their control would bring economic benefits substantially.

Kerala

This state is characterised by coastal climate, acid soils and deep water rice production. Rice cultivation in Kerala is constrained in a major way by insects, diseases, adverse soil and agronomic constraints. In this state, leaf folder causes maximum yield loss 20240 tonnes and the NPV worked out to Rs. 38.54 million and Rs. 28.31 million respectively for biotechnology and conventional breeding (Table 4). Other insects causing major yield losses are yellow stem borer, ear head bug, gall midge and brown plant hopper.

Table 4: Net Present Value of Research Methods (Kerala)

(Rs. million)

Constraints	Bio-technology	Conventional Breeding	Wide-hybridization	Chemical & Cultural
Leaf folder	38.54	..	28.31	..
Yellow stem borer	60.71	42.99	51.76	..
Ear head bug	23.52	15.23	..	..
Rice blast	65.81	40.59	..	..
Gall midge	..	48.85	..	..
Sheath blight	60.49	39.89	..	..
Varietal problem	38.18	22.35	..	..
Lodging	54.03	46.29	46.09	..
Water management	..	..	..	67.56
Salinity	..	29.26	52.28	..
Acid soils	..	29.02	51.87	..
Sheath rot	51.66	36.59	..	..
Brown spot	55.53	34.25	..	..
Brown plant hop	50.66	40.39	43.71	..
RTV	49.63	32.77	39.39	..

.. Not Available

Among the pests gall midge appeared to be a universal problem in Kerala. NPV analysis shows that this pest could be best contained by conventional breeding and yields an expected benefit of Rs. 48.85 million. Deep water areas exist largely in Kerala where blast, sheath blight, lodging, water management and salinity are common problems. This lowland environment is quite different from other production environments of the state. Coastal climate and high relative humidity provide conducive environment for occurrence of blast. Deep water cultivation and continuous stagnation of water are also conducive for the existence of sheath blight in the state. Flood is a problem during monsoon and hence lodging occurs. Water management problem in low-land environment is due to poor drainage facilities as these areas lie below mean sea level. In deep water areas all the problems have to be tackled simultaneously. In certain pockets of Kerala (Problem area zone), a unique system of rice cultivation is prevalent known as pokkali system. It is lucid from the economic analysis that out of 15 major identified constraints in the state, 11 constraints could be best solved by biotechnological research intervention rather than other methods.

Tamil Nadu

In Tamil Nadu, leaf folder is the major constraint causing highest yield loss. It is a common pest in all production environments of the state and its control would bring about significant economic benefits to rice farmers as the NPV indicates. For leaf folder NPV is estimated for different research alternatives and it is the highest in the case of biotechnology research alternative (Table 5).

Table 5: Net Present Value of Research Methods (Tamil Nadu)

(Rs. million)

Constraints	Bio-technology	Conventional Breeding	Wide Hybridization	Chemical & Cultural
Leaf folder	218.91	..	164.22	..
Ear head bug	141.56	82.29	..	..
Imb use of fert	..	..	..	370.80
Rice blast	259.12	153.12	..	..
Water management	..	..	..	312.59
Yellow stem borer	427.78	147.03	180.43	..
Gall midge	..	180.78		..
Weeds	..	..	..	272.34
Low fertility	..	..	..	257.06
Lodging	171.96	147.46	147.94	..
Zn deficiency	..	..	..	227.35
Thrips	155.02	110.02	..	..
Drought	100.04	..	80.20	..
Brown spot	161.83	100.07	..	..
Salinity	..	76.79	137.77	..

.. Not Available

Ear head bug is the second major pest and most serious in the state. The other pests which warrant immediate attention of researchers are yellow stem borer, gall midge and thrips. Imbalanced use of fertilizers is the third most important rice production constraint in the state. Excess use of fertilizers is practiced in certain pockets. It catalyses pest and disease incidence especially in intensive cultivation environments. This is supported by the NPV analysis. NPV for research investment made to tackle this constraint is estimated at Rs. 370.80 million for Chemical and cultural method. Rice blast is the fourth major pest. The subhumid climate prevailing during monsoon season activates blast occurrence in rice. Predominance of IR 50 cultivation in the state seems to be favourable for infection by blast. Water management is ranked fifth in the state. NPV for this constraint is estimated at Rs. 312.59 million. Water stress is a general problem in all the production environments of Tamil Nadu, causing uncertainty for investment on rice production. Scientists suggest evolving varieties which are tolerant to water stress. Adoption of efficient water management practices at nursery and early stage of crop is the prime need of Tamil Nadu today.

Further, frequent drought situation leads to weed problem in the state. As NPV indicates, weed is one of the major problems in environments which are characterised by semi-dry paddy cultivation. NPV for weed control is estimated at Rs. 272.34 million. Besides drought, excessive use of nitrogenous fertilizers activate weed problem. As these agronomic constraints are interrelated, they need to be tackled simultaneously. Low fertility is a common problem in the whole of Tamil Nadu. As evidenced from NPV analysis, control of this constraint through chemical and cultural method would yield Rs. 257.06 million. Lodging also poses problem in the state as perceived by scientists. It is a major problem in production environments which receive high rainfall. As expected, high rainfall and frequent occurrence of cyclone cause lodging. In these environments tall and long duration varieties are cultivated which are susceptible to lodging. Excessive use of nitrogenous fertilizers also contributes to lodging. As evidenced from economic analysis, NPV worked out to Rs. 171.96 million, Rs. 147.46 million and Rs. 147.94 million for biotechnology, conventional breeding and widehybridization respectively. The other constraints which cause significant yield loss are zinc deficiency, thrips, drought, brown spot and salinity.

The ordering of constraints are not exactly the same in all the states and in all rice production environments. Although the pattern of major constraints is uniform, there is considerable variation among the rankings. These variations occur because of special characteristics and idiosyncrasies of certain locales. Research solutions for majority of the constraints are already available. But most of them are inorganic and chemical oriented causing environmental and equity problems which even tend to overweigh the production constraints solved by these alternatives. Hence, evolving low cost technologies in terms of operational, environmental and equity cause through biotechnology, widehybridization and conventional breeding is crucial for reducing yield gaps in Southern India.

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Table 6: Research Methodologies Identified for Major Constraints in Southern India

Constraints	Method of Research
Leaf folder	Biotechnology
Ear head bug	Biotechnology
Yellow stem borer	Biotechnology
Gall midge	Conventional breeding
Thrips	Biotechnology
Brown plant hopper	Biotechnology
Green leaf hopper	Biotechnology
Rice blast	Biotechnology
Brown spot	Biotechnology
Grain discoloration	Widehybridization
Bacterial leaf blight	Biotechnology
Sheath blight	Biotechnology
Sheath rot	Biotechnology
RTV-Rice Tungro Virus	Biotechnology
Imb. use of fertilizers	Chemical and Cultural
Water management	Cultural
Weeds	Chemical and Cultural
Low fertility	Chemical and Cultural
Zn deficiency	Chemical
Salinity	Widehybridization
Acid soils	Widehybridization
Varietal problems	Biotechnology
Lodging	Biotechnology
Drought	Biotechnology

Summary

The results are significant as they show totally 24 important constraints identified across states, which need immediate attention of policy makers and agricultural research managers. The analysis also points out which research method is to be followed to tackle each of the constraint, based on NPV. Table 6 presents these results. It is interesting to note that biotechnology emerges to be a preferred method in majority of the constraints. The result is quite expected as biotechnology ensures both economic (cost effective) and environmental benefits. Evidently, future allocation of research resources must be biased more towards biotechnology.

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The three most things that you must measure are customer satisfaction, employee satisfaction and cash flow.

– Jack Welsh

Welding Process Selection

C. Muralidharan, V. Balasubramanian, N. Anantharaman & S.G. Deshmukh

This paper deals with the application of Analytic Hierarchic Process (AHP) and Activity Based Costing (ABC) for selection of a welding process. Selection of a welding process is an unstructured decision problem involving multiple attributes. In order to facilitate a decision support to welding engineers, an all encompassing analysis of multiple attributes is needed. This paper provides an analytical framework and an illustrative example for promoting and understanding application of AHP and ABC to such multi-attribute decision-making (MADM) problems.

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Welding is a process for joining different materials. There is hardly any material, which cannot be welded, but all materials cannot be welded by every process. Therefore selection of a welding process to accomplish a joint of desired specifications and quality, is imperative before undertaking the fabrication job. Some welding processes are known to be associated with specific jobs and industries. For example, resistance spot welding is extensively used in sheet metal work in automobile industry and for fabrication of refrigerator shells. Gas tungsten arc welding (GTAW) is well accepted for aero, rocket, missile and nuclear industries. Submerged Arc Welding (SAW) is the sole process used for long seams in ship building and pressure vessel fabrication. Electron beam welding (EBW) is mainly employed for welding of reactive metals. Shielded metal arc welding (SMAW) is used for all awkwardly located joints with difficult access or for field welding.

In all the above cases the selection of the process can be attributed to specific application. In specific cases there may not be any other choice and the selection of welding process is fixed. However, there are many instances where a number of welding processes can be nearly equally effective in producing the end product. High strength quenched and tempered steel used in pressure vessels, penstock, earth moving equipments, bridges and structures is widely welded by SMAW, Flux Cored Arc Welding (FCAW), SAW and electroslag welding (ESW) (Balasubramanian & Guha, 1999). Austenitic stainless steel used in nuclear reactors, pressure vessels and transport vehicles can be equally and effectively welded by SMAW, FCAW, and GTAW (Sindo Kou, 1987). The process selection is aimed for such situations and most often the processes involved are of the arc welding family.

