TEA PLANTATIONS ECONOMY FOR MANAGING WATERSHED OF TARBELA DAM

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ABSTRACT

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1. Introduction

1.1. Watershed Management

Physiographically the country can be divided into three major regions: a) high northern mountains; b) Indus plain; and c) lower and more arid western highlands. In addition to these, a relatively small area in the north-west of the Indus plain comprises the Pothwar plateau and salt range, which have elevations ranging between 450 to 600 m. The plateau has badlands topography due to dissection by water and wind erosion (NCS 1991).

Major part of the northern mountains and a part of the Pothwar plateau constitute the major watersheds draining water to the tributaries of the Indus Rivers system. In fact, the watersheds of Tarbela, Mangla and many small dams fall in to this area.

Watersheds of the Indus Rivers system have unfortunately suffered from excessive and wide spread felling of woody vegetation and have over-grazing in the past many centuries. The land is being cultivated even more than 2500-m altitude and on steep slopes, not at all suited for farming. Several million tons of soil is removed annually from the watersheds by water erosion. This sediment is subsequently deposited in streams, channels, lakes, reservoirs and harbors, requiring costly remedial measures to keep up their useful lives. Sediment studies in Pakistan's rivers have been carried out since 1916. In early 70s, soil at the rate of 3-5 thousand tons per km^2 was carried annually in the rivers of Chenab and Jhelum (Saeed 1974).

Geologic erosion is predominated in the watersheds of the Indus, Kabul and Swat rivers, whereas accelerated erosion is caused by defective land use in the watersheds of the other tributaries of the Indus, and of Jhelum (Ahmad and Pervaz 1963).

Due to reasons mentioned already, effective sediment erosion control in the Tarbela catchment is not possible. In fact, over 91.5% of the watershed area of the Indus river at Tarbela, the geologic erosion is a major concern rather than the accelerated erosion. At the most, there is some possibility of alleviation in the monsoon-affected catchment of Siran and Swat rivers. Consequently, a pilot project of watershed management was initiated in 1964-65 for a part of Siran catchment. It was expanded in 1971-72 with the support of the World Food Programme into Kaghan valley and Duar watersheds. The Forest Department of the NWFP in collaboration with WAPDA implemented this project. Further expansions were made in 1977 to cover four divisions east of Indus in 1984-85 to include Kohistan and Bunair districts to the west of Indus. The latter project was concluded in June 1993. The current project is now a second phase of the World Food Programme and also supported by the German Development Bank, Kreditanstalt fur Wiederaufbau (KFW). This Tarbela watershed management programme has a limited impact on sediment control; as the watershed project activities cover only 6% of the area draining water in to Tarbela. In fact, actual coverage in the project was even less than the potential area.

Forest area is 5.3% of the country's geographical area. This area is defined legally and not biologically because of the definitional difficulty due to the colonial legacy. As a result, the estimate of forest area is insensitive to the number of trees, but responsive to changes in areas commanded by the control of the Forest Department. Therefore, the increase in forest area of around 3% at the time of independence to 5.3% has no correlation with the quantum of forestry in the country. On the contrary, widespread anecdotal evidence – in the form of political statements, record of public hearings and journalists' accounts – suggest that there has been a significant reduction in natural forests over the last 30-40 years, a process which may feel is still continuing (GOP et al 1992; NCS 1991; Shah 1989; Shah 1991; Ali 1990; Minissale 1991). The loss of vegetation especially in watershed areas has direct impact on erosion of top fertile soil and increased sediment load to the stream flow. The sediment load in the stream flow ultimately affects the live storage of the large hydropower reservoirs. Thus, reducing the capacity for storage of water and power generation.

Studies conducted in the past have clearly indicated that indiscriminate exploitation of forests and cultivation of steep slopes have resulted in accelerated runoff and soil erosion process. Due to sediment load in the stream flow the Mangla and Tarbela Dams will be completely silted up within about 110 and 50 years, respectively, since the completion time of these reservoirs as per design parameters, if watersheds environment is not improved considerably (WASID 1967).

1.2. Tea Import and Consumption

The annual tea import during the year 1999-2000 was around 110,000 tons, which costed to the country of around Rs. 11 billion. There is around 3% increase in annual consumption based on the data of the last two decades. The increase in import bill was 4% during the last two decades (1980-2000). This means that the import will increase in the future to meet the needs of the increasing population and changes in the dietary habits. Tea is the cheapest drink for the common population in Pakistan.