Selection of Welding Process

For welding a specific material, there are many processes available. Each process has its own merits and demerits and hence from a group of welding processes, we must choose a particular process based on its overall benefits. For joining Mild steel (0.2% carbon) of 6mm thickness, which is known to be the best weldable metal, by arc welding process, the following three processes are most commonly used: Shielded Metal Arc welding (SMAW), Gas Metal Arc Welding (GMAW) and Gas Tungsten Arc Welding (GTAW) (Little, 1990).

The selection of process for the above case is usually based on economic consideration and the welded joint properties. Apart from this, mechanical analysis and metallurgical analysis of the joint are also considered before selecting a process (Parmar, 1995). Mechanical analysis of the welded joints includes destructive and non-destructive testing to find out its Strength, Hardness, Impact strength, Residual Stress level etc. Metallurgical analysis of welded joints includes chemical composition analysis and micro-structural analysis, which give evidence for changes in mechanical properties. In general, process selection considers only the above factors i.e., quantitative factors. However, qualitative factors of each process such as fatigue, skill required, weld quality etc., have been neglected so far in the selection process. When multiple choices are available to select a welding process to accomplish a particular joint, it is essential to base the final decision on quantitative as well as qualitative analysis (Muralidharan et al, 1999). Unlike quantitative factors which are easily tractable, the analysis of qualitative factors requires a more meaningful approach. An attempt is made in this paper to present a well structured methodology using Analytic Hierarchy Process (AHP) for the selection of welding process.

When multiple choices are available to select a welding process to accomplish a particular joint, it is essential to base the final decision on quantitative as well as qualitative analysis.

Analytic Hierarchy Process

To survive and succeed in a customer centric competitive business world it becomes imperative for organisations to be cost competitive as well as render better and sustained performance on qualitative factors (Gourd, 1998). Analytic Hierarchy Process (AHP) (Saaty, 1980) is a tool to combine qualitative and quantitative factors in the selection of a process. The AHP model has found numerous and diverse applications and is practiced successfully (Vargas, 1990). A variety of complex decision problems has been dealt with by AHP. The main advantage of AHP is its ability to handle complex and ill-structured problems which cannot be usually handled by rigorous mathematical models. In addition to simplicity, ease of use, flexibility and intuitive appeal, the ability to mix qualitative and quantitative criteria in the same decision framework has led to AHP's power and popularity as a decision making tool (Wedley, 1990). The availability of software (Expert Choice) has further increased the use of AHP. Three features of AHP differentiate it from other decision-making approaches (Vargas, 1990; Wedley, 1990):

- Its ability to handle both tangible and intangible attributes.
- Its ability to structure the problems, in a hierarchical manner to gain insights into the decision making process.
- Its ability to monitor the consistency with which a decision maker uses his/her judgement.

In addition to simplicity, ease of use, flexibility and intuitive appeal, the ability to mix qualitative and quantitative criteria in the same decision framework has led to AHP's power and popularity as a decision making tool.

Activity Based Costing

As the world moves towards a global market place, there emerges a pertinent need for organisations to gain competitive advantage over others. Therefore the need of the hour is an accounting system which will be able to analyse precisely how costs arise, enable cost control and reduction and also eliminate redundant costs (Ahmad, 1999).

Activity-based costing (ABC) developed by Cooper and Kaplan (1991), attributes variable, fixed and overhead costs directly to each product using the activities required to produce the product as the means of allocation. In ABC the cost of the product equals the cost of the raw materials, plus the sum of all the costs of every activity used to produce the product. Thus, ABC costing is different from traditional costing which accumulates the cost of raw materials and direct labour, then applies overhead using an arbitrary allocation formula based on volume of production rather than activity (McCormick, 1992). By breaking product cost into various activities in ABC, costs can be controlled by managing the activities and the events that cause the cost consuming activity. ABC system identifies how resources are consumed by each product and attaches overheads according to this consumption pattern. There is very little indirect cost in an ABC costing system, since most costs can be "directly" attributed to the product. In ABC, activities performed during the production or support of a product for which costs are associated are called 'cost drivers' (McCormick, 1992). Drivers such as: labour hours, machine hours, floor space used, number of setups, orders, movements, size and weight, complexity, and sales costs etc., can be identified other than the initial investment cost of equipment and accessories. When managers segregate activities in this way, a hierarchy emerges. The hierarchy leads to a structured way of thinking about relationship between activities and the resources they consume. Table 1 gives the cost drivers used to compare the welding costs for the three processes for unit level activities.

Table 1: Welding activity and its cost drivers

Welding Activity	Cost Driver
Labour	Time
Power	Wattage
Electrode	Number
Shielding gas	Cubic meter
Filler wire	Centimeter
Flux	Quantity
Space	Cubic meter
Welding	Machine hours
Quality	Number (percentage) of rejects

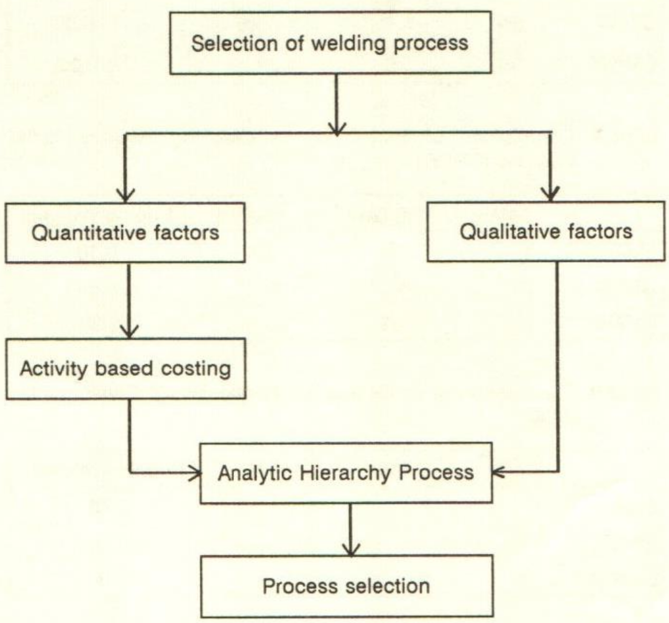

Fig. 1. Methodology for Welding Process Selection

Case Study

AHP has been integrated with ABC in estimating the overhead costs associated for developing a product by Partovi (1991). Schniederjans and Garvin (1997) have integrated AHP and ABC for the selection of cost drivers. In this paper ABC is used for quantitative analysis of welding cost and AHP is used to quantify the qualitative factors of welding and also for integrating both quantitative and qualitative factors. The general methodology for welding process selection for specific material is depicted in Fig. 1. Figure 2 presents a schematic diagram of the format to understand the hierarchy for the problem, wherein, the first level depicts that the overall goal is to rate the best process available. At the second level, factors such as weld quality, skill required, availability of consumables etc., will contribute to the achievement of the above overall goal. Table 2 gives the description of the attributes. At the third level, there are three alternative welding processes (SMAW, GTAW and GMAW) that need to be evaluated through these criteria in a unique way. Table 3 shows the typical scale for pairwise comparison matrix elements for each criterion. Table 4 gives a pairwise comparison of the factors to evaluate the priority weights. It is seen that weld quality is most important (priority = 0.29) followed

Table 2: Description of Attributes

Attribute	Description
Weld quality (WQ)	Percentage of rejects
Initial preparation required (IPR)	Welding machine setting
	Electrode preparation
	Gas flow rate setting
Skill required (SR)	To operate the welding machine
	To weld in all positions like horizontal, vertical, overhead.
Availability of Consumables (AOC)	Electrode
	Gas
Operator Fatigue (OF)	Arc glare
	Smoke and fumes
Cleaning Required After Welding (CRAW)	Slag removal
	Spatter removal

Table 3: Scale for Pairwise Comparison

Degree of Importance	Definition
1	Equally preferred
3	Moderately preferred
5	Strongly preferred
7	Very strongly preferred
9	Extremely preferred
2, 4, 68	Intermediate preferences between the two adjacent judgments.

Reciprocal of the above criteria. If criteria i (Ci) is assigned one of the above non-zero numbers when it is compared with criteria j (Cj), Ci has the reciprocal value when it is compared with Cj.

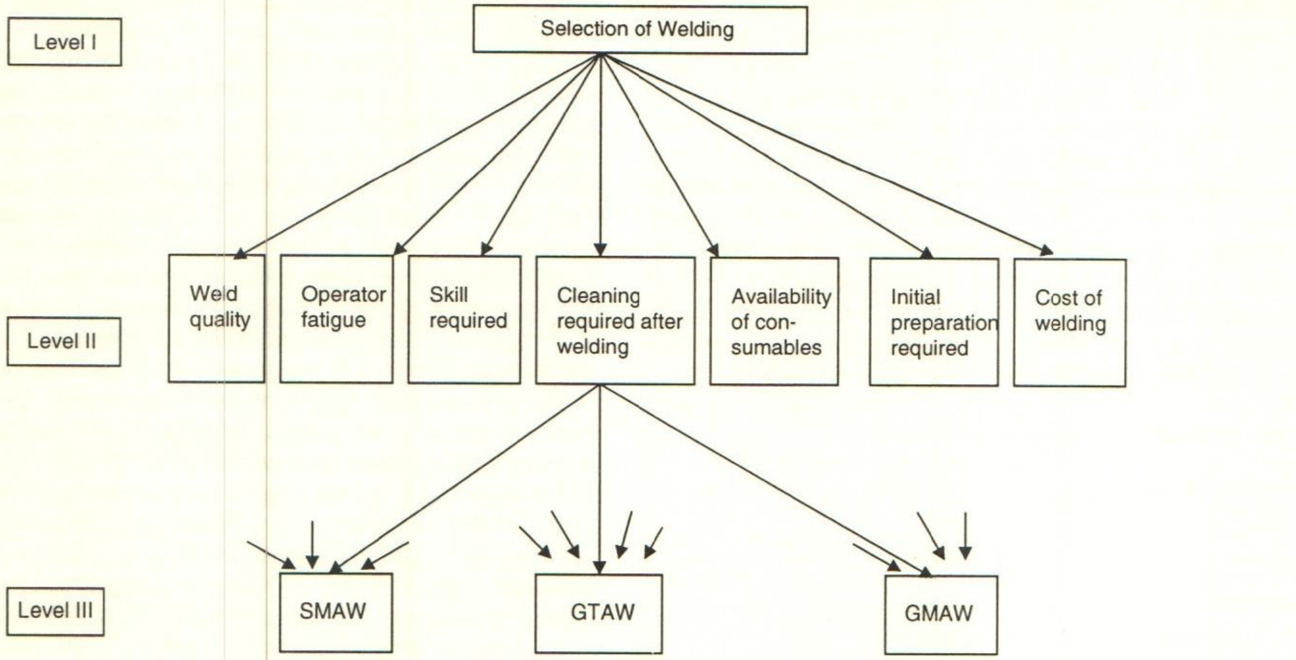

Fig. 2. Schematic Diagram of the AHP Model for Welding

Table 4: Comparison of Factors

Factor No.		WQ	OF	SR	CRAW	AOC	IPR	COW	Priority weights
1	WQ	1	2	4	5	7	9	1	0.29
2	OF	1/2	1	2	5	7	7	1/2	0.19
3	SR	1/4	1/2	1	3	5	7	1/4	0.12
4	CRAW	1/5	1/5	1/3	1	3	3	1/5	0.06
5	AOC	1/7	1/7	1/5	1/3	1	2	1/7	0.03
6	IPR	1/9	1/7	1/7	1/3	1/2	1	1/9	0.02
7	COW	1	2	4	5	7	9	1	0.29

Table 5: Comparison of Processes on Weld Quality (WQ)

	SMAW	GTAW	GMAW	Priority Weights
SMAW	1	1/5	1/3	0.11
GTAW	5	1	3	0.63
GMAW	3	1/3	1	0.26

Table 6: Comparison of Processes on Operator Fatigue (OF)

	SMAW	GTAW	GMAW	Priority Weights
SMAW	1	5	7	0.72
GTAW	1/5	1	3	0.19
GMAW	1/7	1/3	1	0.08

by cost of welding (0.29), operator fatigue (0.19), skill required (0.12), cleaning required after welding (0.06), availability of consumables (0.03), and initial preparation

Table 7: Comparison of Processes on Skill Required (SR)

	SMAW	GTAW	GMAW	Priority Weights
SMAW	1	9	5	0.72
GTAW	1/9	1	1/5	0.06
GMAW	1/5	5	1	0.22

Table 8: Comparison of Processes on Cleaning Required after Welding (CRAW)

	SMAW	GTAW	GMAW	Priority Weights
SMAW	1	1/3	1/2	0.16
GTAW	3	1	2	0.54
GMAW	2	1/2	1	0.30

Table 9: Comparison of Processes on Availability of Consumables (AOC)

	SMAW	GTAW	GMAW	Priority Weights
SMAW	1	7	5	0.73
GTAW	1/7	1	1/3	0.08
GMAW	1/5	3	1	0.19

required (0.02). Tables 5 through 11 give pairwise comparison of the processes on each of these factors / attributes. The cost of each process for welding is found by using the activity cost drivers and is used in Table 11. Table 11 gives the priority weights for the cost data (in thousands of rupees) for welding processes by applying AHP (Wedley, 1990). The consolidated result in arriving

Table 10: Comparison of Processes on initial Preparation Required (IPR) before Welding

	SMAW	GTAW	GMAW	Priority Weights
SMAW	1	4	6	0.69
GTAW	1/4	1	3	0.22
GMAW	1/6	1/3	1	0.09

Table 11: Comparison of Processes on Cost of Welding (COW)

	SMAW	GTAW	GMAW	Priority Weights
SMAW	1	73/27	105/27	0.63
GTAW	27/73	1	103/73	0.22
GMAW	27/105	73/105	1	0.15

Table 12: Final Composite Rating of the Processes

Attribute	Priority Weights	Process		
		SMAW	GTAW	GMAW
WQ	0.29	0.11	0.63	0.26
OF	0.19	0.72	0.19	0.08
SR	0.12	0.72	0.06	0.22
CRAW	0.06	0.16	0.54	0.30
AOC	0.03	0.73	0.08	0.19
IPR	0.02	0.69	0.22	0.09
COW	0.29	0.63	0.22	0.15
Total composite weight		0.48	0.33	0.19

at the overall benefit score of each of the process is presented in Table 12. It is seen that, SMAW (with overall maximum benefit score of 0.48) is the most preferred one followed by GTAW (0.33) and GMAW (0.19). The process must be prioritized according to benefits and costs i.e., in terms of what purposes the process fulfills and how strongly and also in terms of what it would cost to bring about these processes. The difference between the benefit attributes and cost attributes is that while one wishes to maximize the benefits derived by the proposed system, the cost attributes deal with those issues and parameters whose influence one wishes to minimize. It is seen that, SMAW with the score of 0.48 is to be selected for joining Mild steel (0.2% carbon) of 6 mm thickness. Though GTAW and GMAW are technically feasible welding processes for the case under study, they reveal their economic non-viability, since their scores are less than SMAW.

The process must be prioritized according to benefits and costs i.e., in terms of what purposes the process fulfills and what it would cost to bring about these processes.

Conclusion

For welding of a given work piece material, process selection is an important Engineering issue, especially when many of the factors are intangible. The selection of welding process at the lowest overall cost requires an understanding of the interrelation between qualitative and quantitative factors. AHP makes it possible to quantify the intangible factors in a more elaborate way. The model and the case study presented in this paper may provide a decision support for practitioners. Utility of such decision support lies in providing information articulation, practicability and immense value in managerial understanding. Benchmarks can be established using AHP and ABC for process selection. Computational efforts are greatly reduced with software available for 'n' levels of hierarchy and 'm' factors of comparison.

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News and Notes

Water Pollution: Shrinking Resources

Rising industrial and domestic pollution has choked lakes, rivers, estuaries, coastal seas, and groundwater aquifers. A 1994 government survey of 22 industrial zones showed that the groundwater in these places was unfit for consumption. According to studies between 1979 and 1991 by the Central Pollution Control Board (CPCB), 28 major rivers in India have suffered 'severe' biological pollution. Sewage pollution is serious, as facilities to treat wastewater are woefully inadequate. In major cities, only five per cent of the wastewater is collected, of which only 25 per cent is treated. More than half the cities have no sewerage.

As per the official data only 85 per cent of the urban population and 79 per cent of the rural population have access to safe drinking water. Data show that 21 per cent of all communicable diseases in India are waterborne.

In Madhya Pradesh, scores of handpumps installed during the 1980s tapped ground-water saturated with fluoride, whereas borewells in West Bengal pumped out arsenic, both toxins (see paper on arsenic).

Biological and natural pollution is often compounded by acute water pollution through chemical industrial discharges. A recent study by the Calicut Medical College has shown an increased rate of sickness in people who live on the banks of the polluted river. The so-called Green Revolution in the upstream villages of Haryana state has led to the pesticide contamination of the Yamuna river, Delhi's drinking water source. Downstream at Agra, sewage and industrial pollution has turned the Yamuna into a virtual drain.

Industrial pollution has rendered groundwater unpotable in many parts of India. In Bichhri village in Rajasthan, groundwater is a dirty brown colour due to iron salts leached from an industrial unit several years ago. In several industrial centres, the groundwater is contaminated with heavy metals. Meanwhile, in the Green Revolution belt of Punjab, excess nitrate from fertilisers has percolated into the groundwater.

Depletion or the deterioration of the quality of water is also caused by over-extraction for industrial and irrigation purposes. According to the Rajiv Gandhi National Drinking Water Mission, some 82,000 habitations of 44 million people suffer from a water quality problem.

There have been multi-crore government attempts to reduce the pollution in major rivers such as the Ganga and the Yamuna. Relentless pollution blunts these efforts. The Supreme Court has ordered the closure and shifting of several polluting units such as tanneries along the riverbanks – ironically sparking off a debate on labour rights.

Meanwhile, coastal waters are affected by land-based pollution from transport, tourism, industrial activities, coastal mining, municipal waste, and a heavy load of sediments and fertiliser wash-off. Industrial aquaculture on the eastern coast has led to nutrient population. Perversely, several state governments are pushing for a change in the environmental rules that protect the coastline, in order to put up more resorts, ports, aquaculture farms, and housing complexes. Problems from shipping, waste dumping from ships, oil spills, and in sludge disposal are well known. Waste dumped by ships have threatened wildlife on the Andaman and Nicobar Islands coastlines. Plastic and styrofoam waste choke amphibian and marine life.

Source: India's Disaster Report, 2000.

Industrial Performance of Indian Engineering Industry

It was a heterogeneous trend in the Indian engineering industry, during the first three months of 2000-2001. Some notable sectors registered a steep fall in output, while some others did convincingly well. A case of two extremes! Likewise, there was hope and despair within the user sectors of machine tools.

The automotive sector being a case in point. Although, the automotive industry averaged a growth of nine per cent in April-June 2000, three of its vital segments—medium & heavy commercial vehicles (M&HCVs), two-wheelers, and three-wheelers sharp fall in output. Decline in production could affect capital investment in these segments, albeit temporarily.