In fact the country has to spend foreign exchange for the import of tea. The country is already facing shortage of foreign exchange. Therefore, the government has placed higher priority for import substitution in agriculture covering both the tea and edible oils.

1.3. Tea Plantation in Pakistan – Historical Perspective

Pak-China Expert Team surveyed the catchment area of the Siran and the Swat rivers during 1984 to identify suitable areas for plantation of tea. The major criteria considered for this purpose was pH (less than 6), good drainability and access to water. Around 160,000 acres were identified as suitable area for the plantation of tea, which are located in Hazara and Malakand divisions. Pakistan Agricultural Research Council started systematic effort for plantation of tea in 1986, when a pioneer plantation of 33 acres was completed at Shinkiari, Mansehra. Presently, this plantation is producing tea leaves, which are now being used for processing of black tea. Plantations on farmers' fields were started during 1998 by PARC. Around 50 acres of tea was planted in farmers' fields. Lever Brothers also joined these efforts during 1989. The tea planted area in farmers' fields by the Lever Brothers is around 200 acres.

Table 1. Historical perspective of tea plantation in Pakistan.

Year	Activity
1973	Research and Introduction of Tea Crop in Pakistan – Research Scheme by MINFAL
1976-83	Scheme handed over to PARC; Tea seeds imported from China, Sri-Lanka and Japan and screening at NARC Chinese varieties planted at Baffa and Daively, Mansehra
1984	PARC invited Chinese Tea Experts for survey of Hazara and Malakand divisions to identify suitable areas
1986	Established National Tea Research Station, Shinkiari
1986	Completed Pioneer Plantation at Shinkiari
1989	Lever Brothers Established Tea Nursery at Shinkiari
1996	Upgraded NTRS to a National Tea Research Institute
1996	Established Green Tea Processing Plant
1998	Initiated Plantations at Farmers' Fields under Development Project
2001	Established Black Tea Processing Plant

1.5. Potential of Tea Plantation in Watersheds

The life of tea plant for producing economic harvests is over 100 years. The plantation provides complete cover and no other plant can compete with tea in providing complete cover in the watershed area. The other benefit of tea plant is that it is not palatable for all the animals including goats. Thus, tea is the best watershed plant. Being a watershed expert, I feel so much concerned with the efforts of the watershed management projects, which are facing difficulty in improving surface cover because trees can not provide complete cover. Thus tea will be an ideal plant for watersheds of the Tarbela dam.

Area suitable for tea plantation in Pakistan is around 160,000 acres, whereas around 110,000 acres are needed to meet the present requirement. The Pioneer Plantation at NTRI of 33 acres is a good demonstration for future expansion of tea area. Furthermore, there is a facility to manage nursery at NTRI over an area of 12 acres, which will be sufficient to provide plant saplings for around 600 acres. The institute has also developed Production Technology Packages for varied ecologies. The black tea processing plants of NTRI and Lever Brothers can provide buyback arrangement to the farmers. At present, the plantations at farmers' fields are around 250 acres by the NTRI, the Lever Brothers and the Tapal.

Paper includes review of the past achievements related to tea plantation and watershed management in the country. Furthermore, efforts were made to conduct study for the economics of tea plantation using two scenarios. Future strategy was also formulated for the plantation of tea including the option of tea as a watershed plant.

2. Sedimentation in Tarbela Reservoir

2.1. Sources and Load of Sedimentation

Indus River emerges from the land of glaciers on the northern slopes of Kailash ranges, some 5182-m above sea level; the Indus River has its source near the Lake Mansrowar in the Himalayan catchment area. It largely brings in snowmelt supplies in addition to some monsoon rains. Four main upstream tributaries join the Indus Shyok River at an elevation of 2438 m near Skardu. Gilgit and Hunza rivers join near Bunji and Siran river just north of Tarbela. All these tributaries except Siran are located in semi-arid to hyper-arid environment, where hardly any vegetation exists in the watershed area. Geologic erosion is a common phenomenon.

At Tarbela, Indus River drains a catchment area of 167,700 km^2 mostly comprising highly denuded barren and glaciated landscape. Indus is in fact one of the largest sediment-producing rivers of the world. Upstream of Tarbela, Indus is fed by the Right Bank tributary of Siran draining monsoon-influenced area of about 10,200 km^2, which is only 6% of the total catchment area. Thus 94% of the catchment area is located in semi-arid to hyper-arid environment.