In fact, several reports emanating in the media do suggest new projects on the anvil in the commercial vehicle segment. Similarly passenger car manufacturers, in particular the market entrants, have finalised plans to increase capacities as well as increase production shifts, over the next couple of years.

In the intermediate goods sector, user industries managed to stay afloat by posting reasonable growth. Auto component manufacturers, riding on an increased off-take by the automobile industry, recorded a growth of ten per cent in the first three months of 1999-2000.

Indicators	Growth/Decline (in %) during First Quarter of 2000-2001 *(April-June 2000)*
Automobile Industry	9.0
Medium & Heavy Commercial Vehicles	–18.0
Light Commercial Vehicles	13
Passenger Cars	8.0
Multi-utility Vehicles	13.0
Scooters	–17.0
Motor cycles	31.0
Mopeds	16.0
All Three-wheelers	–10.0
Auto Components	10.0
Ball & Roller Bearings	5.0
Electronic Components	8.5
Diesel Engines	13.0
Earthmoving Construction Equipment	14.0
Electrical Cables & Wires	–7.6
Telecom Equipment	15.0
Textile Machinery	53.0
Air conditioners	35.0
Audio Products	28.0
Refrigerators	4.0
Washing machines	5.0
Water coolers	15.0

Likewise, the electronic components' industry grew by 8.5 per cent, on the back of continued buoyancy in demand for consumer durable in the Indian market. Tempo in the consumer durable sector is expected to run amok for the fourth successive year, notwithstanding variations in some segments.

Source: Precitech Information Vol. 16(4), 2000.

Regulations Update:

Ozone Depleting Substances (Regulation) Rules, 2000

The rules aim to phase out production and consumption of Ozone Depleting Substances (ODS) in the country.

Salient Points of the Ozone Rules are as follows:

ODS as defined in the Rules

"Ozone Depleting Substances" (ODS) means the those substances specified in Column (2) of Schedule 1 of the Rules, whether existing by itself or in a mixer, excluding any such substance or mixer (blend) which is a manufactured product other than a container used for the transportation or storage of such substance: (Schedule 1 specifies a total No. of 95 substances including CFC- 11, CFC-12, CFC-113, Halon 1211, carbontetrachloride and methyl chloroform. Their chemical compositions, the Group that they belong to and their ozone depleting potential are also provided in the Schedule).

The Rules applies regulations on production, consumption, export/import, sale, purchase and use of ODS from the dates specified in the rules. Also intended to prohibit new investments with ODS as well as to regulate reclamation and destruction of ODS and manufacture, import and export of compressors. In addition, procedure for registration, cancellation of registration and monitoring and reporting requirements are described in these rules.

The rules prohibit the use of Chloroflouro-carbons (CFCs) in manufacturing various products after January 1, 2003 except in metered dose inhalers and for other medical purposes. Use of halons is prohibited after January 1, 2001 except for essential use.

Other ODS such as carbon tetrachloride and methyl chloroform and CFC for metered dose inhalers can be used up to 1 January 2010 while the time limit for use of methyl bromide is 1 January, 2015. Since HCFCs are used as interim substitute of CFCs, these are allowed to be used up to 1 January, 2040.

No person shall import or cause to be imported from or export or cause to be exported to any country not specified in Schedule VI [it lists the names of countries which are party to the 1987 Montreal Protocol] any ODS after the commencement of these rules. The import/export of ODS from Schedule VI nations shall be carried out under a license which may be obtained according to the procedure outlined in the Rules.

It stipulates that no person shall himself or by any other person on his behalf or enterprise i) sell, stock or exhibit for sale or distribute any ODS, ii) establish or expand any manufacturing facility for production of ODS iii) reclaim or caused to be reclaimed any ODS and iv) manufacture, import or import of compressors after the date specified in Schedule V unless he is registered with the Authority as specified in that Schedule.

Source: Green Business Opportunities, October-December 2000.

Six Sigma – the Breakthrough Management Strategy Revolutionising the World's Corporations

Six Sigma is first and foremost a business process that enables organisations to increase profits dramatically by streamlining operations, improving quality, and eliminating defects in its operations. While traditional quality programmes have focused on detecting and correcting defects, Six Sigma encompasses something broader: It provides specific methods to re-create the process itself so that defects never occur in the first place.

Most organisations operate at a three to four Sigma level, where the cost of defects is roughly 20 to 30 per cent of revenues. By approaching Six Sigma fewer than one defect per 3.4 million opportunities – the cost of quality drops to less than one per cent of sales. This is because highest quality also results in lowest costs.

Taken from a letter in the Greek alphabet, the term "sigma" is used in statistics as a measure of variation. And what the metric really refers to is the extent to which a process can deviate from pre-set specifications without causing errors. Thus, higher the Sigma rating, higher the capability. What Six Sigma means is that it allows variations of up to six times the standard variation, without causing flaws.

Six Sigma endeavours to track down faults, take them back to the origin, and thereafter eliminate them – in a customer-focused manner. In other words, when attempting to improve quality, a business enterprise would begin by looking at the areas that are most primary to a customer, and set about improving these first. This is known as identifying the critical-to-quality (CTQ) opportunities, where defects can spring up. So, an organisation will start with the most CTQ fault, and then move on to the next one, so on and so forth.

Sigma Variation

Sigma level	Defects per million opportunities	Cost of quality
(2)	3,08,537 (Non-competitive organisations)	N.A.
(3)	66,807	25-40 % of sales.
(4)	6,210 (Industry average)	15-25 % of sales.
(5)	233	5-15 % of sales.
(6)	3.4 (world class)	< 1 % of sales.
	Each Sigma shift provides a ten per cent net income improvement.	

Six Sigma experts deliver the know-how and tools to pinpoint CTQ characteristics; measure products against the ideal; re-create processes; revitalise design innovation; inspire organisation-wide commitment to change; exceed customer expectations; and strengthen employee morale and loyalty.

A Manager's Road Map to Achieving Breakthrough Performance through Six Sigma:

(a) **Recognise** the true states of a business. A business "state" describes global business conditions created by the pivotal underlying systems used to guide and manage a business.

(b) **Define** what plans must be in place to realise improvement of each state. This requires an understanding – statistically and practically – of how customer satisfaction relates to key business systems.

(c) **Measure** business systems that support the plans. Know what to measure. Know how to measure. Secure executive commitment to go after the right measures.

(d) **Analyse** the gaps in system performance benchmarks. Before an organisation can begin to improve any system, it must diagnose capability measures and assess performance gaps.

(e) **Improve** system elements to achieve performance goals. Once an organisation defines its measuring system and sets clear performance goals, the work of improving any aspect of a business system is straightforward, though seldom easy.

(f) **Control** system-level characteristics that are critical to value. To sustain success, the elements used to create the solution need to be monitored over a period of time.

(g) **Standardise** the systems that prove to be best-in-class. Once the critical-to-value characteristics have been identified, characterised, improved, and property controlled, the optima performance of a system should be compared to similar systems for any shortfalls.

(h) **Integrate** best-in-class systems into the strategic planning framework. To overcome organisation-wide resistance to adopting a new improved best-in-class system, fold it into the strategic plan of business so that it becomes critical to achieving immediate or long-term goals and objectives.

Conclusion

Six Sigma is an ideal tool for all forward-thinking executives and managers who are determined to make their organisations world-class in their industry. Six Sigma implementation results in radical improvement in the net income of corporations. Most often, the financial results are seen shortly after the implementation of Six Sigma in organisations.

In addition to the material and labour savings, which flow directly to the bottom-line, an organisation engaged in Six Sigma can expect to see:

- Improved customer satisfaction.
- Reduced cycle times.
- Increased productivity.
- Improved capacity and output.
- Reduction in total defects.
- Increased product reliability.
- Decreased work-in-progress.
- Improved process flow.

Credit & Source: www.6-sigma.com

India's Sustainable Development (SD) Priorities

India's Ninth Plan recognises the integral link between rapid economic growth and the quality of life of the people and has set SD priorities. They are:

- Accelerating the growth rate of economy
- Ensuring food and nutritional security
- Providing the basic minimum services like safe drinking water, primary health care facilities, universal primary education, connectivity to all
- Containing the growth rate of population – Increasing population has led to a number of interlinked issues: inequalities of income levels, low level of literacy, unemployment and ultimately poverty.
- Ensuring environmental sustainability of the development process – Environment protection does not only involve prevention of pollution and degradation of natural resources, but it also involves integrating with the overall development process and the well-being of people.
- Empowering of women and socially disadvantaged groups
- Promoting and developing people's participatory institutions (like Panchayati Raj)
- Strengthening efforts to build self-reliance (capacity building) – Rapid urbanisation has progressively declined essential services and the quality of life in urban areas. Therefore, synergy between environment, health and development needs to be specially recognised, as no development process leading to better quality of life can be sustained in a deteriorating environmental condition.

Poverty alleviation, economic and social development and environmental protection are overriding SD goals and priorities of India.

Incentives for Adopting Sustainable Practices

- Financial gain – Pollution avoidance is less costly than pollution control
  * Stronger enforcement of environmental regulations
  * Layering of environmental regulations
  * Reduced risk of control costs from future domestic environmental requirements
  * Reduced risk of control costs from meeting future international environmental standards
- Boosts profits by substituting knowledge for material inputs
  * reduces inputs to production (energy, water, materials) per unit output
  * reduced dependence on external inputs insulates against price volatility
  * spill-over benefits in terms of enhanced managerial and technical capacity
- New opportunities in "green" markets
  * CERs are contingent upon the process having contributed to sustainable development
  * Final users, especially in overseas markets, are interested in sustainability
  * Potential for revenue growth in new markets for products and services
  * Gain trust/identify emerging markets by forging connections with communities.
- Enhance profitability by generating revenues from

nature's services through ecosystem protection and restoration

  * Offset degradation from other operations.
  * Use natural systems to reduce operating costs.

- Overall benefit to the workers and other factors of production.

Work done in India

Although the government of India has not adopted SDIs, several organisations in India have implemented and taken initiatives to measure progress toward sustainability. As discussed earlier India's Ninth Five Year Plan emphasizes measures to ensure sustainability along economic, social and environmental dimensions.

In the private sector, increasing competition due to globalization and increasing awareness of environmental deterioration have stimulated interest in internationally-recognized and certified environmental management systems that include tracking progress. Several Indian firms have gone through ISO 14000 certification.

At least one Indian company, Excel industries, is participating in the pilot phase of the previously-referenced Global Reporting Initiative (GRI). The participation of this chemical firm will ensure that the GRI is applicable to developing country conditions before the GRI is implemented more broadly.

Source: Green Business Opportunities, October-December 2000.

How does ISO 9000: 2000 compare to ISO 9000: 1994?

The two standards offer a different model for quality. ISO 9000: 1994 defines quality around 20 key elements that an organisation uses to effectively and consistently manufacture products and services for customers. The standard was originally designed for manufacturing organisations, although it can and has been adapted to apply to processing and service organisations, as well.

Primary purpose is to assure customers that the certified organisations manufacture products at a consistent level of quality. To register to ISO 9000: 1994, organisations must document what they do; do what they document; and be prepared to prove it.

Quality model in ISO 9000: 2000 is quite different. Instead of 20 elements, it is based on a process model that enterprises can use whether they manufacture parts, process chemicals, or provide services. Process model, as laid out in the new ISO 9001, is composed of four sections:

- Section 5 - Management responsibility.
- Section 6 - Resource management.
- Section 7 - Product realisation.
- Section 8 - Measurement, analysis, and improvment.

The other sections in ISO 9001 support the model – Sections 0 through 3 provide background information. And Section 4 for quality management system, which is a precursor to the process model itself, describing how organisations must establish documented QMS.

Sections 5 through 8 contain all requirements for the new ISO, stated in more generic and less prescriptive terms than in the previous 20-element model. This makes it easier for various enterprises to fit their operations to the new ISO.

Although the new model may be simpler and less prescriptive than its predecessor, the requirements are progressive. The model's four Sections are similar to the plan-do-check-act (PDCA) improvement process popularised by W. Edwards Deming. This is much more rigorous than the 1994 ISO's watchwords: do what you document; document what you do; and prove it.

How do we implement the new standard? Will the process be any different than for the 1994 revision?

The implementation process for the 2000 revision should not be much different than the previous version. However, under ISO 9000: 1994, an organisation could choose to exclude activities they performed, such as design control, from the scope of their registration and seek certification to ISO 9002.

Under ISO 9001: 2000, businesses will no longer have the option of excluding activities they actually perform. If organisations perform an activity, they must include it as part of their ISO 9001 system.

Basic Conversion Steps.

(1) Obtain copies of the standard and review them. Although ISO 9001 is the key document, ISO 9004 is central because it contains the requirements.

(2) Set up a core implementation or conversion team. If possible, reconstitute the group used in the original registration effort. This team will bear the primary responsibility for managing the initiative.

(3) Contact the registrar to discuss options and obtain input. If expertise is not there internally to carry out the transition, consider hiring an outside consulting and training organisation.

(4) Conduct a gap analysis to determine holes between the current systems and requirements of the new ISO 9000. Start with Annex B of ISO 9001, which provides tables that show the correspondences between the 1994 and 2000 versions.

Don't confine the gap analysis to QMS. Consider the elements of the business management system and other business processes that may be incorporated into ISO 9000: 2000. For example, if customers are surveyed to get feedback about the organisation's products and performance, the initial ground for the customer satisfaction process required in the new version, is available.

(5) Decide how documentation is to be structured. The best route is to renumber and restructure current documentation into the new system. This will take more work up-front, but will create a more streamlined system in the long run.

(6) Determine whether new training needs exist or don't. Consult instructors who can help set up a business operating system based on the PDCA process; establish a continuous improvement system; or design customer satisfaction processes.

Credit & Source: 'American Machinist' (July 2000).

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"I suppose leadership at one time meant muscles, but today it means getting along with people".

– Indira Gandhi

Book Reviews

Management Development—A Guide for the Profession, International Labour Office (*Edited by Joseph Prokopenko*), Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, 1999, pp. xxiv+597 Price Rs. 590, (paperback)

In the new millennium, business organisations are linking their business strategies with human resource management (HRM) philosophy. One of the key strategic themes of HRM is management development. Unlike the managers of the 1970s and 1980s who focused on assets management, today's managers give far greater emphasis on knowledge management,intellectual capital management, and human capital development. There is greater emphasis on flatter organisation structures, focusing on the critical importance of the development of human talent and competencies. People today work for "the new organisation". They have to shed the mindsets attributable to the "old" organisation. Old organisations are bound to die unless they change. They depended on sustained competitive advantages in a defined market with restricted competition. New organisations, however, are aware that their product or service superiority will be for short term, and will need constant innovation. Thus, there is a need for generalist management education, increased attention to action dimensions, and an urgency to develop leaders rather than administrative managers. To make the managers prepared for these new realities there is a much sharper focus on management development today than ever before. The book under review is an effort by the International Labour Organisation (ILO) to meet the changing needs of management development.

The book consists of 28 chapters divided into five parts: management development in perspective (5 chapters); the management development cycle (4 chapters); compendium of methods and techniques (8 chapters); management development programme in practice (7 chapters); and developing effective managers (4 chapters). Chapters in the book have been contributed by distinguished specialists in the field of management and allied disciplines. Among others, they include: Derek Abell, Lester Bittel, Valerie Hammond, Alan Mumford, John Reynold, Philip Sadler, and Gordon Wills. Some of the key themes handled, among others, include: managers' competences; training programme design; implementation and monitoring; self development methods; experiential and action learning; towards a learning organisation; open and distance learning; management development for public service organisations; training and development for entrepreneur-managers; and programmes for the training of trainers.

A reading of the book reveals that it caters to the following changed realities in training and development; need to focus on practical abilities rather than academic training; training as a part of company strategy; shift away from trainer-centred to a trainee-centred learning process; shift away from individual learning to development of a learning organisation; emergence of flexible, result-oriented, learner-controlled development systems; and shift from outside training programmes to in-company, task-oriented management development.

The book has been claimed by the editor to be a "guide" (p. 4). This hints that it is intended to be a simpler "how to" book than a "why is" analysis, and has been so conceptualized as to reach a very large audience of managers, trainers, developers, guides and mentors. It is free from jargon and is replete with illustrations, tables, examples, questionnaires and checklists. It is a good effort to translate research and analysis on management practices around the world into simplest possible formulations for practical use. In fact, its hallmark is a remarkable balance between conceptual rigour and practicability of prescriptions for the trainers.

Most chapters have been developed on lines similar to any typical book on management development. But there is a striking purposiveness and coherence in almost all the chapters. Also, they do relate the formulations to the new realities of business organisation and management. Some chapters, however, are unique. I would like to mention three of them: "learning organisation" by Olle Bovin; "management development for scientific and engineering personnel" by Lester Bittel; and "management development for public service organisations" by Harald Stockeland and others.

Traditionally, managers have been trained to be reactive i.e. to solve problems as and when they encounter them. This is now giving way to the need for developing competence to manage changing organisations. They are required to be proactive so as to conform to the requirements of truly a learning organisation. Moving away from the premises on which other chapters are based, Olle Bovin's chapter on learning organisation emphasizes the need for proactiveness and flexibility in learning, training and development. Probably the most challenging task which trainers, management developers and CEOs today face is developing learning culture as a way of organisational life. Bovin gives two interesting cases of Asian Brown Bovery (ABB) and Hewlett Packard (HP). The former case relates to developing project organisations that readily respond to customer needs while learning and inspiring the best from their people, and the latter case shows how individuals can achieve effective learning through networking and information sharing. While this chapter is very well developed, it would have been of a much greater value if it had dealt with issues such as leadership and diversity management in developing a learning organisation.

Overall, while the book deals with most issues related to management development, it does not fully answer how managers could be promoted to work as developers of delayered and boundryless organisations. This required an overall linkage to other strategic themes in HRM such as promoting commitment, empowerment, culture, flexibility and leadership. If the book had included a chapter that could view management development in the context of these critical variables of performance management, it would have ended much more convincingly. However, that should not undermine the other merits of this useful book. In fact, it is heartening to note that ILO is realizing that pursuing the social justice or dignity of work agenda cannot take place in isolation. It has to be an overall integrated exercise where management systems can be designed and promoted with appropriate scope of management development so as to facilitate these values in the emerging environment where collaborative rather than adversarial values need to be underscored.

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Implementing ISO 1400 standards in Asia and the Pacific by Asian Productivity Organisation, Tokyo, Japan, 1999, p. 142.

This publication is a compilation of the resource papers, country papers and the report of the workshop on the ISO 14000 standards: Environmental Labeling, Environmental Performance Standard, and Life Cycle Assessment organized by Asian Productivity Organisation during 9 to 12 December 1997 at New Delhi. ISO 14000 standards are gaining wide acceptance and it has become difficult for business corporations, be they small or big, to ignore them. However, implementation of these standards has raised various issues. In order to address these issues and resolve them, this workshop was organised with special focus on developing countries. This book consists of four resource papers and fourteen country papers presented by the various participants of the workshop.