The main source of inflow of sediment is glacial- and snowmelt. The glacial- and snowmelt is also an indicator that plantation beyond snowline is not possible. Thus, it is not possible to control the geologic erosion. Furthermore, glacial- and snowmelt is drained to the river through steep slopes in formations, which are geologically young. These areas are completely barren, only some natural vegetation is seen along these waterways below the snowline. Thus, plantations can't help to reduce the sediment inflow to the river.

The sediment load varies with discharge, seasonal differences and conditions of the watershed and river morphology. In the design stage, the average annual sediment transport of the Indus at Darband was estimated at 440 million tonnes (Mt) or 0.294 BCM per annum.

2.3. Sedimentation Rate [predicted vs. actual]

Sediment deposited in Tarbela reservoir is expected to consolidate to a final density of about 1.1 kg/m^3. This high value was estimated because of the predominance of fine sand in the suspended sediment. Based on these predicted estimates, Tarbela reservoir was expected to silt up at the rate of approximately of 2% per year. Thus predicted life was 50 years when the reservoir would be fully depleted to a final volume of 1.2 BCM (Lieftinck Report 1967). The predicted life of 50 years in the Liftinck Report is also an indication of additional storage required as replacement of lost storage of Tarbela. It may be pointed out that a basic consideration in selecting Tarbela site was its suitability for diverting the water for off-channel storages in the side valleys with much longer life.

Systematic sediment sounding of the reservoir was started in 1979. The results indicated total sedimentation of 0.891 BCM during 1974-79. Thus the average annual loss of around 0.149 BCM was almost half of the predicted. It was reduced further and the average annual sediments were 0.127 and 0.092 BCM for the periods of 1974-83 and 1984-99, respectively. The overall average annual sedimentation was 0.106 BCM during the period of 1974-99, which is almost 36% of the predicted annual sedimentation of the reservoir (Table 2). The decline in sedimentation of reservoir was due to the increased outflow of sediments because of the continued loss of dead storage capacity of the reservoir. The reduction in sedimentation during 1979-82 was due to the reduced river flows as these years were drier compared to the average years.

Table 2. Actual Sedimentation of Tarbela Reservoir.

Observation Period	**Elapsed Years**	**Total Sedimentation of Reservoir**		**Average Annual Sedimentation of Reservoir**	
		Mt	**Billion m^3**	**Mt**	**Billion m^3**
1974-79	6	1320	0.891	220	0.149
1974-81	8	1635	1.102	204	0.138
1974-82	9	1726	1.165	192	0.129
1974-83	10	1879	1.268	188	0.127
1979-81	2	315	0.212	158	0.106
1979-82	3	331	0.223	110	0.074
1981-82	1	91	0.062	91	0.062
1982-83	1	153	0.103	153	0.103
1984-99	15	2057	1.385	137	0.092
Average 74-83					0.127
Average 84-99					0.092
Average 74-99					0.106

Source: (a) Sector Planning. Main Report. WB Study Group. Vol. 1, 1968; (b) Tarbela dam Project Completion Report on design and construction. Vol. I, TAMS. 1984, WAPDA, Lahore; (c) TDP, WAPDA.

Sedimentation of the reservoir is taking place more slowly than originally foreseen. Therefore, the life of the reservoir is expected to be higher than 50 years. It is estimated that with careful operations in the future, the storage life could be enhanced to around 85 years. Assuming the average annual sedimentation rate of 0.106 BCM, and satisfactory resolution of delta movement the expected life of the reservoir could be around 100 years.

2.3. Problems Associated with Sedimentation

Currently the most serious problem associated with the reservoir sedimentation is under water sediment delta (Figure 1). With the yearly cycle of reservoir operation, the delta formation is continuously reworked and moved downstream closer to the dam. On an average rate, the pivot point of delta has been advancing about one km per year. It is presently located at about 14 km upstream of the dam at an elevation of around 416 m. The yearly hydrographic surveys revealed that about 62 m sediment deposits have accumulated between 16-48 km upstream of the dam.

The accumulation of sediments within Tarbela reservoir is causing two major problems. Firstly loss of live storage, which is causing gradual reduction in the regulated yield of reservoir. This in turn would result in reduction in water availability for agriculture especially for *rabi* and early *kharif* seasons and also reduction in the firm energy available from the Project. Secondly, the physical effect of sediment would increase the risk of clogging of lower intakes and low level tunnel outlets by liquefaction of delta particularly in a seismic activity with ground acceleration of 0.13 G. The erosive action of sediment laden water on outlet concrete structures and power turbines would result in exorbitant maintenance costs.

Due to combination of favourable conditions, particularly lower inflows, actual loss of storage in the Tarbela reservoir is around 22% during the period from 1974 to 1999. However, due to the serious operational problems created by advancement of the sediment delta towards the dam, the actual available storage for the year 1998-1999 was around 61% of the usable storage. This was due to the operational strategy of the reservoir as dead storage of 417 m was maintained during 1998-99. This had impact on power generation.

3. Economics of Tea Plantation

Economics of tea plantation depend on number of factors. The most essential is the land and water development. If surface irrigation has to be practiced than the cost of land levelling will be higher as the topography is not suitable for basin irrigation. Sprinkler irrigation is ideal for tea plantations as light showers would help to increase productivity of foliage. Furthermore, it provides cooling and frost control to maintain quality. Therefore, two scenarios were considered, while conducting economic analysis of tea plantations. However, yield levels were kept same for both the scenarios to have realistic estimates. In fact, productivity under sprinkler irrigation will be higher from that of the surface rather flood irrigation.

3.1. Economics using Scenario of Sprinkler Irrigation and Plucking Cost

The locally manufactured Raingun sprinkler irrigation can be used for tea plantation for irrigation can be used for irrigation and fertigation. Application of folic fertilizers both chemical and bio can help to impose productivity of foliage and thus plucking period will be increased significantly. The cost of land development for irrigation is completely eliminated, which might be more than the cost of sprinkler irrigation in certain cases.

Medium and large size farmers were the target, where they have to pay for the plucking cost. Plucking cost is almost two-third of the total operational cost. Thus it is the major cost. In addition to plucking cost, land rent, ixoation, weeding and fertilizer costs were included in the operational cost. The plucking cost is assumed @ Rs. 5/Kg, whereas the produce of fresh leave is costed @ Rs. 15/Kg. The details of economic analysis are given in Tables 3-6.

Table 3. Capital Investment for Tea Plantation in Pakistan (First Year Cost)

Particular of Cost	Capital Investment (Rs./acre)
Land Preparation (levelling, tillage, pit forming)	6,000
Amendments (100 gm of Sulphur per plant)	2,500
Sprinkler Irrigation System	15,000
Tea Seedlings (5,000 plants @ Rs. 3 per plant)	15,000
Transplantation (30 mandays @ Rs. 80 per day)	2,400
Total	**40,900**

Table 4. Annual Operational Cost (Rs./acre/year) of Tea Plantation over a Period of 7 Years

Particular of Cost	*Years*						
	1st	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**
Land rent	5000	5000	5000	5000	5000	5000	5000
Fertilizer	2500	4200	6000	6000	6000	6000	6000
Weeding	4800	4800	4800	4800	2400	1200	-
Irrigation Cost (6 irrigation @ Rs. 300 per irrigation)	1800	1800	1800	1800	1800	1800	1800
Plucking of Tea Leaves (Rs. 5 per kg)	-	-	5400	12600	15000	17500	20000
Annual Operational Cost	14100	15800	23000	30200	30200	31500	32800
Cumulative Operational Cost	14100	29900	52900	83100	113300	144800	177600

Table 5. Economics of Tea Plantation (Rs./acre) at Point of Breakeven (after a period of 7 years)*

Particular of Cost	*Years*						
	1st	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th***
Capital Investment	40900	-	-	-	-	-	-
Cumulative Operational Cost	14100	29900	52900	83100	113300	144800	177600
Cumulative Total Investment	55000	70800	93800	124000	154200	185700	218500
Annual Gross Return	-	-	16200	37800	45000	52500	60000
Cumulative Gross Return	-	-	16200	54000	99000	151500	211500

* At the end of the 7th year, cumulative gross return equals the total investment (capital and operational)

Table 6. Economics of Tea Plantation after a Period of Eight Years since Plantation*

Particulars	(Rs./acre/year)
Annual Operational Cost	32,800
Annual Gross Return	60,000
Annual Net Return	27,200

* The cost of plucking of Rs. 20,000 was included. If plucking cost was taken as an opportunity cost, then the net return would increase to Rs. 47,200 per year.