First resource paper talks about Implementing ISO 14000 in India. As small and medium enterprises (SMEs) dominate the industrial scenario in India, special emphasis has been given to implementation of environmental management system in SMEs. The SMEs sector account for around 60 per cent of the industrial production and 35 per cent of exports. There are about 7500 items being manufactured in SMEs sector. The author establishes the importance of (EMS) and links it with productivity in SMEs. He has also identified impediments at various levels in implementation of EMS. (Environment Management System). The author recommends various measures namely legislative, financial and institutional. In legislative measures, the author focuses on holistic approach to environment protection rather than end-of- pipe, information sharing, public hearing, awareness etc. and also making implementation of ISO 14001 mandatory. Under financial measures, the author suggests establishment of a separate company called "Pollution Control Investment Corporation" to fund pollution control activities. The author stresses upon establishment of accreditation institutions and certifying bodies under institutional measures. In appendix to the paper, list of names of the units already certified and currently implementing ISO 14001 have been provided.

Second resource paper on ISO 14000 – Management Standards for the Environment starts with establishment of TC 207 and its sub-committees and working groups dealing with various standards of ISO 14000 series. It describes two major groups of standards; organisation-oriented and product-oriented. Brief insight to the setting up of both groups of standards has been given. It becomes clear from the paper that implementation of Environmental Management System has lots of benefits. The author has justified the implementation of EMS in the best interests of the organisation to manage their environmental performance. The paper also throws light on various issues for effective implementation of ISO 14000 standards. These issues are conformity assessment and trade issues. The author has suggested integrating conformity assessment, government regulations and standards. In trade issues, the author has elaborately discussed the effects of environment management standards on trade in developing countries.

The paper on Meeting the Challenges of Environmental Requirements for Textiles – A Developing Country's Perspective presents an overview of prevailing eco-labeling schemes and equivalent standards in various countries (mainly European). The paper covers, in brief, various eco-standards prevailing in countries like Netherlands, Canada, Japan and Sweden. It also discusses the possibilities for harmonizing broad principles for eco-labeling within the framework of International Standards Organization (ISO). A five stage self-assessment tool that would enable manufacturers and exporters of developing countries to assess their performance against social and environmental requirements of importing countries has been explained and some preliminary findings from application of this tool in a selected sample of textile processing units in India, Indonesia and Zimbabwe have been discussed.

The fourth resource paper is on "Environmental Audit and Environmental Management". In the paper, it has been explained how environment audit can be utilized as tool for environment management. The author also compares financial audit and environmental audit and points out what is additionally required in environment audit. The process of environment auditing has been divided in three phases – Pre-audit, On-site and Post-audit phase. Pre-audit phase covers basically team formation, setting objectives & scope and assigning tasks and priorities. In on-site phase, interaction has to be carried out with the unit staff and then field studies including sampling and analysis work has to be taken up. At the end of this phase, the auditor has to come out with some tentative findings. Last phase of post-audit consists of finalizing of the report and evolving action plan. At the end, the author mentions the benefits of environmental audit.

Country paper of Bangladesh describes policy on environment and a case study on quality policy and pollution control. Second country paper is on Republic of China. It briefly deals with administrative framework and administrative strategies for implementing ISO 14000 in China. It also describes various Chinese National standards developed in line with ISO 14000 series of standards. Country paper of Fiji presents an overview of present environmental situation including environment impact assessment and waste management. It also throws light on proposed environmental legislations in Fiji. Country paper of India is the fourth one. In this the authors have described current environmental situation in India and presented statistics in graphical form regarding per cent growth in GDP, industrial growth during 1991-96. The paper also describes policy and strategy for environmental management delineating various environment-related laws and institutions in India. It also briefly highlights implementation status of ISO 14000 in India.

Country paper from Indonesia highlights the prevailing rules governing environment in Indonesia. It also touches upon issues of the eco-labeling principles and their impact on foreign producers. In the paper on Islamic Republic of Iran, role of the Institute of Standard and Industrial Research of Iran (ISIRI) has been given and its organisation structure has been described. Country paper of Republic of Korea is the Seventh. This country paper starts with the structure of Task Force constituted for the environment management standardization. It also outlines the trends of environment management in major fields and depicts the procedure for certifying products. A typical product environmental criteria selection matrix has been given in the paper. Paper on Mongolia briefly deals with existing environmental standards and constraints to implement ISO 14000 standards in Mongolia.

In country paper on Nepal existing environmental regulations have been given briefly and role of bureau of standards and methodology towards establishment of various standards have been presented. The paper also touches upon the ongoing UNDP UNIDO project on Industrial Pollution Control Management aimed at building institutional capabilities within the Ministry of Industry. Country paper on Pakistan succinctly describes the various elements of ISO 14000 and local scenario with respect to environment. Paper on Philippines is the eleventh. In this paper status of government policy and subsequent action on ISO 14000 has been given. It also talks about setting up of multi-sectoral committee on environmental standards with a wide range of government agencies and industrial associations as members. At the end, the paper describes the "The Industrial Eco-Watch Project" started for evaluating the performance of industries on environmental management and protection. In the paper on Sri Lanka, focus is on the Sri Lanka Standards Institution (SLSI), which is engaged in implementation of ISO 9000 and ISO 14000. It also touches upon formulation and implementation of national standards. Present status with regard to environmental management has also been depicted. The country paper on Thailand. Talks about status of ISO 14000 in Thailand and barriers in implementation of ISO 14000. The last country paper is of Vietnam. In this paper, various standards of ISO 14000 to be adopted into Vietnam National Standards have been given. However, it appears that this paper has not been covered fully in the book.

Consultants providing services in the area of ISO 14000, industries and association of industries, government bodies, policy makers, NGOs, and regulatory agencies comprise the target group of this book. They would find it useful.

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Institutions, Incentives and Economic Reforms in India edited *by Satu Kähkönes and Anthony Lanyi*, Sage Publications, India Private Limited, April 2000, Price Rs. 595 (cloth).

Some of the best Working Papers of the Center for Institutional Reform and the Informal Sector (IRIS) at the University of Maryland in College Park, Maryland, USA by eminent Indian scholars working both in India and abroad on a broad range of topics related to economic reforms in India are presented in this volume. Almost all the papers in this book are of very high quality, marked by conceptual clarity, excellent analysis based on hard data and not on casual empiricism. This book can very well form the basis for any informed debate on institutions and economic reforms in India.

Economic reforms in India have been examined in the context of institutions and incentives. 'Institutions', in this book, are understood as the 'rules of the game' that govern the economy and economic policy making. In the broad context of 'New Institutional Economics', this work is based on a multidisciplinary approach. A basic premise of this approach is that a proper set of institutions is essential for economic growth and development. The papers in this book are grouped under five main headings: political economy of reform, fiscal reform, reforming public goods delivery, reform issues in agricultural parastatals and rural governance and reforming the industrial and finance structure. In each of these areas, the papers indicate that a major reform effort must deal not only with the well-known straightforward policy prescriptions such as lower fiscal deficits, but also with serious institutional impediments to carrying out those policy prescriptions and therefore to achieving a more efficiently functioning and rapidly growing economy. This approach represents a change from the earlier thinking that development depends most critically on the availability of natural resources and physical and human capital. In the new approach, economic policies and institutions now appear as key factors in economic growth.

The first chapter, "Indian Fiscal Federalism: Political Economy and Issues for Reform" by Kenneth Kletzer and Nirvikar Singh deals with the political economy of reforms in India with special reference to fiscal federalism. A natural starting point of political economy is fiscal policy. The authors argue that effort to control the Central Government deficit since 1991 has been unsuccessful mainly because the burgeoning deficits of the state government have had to be covered largely by transfers from the Central Government. The authors argue for allocative efficiency and the need for containing the fiscal deficits. The Central Government's deficit has continued to be in excess of 6 per cent of the GDP. Much of the deficit comes from the statutory and discretionary transfers to the states from the centre. The states rely heavily on these transfers to cover their expenditures. Therefore, the Central Government is unable independently to tackle the issue of fiscal deficit. In addition to rationalizing indirect taxes and broadening the overall tax base, they suggest reducing incentives for costly 'influence activities'. The term 'influence activities' is the euphemism they have used for rent-seeking, that is, corruption.

Bhaskar Dutta deals with Fragmented Legislatures and Electoral Systems: The Indian Experience. In it, he analyses the political economy of fiscal policy in terms of electoral systems and the resulting ruling coalitions and examines the impact of electoral laws on the stability of legislative coalitions. Dutta's conclusion is that unstable coalition governments tend to be associated with higher expenditures, a smaller volume of non-tax revenues and higher fiscal deficits (or lower surpluses). The last two chapters in this section deal with the questions relating to privatization of public enterprises. Privatisation is a major political-economic issue that lies at the heart of both fiscal reform and achievement of a more efficient, market-oriented economy.

Anand Gupta in "The Political Economy of Privatisation in India" examines the ways in which privatisation has been advanced but also impeded, and the incentives that explain the slow progress of parastatal reform thus far. After listing the benefits of privatisation, he points out that there have been only a few cases of 'true complete privatisation', but a number of cases of incomplete privatisation. Gupta's view is that politicians are reluctant to transfer public enterprises to the private sector due to many incentives such as electoral support, patronage (providing jobs and seats on government boards for supporters) and resources that can be leaked from these enterprises to provide election finance. Leslie Armijo and Prem Shankar Jha in "Centre-State Relations in India and Brazil: Privatisations of Electricity and Banking" discuss a number of cases where federal and state governments have been at odds on privatisation issues. After identifying the major sources of conflict between the Centre and the states on privatisation, they have rightly concluded that 'ideology and politics have played a much smaller role—although occasionally a significant one—than real conflicts of interest with regard either to economic benefits, or political credit or blame'.

In the section on Fiscal Reforms, Dilip Mookherjee and Arindam Das-Gupta in their paper 'Reforming Indian Income Tax Enforcement' discuss the need for wide-ranging tax reforms with special reference to Income Tax enforcement. Their main point is that despite reforms of the income tax schedule and tax base since 1991, "relatively little effort had been made so far in improving the nature of tax administration". An important suggestion made by them is that penalties must be raised for larger evasions rather than minor offences. An important statistic given by the authors is that the personal income tax generated about Rs. 50 billion in 1989-90, which was less than the entire amount spent on fertiliser subsidy that year (p. 164). And tax amenities in 1965-66, 1980-81, 1985-87 and 1991-92 had negative effects on compliance and revenue. M. Govinda Rao in his *"Fiscal adjustment and the Role of State Governments in India"* (chapter 6) has made an attempt to identify the Indian fiscal problem from the angle of states' revenue and expenditure policies and to suggest policy changes needed to improve fiscal management in the states. After analysing the fiscal imbalances in the states and explaining their difficult fiscal situation, he has evaluated the problem in terms of the inability of the state governments to contain the fast growing current expenditures and the consequent displacement of capital expenditures, particularly on infrastructural sectors. He has highlighted the adverse efficiency consequences of raising revenues from tax and non-tax sources and indicated the direction for reform. The fiscal adjustment process initiated in 1991 at the insistence of the IMF has been confined to the Central Government. Arindam Das-Gupta and Dilip Mookherjee in *"Tax Amnesties in India: An Empirical Evaluation"* examine the question of tax amnesties, as a part of tax administration, in the context of tax evasion. They are of the view that a policy of repeated amnesties could be favoured by a government that gave more importance to short-term revenue gains from amnesty disclosures than to long-term revenue losses. And most amnesties appeared to have been *sales*, in the sense of offering a concession over the tax normally levied on white income disclosures.

Part III deals with *'Reforming Public Goods Delivery'.* The main problem with the health sector in India, according to the authors, is the distribution of government health resources—across states, between rural and urban areas, among different levels of health care (primary, secondary and tertiary) and between preventive and curative health care programmes. They suggest better targeting of government expenditure to poorer states that have high infant mortality rates. This will not only improve equity but also raise the internal efficiency of health expenditure. Mukesh Easwaran in his paper, "Fertility, Literacy and Institution of Child Labour discusses how the institution of child labour has some serious long-term consequences. Child labour affects the education of children. Apart from perpetuating an uneducated labour force, the institution also renders a reduction in fertility less likely. The chapter examines the issues in an old-age security model for fertility in which the opportunity cost of child labour is taken to be foregone education. Based on the model, Easwaran suggests two complementary policies that would contribute to the eradication of child labour—the universalisation of access to health care services in order to reduce child mortality rates and the legislation of compulsory education. The policy recommendations are a fine example of how policy needs to take into account the actual social institutions and the incentives perceived by households.

Part IV deals with *Agricultural Parastatals and Rural Governance.* The authors show that while FCI has succeeded in improving the overall availability of foodgrains, it has failed to target the foodgrain distribution to poor people and regions and its operations are economically inefficient and it has resulted in heavy losses. The reform options proposed by the authors include the removal of FCI from its middleman role in domestic and foreign trade; the removal of zonal trade restrictions; a large reduction in grain stocking activities. However, their suggestion of replacing PDS by a system of food stamps may not be desirable and feasible in India. Ashok Gulati and Sangeeta Shroff in their paper, *"Economic Reforms and Agricultural Parastatals: The case of the Cotton Corporation of India and the Maharashtra Federation"* elaborate on the theme of inefficient government intervention in markets for agricultural products. They have evaluated the performance of the Cotton Corporation of India and the Maharashtra Federation in terms of whether they have been able to achieve the objectives set for them, and at what cost they have carried out their operations. They note that by and large, these parastatals have failed to reduce price instability and they have a mixed record with regard to commercial viability. The authors' conclusion is that the

Monopoly Purchase Scheme is inefficient in serving the farmers' interests; that controls on internal and foreign trade of cotton (both imports and exports) should be abolished; and that the CCI's role should be limited to that of marketing agency on commercial lines, undertaking price support operations as required. Chandrika Gulati in her paper, *"Panchayati Raj in India: Problems and Prospects"* has made an attempt to tackle the institutional issues from the standpoint of a major political reform (73rd Amendment of the Constitution, 1993, which gives constitutional status to Panchayati Raj) that is only in the process of being incorporated fully into Indian rural society. The paper concludes with the comment: "Without financial autonomy, devolution of power and responsibility to panchayats will be futile".

Part V deals with *Reforms in Industrial and Financial Structure*. The author supports measures such as dismantling barriers to entry and expansion of private banks, deregulation of credit allocation and decontrolling interest rates and concludes by saying that the Indian authorities have been correct to reform gradually. Mrinal Datta-Chaudhuri in his paper, *"Labour Markets as Social Institutions in India"* discusses the emergence of institutions – social, political and legal arrangements – that govern labour use in the modern sector of the Indian economy. The chapter concludes with the suggestion that without direct attempt at institutional reforms – particularly of labour laws and of public sector management – current liberalisation efforts may not induce efficient industrial growth in India. The last chapter in this book considers the labour policies and their outcomes in India and many other countries, mostly from East Asia (namely South Korea, Taiwan, Singapore, Malaysia, Thailand and Indonesia). The chapter concludes with suggestions for reforming India's labour laws to make labour more productive and thereby generate more employment and higher earnings per employee. The editors are to be congratulated for the selection and elegant presentation of papers by renowned scholars.

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Supply Chain Management in the twenty first Century *edited by B.S. Sahay*, Macmillan India Limited, 2000, p. 292.

The twenty first century has begun with a basic difference to its predecessor; it will promote and look for convergence of all technologies and management systems that developed and thrived independently in the twentieth century. Supply Chain Management (SCM) is the new identity of this convergence for business enterprises. No surprise, that recent attention of management experts is focused on this subject. The book under review is a compilation of selected papers presented in the first international conference on the subject held at MDI, Gurgaon in 1998. The book comprises five sections covering the overview of the subject, inventory and logistics management, vendor relationship, IT applications and Integration of SCM concepts.

The first section presenting overview of the subject contains four papers which deal with the broader framework for SCM, tools and techniques like activity based management and IT based distribution networks, SCM – Corporate Profitability linkage and enhancement of shareholders' values. The fifth paper which describes SAIL's experience in vendor management should have rightly belonged to the third section. The second section on inventory and distribution management comprises two case studies from Maruti Udyog Ltd and ONGC. The example of Maruti to streamline its distribution system and reduce costs while simultaneously improving customer service is well illustrated with facts and figures. The other three papers of this section basically describe detailed models that can be used to solve SCM problems in situations like distribution, transportation etc. These models are highly mathematical and would interest mainly academicians and researchers. The third section throws light on the changing trends in respect of buyer-seller relations. The case of Modi Xerox where the vendor/supplier relations are dealt with in terms of continuous supplier involvement (CSI) is well brought out.

The fourth section on IT applications in SCM has papers by both the users and suppliers of IT applications. The paper by Modi Xerox describes its IT infrastructure systems and how they have been able to control inventory and distribution with its help. The other papers in the section deal with well known ERP/Groupware techniques like SAP and Lotus Notes giving application examples. A brief paper also deals with recent developments like Data Mining. The final section tries to bring out an integrated framework for SCM. Again, this section contains some case studies from ICI and SPL on their experience in reorganisation to foster SCM. The section also deals with individual applications like ERP tools which could be used to integrate different aspects of SCM. The book deals with both the academic and practical sides of different facets of supply chain management. The papers have been contributed by well known professors and executives from top class organisations. Their experience would certainly be of value for any person seeking guidance on the subject.

A drawback noticed in the book was that the various papers in the book deal with different and individual aspects on the subjects, with individual perception of the authors, their backgrounds and organisations. There has been no attempt of synergise these contributions and present an overall model of supply chain management. Neither the discussion points and nor the recommendations of the seminar have been brought out. Excepting these minor aberrations, the book seems to be a good reference material on SCM and is recommended for learners and practitioners of the subject.

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Managing Quality—A Practical Guide to Customer Satisfaction *by D.B.N. Murthy,* Response Books, Sage Publications India (P) Ltd., New Delhi, 1999, p. 226, Price Rs. 185.

Quality has become a buzzword and consumers all over the world are looking forward to a genuine choice of goods and services. Producers have been left with only two options today, match with international quality or perish. Customers are placing greater stress on quality as it affects not just the quality of their life but their very existence while using goods and services. The winning formula in the race of quality is the philosophy of customer satisfaction as a corporate culture supported by the judicious combination of quality techniques. The author raises concerns about quality of several services like postal, electricity, roads, transport and other civic services controlled by the Government and rightfully hopes that winds of changes will focus them to customer-oriented service.

The book covers various aspects of quality. Separate chapters have been devoted to each of the facets such as quality in inputs, production, R&D service and above all, the people. The book emphasizes on a holistic and pragmatic approach to quality and all other related issues. It is the total quality image as seen by the customer which matters, not just how excellent the R&d set up is or how modern the production facilities are. The presentation of book is a good blend of theory of quality with a Do it yourself approach. The author had drawn extensive inspiration from Dr. Juran the 'Quality Guru' and blended the principles with day to day examples and case studies. The contents of this book have been put in a systematic and easy to grasp manner. Readers would find the book a real practical guide on quality and a good value for money. It is a deserving attempt to simplify the latest management jargons in common man's language and will find pride of place in the shelves of budding entrepreneurs of SME's.