3.1.1. Factors for Slow Adoption of Tea in Pakistan

The reasons for slow adoption of tea plantations in Pakistan are as under:

- Long gestation period of 7 years, as gross returns equal investment after a period of 7 years;
- Farmers' livelihood depends on seasonal income from maize-wheat or rice-wheat cropping systems, therefore, livelihood support is needed for a period of 7 years;
- Small landholdings and irrigation facility is limited;
- Investment of Rs. 2,19,000 is needed over a period of 7 years. Around Rs. 55000 are needed for the first year and Rs. 27,000 as average annual operational cost for the next 6 years.

3.2. Economics using Scenario of Surface Irrigation and without Plucking Cost

In the potential areas of Hazara and Malakand divisions, farmers' holding are normally small and they can afford to use their family labour in plucking of tea leaves. If plucking cost is considered as an opportunity cost then the gestation period of seven years is reduced to 5 years under surface irrigation scenario. Thus for resource-poor farmers, There is an option to develop family labour system of plucking. The capital investment and annual operational cost were also reduced. However, Rs. 98,000 are needed as an investment for a period of five year with first year investment of Rs. 37,000 and Rs. 14,000 as annual operational cost for the next four years.

Table 7. Capital Investment for Tea Plantation in Pakistan (First Year Cost)

Particular of Cost	Capital Investment (Rs./acre)
Land Preparation (levelling, tillage, pit forming)	6,000
Amendments (100 gm of Sulphur per plant)	2,500
Tea Seedlings (5,000 plants @ Rs. 3 per plant)	15,000
Transplantation (30 mandays @ Rs. 80 per day)	2,400
Total	**25,900**

Table 8. Annual Operational Cost (Rs./acre/year) of Tea Plantation over a Period of 5 Years

Particular of Cost	*Years*						
	1st	2nd	3rd	4th	5th	6th	7th
Land rent	5000	5000	5000	5000	5000	5000	5000
Fertilizer	2500	4200	6000	6000	6000	6000	6000
Weeding	4800	4800	4800	4800	2400	1200	-
Surface irrigation	480	480	480	480	480	480	480
Annual Operational Cost	12,780	14,480	16,280	16,280	13,880	12,680	11,480
Cumulative Operational Cost	12,780	26,780	42,580	58,380	71,780	83,980	94,980

Table 9. Economics of Tea Plantation (Rs./acre) at Point of Breakeven (after a period of 5 years)*

Particular of Cost	*Years*						
	1st	2nd	3rd	4th	5th*	6th	7th

Capital Investment	25,900	-	-	-	-	-	-
Cumulative Operational Cost	12,780	26,780	42,580	58,380	71,780	83,980	94,980
Cumulative Total Investment	38,680	52,680	68,480	84,280	97,680	109,880	120,880
Annual Gross Return	-	-	16200	37800	45000	52500	60000
Cumulative Gross Return	-	-	16200	54000	99000	151500	211500

* At the end of the 5th year, cumulative gross return equals to the total investment (capital and operational)

Table 10. Economics of Tea Plantation after a Period of Eight Years since Plantation*

Particulars	(Rs./acre/year)
Annual Operational Cost	13,400
Annual Gross Return	60,000
Annual Net Return	46,600

Factors for Slow Adoption of Tea in Pakistan

- Medium gestation period of 5 years - gross returns equal investment after 5 years
- Farmers' livelihood depends on seasonal income from maize-wheat cropping system
- Small landholdings
- Livelihood support is needed for a period of 5 years
- Investment of Rs. 97,680 is needed over a period of 5 years – Rs. 38,680 for the first year and Rs. 14,356 as average annual operational cost for the next 4 years

4. Future Strategy

Five elements of the proposed strategy for future development of tea in Pakistan are given as under:

4.1. Public-Private Sector Compact

The NTRI may be made responsible to provide the technical backstop support for plantations and production technology to all the agencies involved in tea plantations. Two existing Tea Processing Plants (NTRI and Lever Brothers) may serve as nucleus for further introduction of tea plantation in the country. ADBP and Commercial Banks may be encourage to provide interest-free credit line for farmers and Tea Processing Plants. The credit line for farmers should be based on the concept of support in kind, where banks provide finances for plants, irrigation, land development, inputs, etc.