Management has the greater responsibility of leading the people from the front in quality matters. Quality needs to be nurtured in an environment maintained by suitable recognition and rewards. Often quality can be achieved by simple and cost-effective solutions emanating from even the lowest rung of organisation. Thus the focus throughout the book is on how to meet customer needs and expectations rather than on complicated statistical techniques on quality or the modern concepts of Business Process Re-engineering, Benchmarking, Enterprise Resource Planning, Total Quality Management etc. To achieve better customer satisfaction is the primary goal for existence of any organisation around which all its activities and resources should revolve. The ultimate objective of managing quality is to develop long-term customer relationship, is the clear-cut message delivered by the author through this book. The author who is a prolific writer had experienced the evolution of quality concepts in various organisations and has become torchbearer of quality mission that has been amply reflected in the present book.

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TQM: Concepts and Practices, Asian Productivity Organisation, Tokyo, 1999, p. iii+112, ISBN 92-833-2244-4, Available through National Productivity Councils.

This volume is the Proceedings of a Top Forum organised by the Asian Productivity Organisation (APO), from 24 to 27 November 1998 in Bangkok, Thailand, on total quality management (TQM) with emphasis on customer satisfaction and product liability (PL), which had participation from 15 APO member countries and five non-member countries. TQM has been a thrust area for APO over the last decade, in recognition of its importance for organised businesses in the member countries and beyond. Quality of a firm's products or services acts as a positive discrimination factor in the consideration of customers for allowing any competitive advantage to that firm in the market-place. When the activities in the firm are oriented towards satisfying customer needs, those activities alone can create the value for which customers pay. TQM urges for managing all such activities more meticulously, consciously and with utmost care, which should be naturally of immense benefit to organisations. The volume provides a very useful compilation, documenting the relevant concepts and some actual current practices in this field across the various APO member countries.

The volume starts with the report of the forum followed by overview of TQM and 14 case studies by 11 participants from nine APO member countries, viz. Fiji, India, Indonesia, Iran, Philippines, Singapore, Sri Lanka, Thailand and Vietnam. These cases are descriptions of actual management problem situations from the experiences of organisations in a wide range of settings. Each case presents facts as captured by the executives responsible for dealing with the situations. Business corporations or service setups are known to exist in various stages of TQM implementations – TQM-proficient, – beginner, or – illiterate. Depending on past attainments in this field, several authorities, such as companies, industry associations, independent societies, chambers of commerce, and governments can obtain useful clues for themselves, in various proportions from the given case studies and policy recommendations made by the Forum to APO and the National Productivity Organisations.

In summary, TQM has been noted as "an element of corporate culture which represents a vision and behavioural pattern shared by all members of organisation. ...Hence, top management initiative, interest, and leadership, which should be demonstrated through action programmes, are called for. Business corporations decide to initiate TQM when they experience a sense of crisis. ...It is desirable to combine TQM with strategic planning in order to sustain long-term business performance. ...A solid infra-structure should be established for the introduction of TQM. ...Firms should consider ISO 9000 implementation as the first milestone on the road to TQM and quality excellence. One of the most important factors in successful TQM implementation is the involvement of workers at all levels and good teamwork for continual improvement of management systems."

Report of the Forum singles out the consensus critical factors for implementation of TQM, and for attending point-by-point to the basic PL issues confronting the organisations, which should prove quite illuminating and reassuring to potential practitioners and confirmed believers alike while embarking on the path of TQM. Several identified emerging issues having impact on TQM in the next decade and link with the strategies and means to satisfy customers, like information technology, mass customisation, global manufacturing, service quality, environment care and PL protection should help muster counter-strengths for channeling organisational energies towards seeking timely advantages on these counts. This book likewise can also be used as both a ready reckoner and a reference manual for and by management professionals loaded with concerns for the underlying vital performative issues posing perpetual challenges and promise of opening up the avenues of sustainable advantages for their organisations.

The keynote presentation on the 21st century quality perspective by Dr. C.-H. Wang, ROC, included as first paper in the Overview section, discusses the present and future scenarios of TQM requirements. Based on survey of organisations that received quality awards, there appeared many common elements in their implementation of and approach to TQM. The second overview from Mah Lok Abdulla of NPC-Malaysia, captures the fact succinctly in the TQM implementation model, by specifying the important steps and thrust areas which should prove conducive for aligning the thought process for its implementation anywhere. In the Case Study section, the 14 studies present a glittering array of TQM implementations on a broad spectrum of psychosociologic and techno-economic settings across the various geographic locations, underscoring a remarkable commonality of critical success factors which are certainly worth carrying forward elsewhere too as examples of proven effective approaches.

The range of case studies includes seven manufacturing oriented and another seven services oriented activities. The former covers such diverse areas as Chemicals for Industrial and Domestic Use (India), Vaccines (Indonesia), Automobile (Iran), Mass Consumption item Biscuits (Sri Lanka), and Steel Fabrication and Ceramics (Vietnam). The latter focus spreads over Air Terminal Services (Fiji), Educational Services (India), Fast Food Restaurant Chain (Philippines), Housing Development Board (Singapore), Healthcare (Thailand), and Consulting Business (Thailand). These cases provide very interesting ring-side views of how the TQM-literate organisations are attending to some of their management problems to their real-term advantages. This volume with its sharp coverage on concepts and practices, is very much capable of becoming a desirable overall model in its entirety for subsequent implementers in other places. With this in perspective, the Forum has also brought forward that "TQM should not be limited to manufacturing activities but should expand to finance and monetary management, utility management, public services, government policy making, environmental protection, agriculture and transportation", beyond the selected few front-end services, for overall national economic advantage, as they greatly influence the quality of life of people in the societies. TQM can touch all conceivable facets of better living, indeed.

Many books can be found on TQM which are just theoretical and conceptual and more of advisory nature. As in any such field, books on practice aspects come very few and far between. Since the process of management, both in general and in particular, is more an aspect of practice or application than anything else, such books on practice of management are highly valuable. One example is equivalent to several instructions from distance to reinforce the learning for launching an effort. This volume certainly addresses this professional need and comes as one very timely and important to fill this lesser addressed information (knowledge) gap in the world of practice.

Anybody related with effective managerial performance in organisations should find this book highly useful. The presentations are quite informative, lucid and easy to understand, nowhere loaded with unnecessary jargon which impedes assimilation and appreciation of the intended messages. On-line management educators, management professionals, and learners alike, will find it a rewarding experience to include it in their must-read list, with thanks to APO, for bringing out such a volume in the present form. Involved readers in the field, where advantage battles are required to be continuously fought from their trenches and won, would invariably want to see many more such volumes from APO in the time to come. Interested organisations for their copies of this book should approach their respective National Productivity Councils.

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Qualitative Methods for Valuation of Financial Assets *by A.S. Ramashastri,* Response Books Publications, January, 2000, p. 199, Price Rs. 325 (cloth) & Rs. 175 (paperback).

The book "Qualitative Methods for Valuation of Financial Assets", by A.S. Ramashastri is useful to familiarize oneself with the quantitative methods required for valuation of financial assets. The author tries to reach out to the reader by writing in an interactive mode. He has selected one hundred questions from areas relating to financial markets. Though the list is not exhaustive, the questions are sufficient to provide necessary familiarity to the users. The book is divided into five chapters. The first four chapters are on bonds, equity, portfolios and options, which are vital in the financial markets. Each of these four chapters is further sub-divided into four or five sections. The first section is on preliminary ideas about the concerned topic, an introduction in every chapter relating to the topic concerned, in which with the help of basic questions the author tries to clear the concerned concept. In the final section in each chapter the emphasis is on the quantitative background i.e. the quantitative methods useful for the evaluation of the particular financial asset discussed in the chapter. The other sections deal with the valuation methods or the uses of the particular instrument and the application of the instrument to further prospective gains.

The first chapter, which deals with bonds, covers the concepts relating to the time value of money, net present value, internal rate of return and the spot and forward rates. The author deals with different types of bonds, their characteristics and how the bonds can be immunized. Measures of central tendency and dispersion as well as random variables and the probability distribution are discussed in the second chapter. All aspects relevant to the investors on equity have been dealt with. The other informative aspect in this chapter is about the expected returns from shares as well as how to measure risk factors of a particular share which will be of use to the investor. The chapter on portfolios gives an understanding about correlation, regression and optimization. The author tries to explain the need for diversification of stock, why a portfolio of stocks should be maintained, how to measure the performance of portfolios and how portfolio holdings earnings can be optimized. The concept of Beta and its interpretation is also dealt with which is of use to financial analysts. The chapter on options explains binomial and normal distribution. Options are derivative instruments, which are yet to make an entry in the Indian bourses. The author explains how overall gains can be maximized and also cautions about the risk of using the options. The author dwells upon the relationship between European and American option values in detail. In addition, the Black-Scholes option pricing formula, which is used quite frequently by different financial analysts, the application of these options in the form of warrants and the aspect of convertible debentures are also dealt with which can be of use to investors.

A unique feature of this book is the inclusion of spreadsheets, as a separate final chapter, for each of the financial instruments using the helpage package of Microsoft Excel. In this chapter, spreadsheets are explained in detail as also their use in computations. A step by step procedure of the use of spreadsheets to solve problems regarding the four financial instruments is also given. Use of case studies and numerical examples has made the topic, more clear and interesting. The interactive mode i.e. a question-answer format does achieve the objective of familiarizing the reader with quantitative methods for the valuation of financial assets.

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