4.2. New Tea Plantations

Hedge-row plantation on farmlands and farmhouses is the most promising intervention in the area, as it will not affect the livelihood of farmers. The interventions recommended are as under:

- Hedge-row plantation on farmlands and farmhouses;
- Farmland plantations;
- Plantations in watersheds;
- Lawn plantations in public/private institutions.

4.3. Balancing Quantity Vs Quality

The NTRI is providing saplings of tea propagated using both the seeds and colones. The plants produced using seeds are hardy for the climatic conditions of the potential areas as these plants have deep tap-root system, which can extract water from deeper depths. The plants produced by colones although provides better quality tea but establishment of these plants require more frequent irrigatios using sprinkler irrigation, as the rooting system is shallow. Thus upper layers of soil should have sufficient moisture to meet the plant requirement during the dry spells. The elements of the strategy are as under:

- Propagation of plants through seeds for higher survival rate and scale;
- Propagation of plants through colons for quality tea production.

4.4. Training

The training will be a vital element of the strategy for introducing tea in the country. NTRI should develop training programmes and modules for different levels to meet the requirement of the clients. The institutions identified for the provision of training to the farmers are as under:

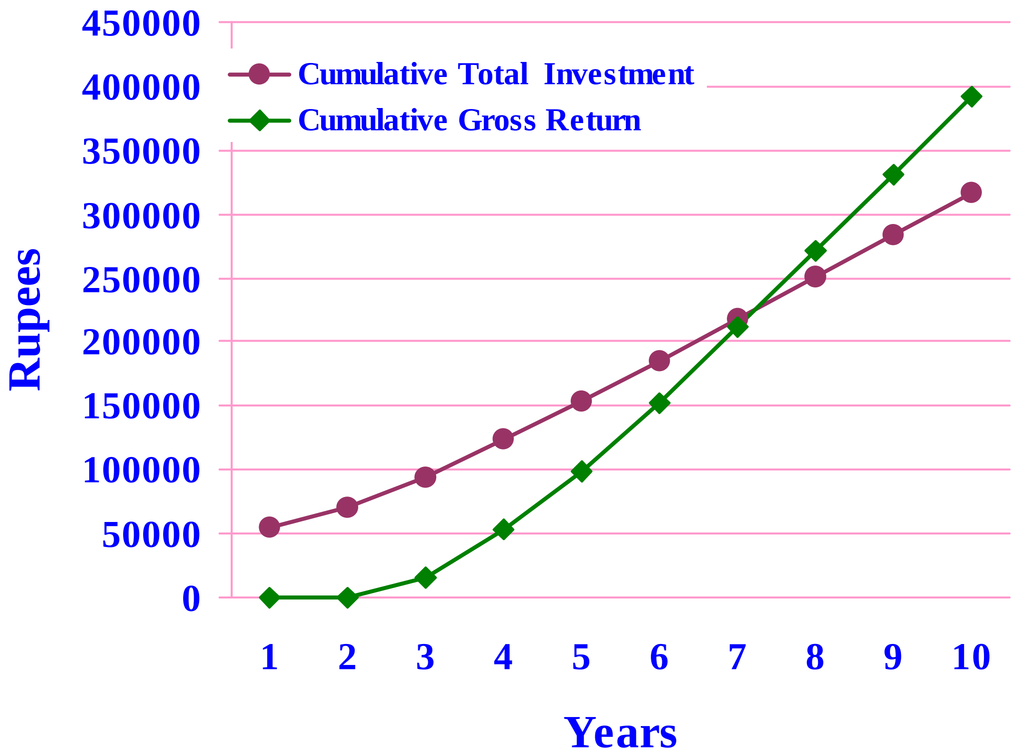
- NTRI
- Private Sector - Lever Brothers, Tapal, etc.
- Line Departments - Agriculture, Forestry
- NGOs
- Schools
- Mosque Madrassas

4.5. Promotional campaigns

Promotional campaigns are needed for systematic introduction of tea in the country. For this purpose mass media, local schools and mosques should be involved.

Economics of Tea Plantation in Pakistan

(with sprinkler irrigation and plucking cost)



Economics of Tea Plantation in Pakistan

(with surface irrigation and without plucking cost)