

INDICATORS OF AGRICULTURAL PERFORMANCE IN THE MUDA IRRIGATION SCHEME, MALAYSIA

by

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INTRODUCTION

During the next decades, irrigated agriculture is threatened by water shortages arising out of increasing competition from domestic, industrial and other sectors. This situation is further worsened by dwindling financial resources available for capital expenditures as the cost of new schemes increase. However, despite the twin challenge of reductions in available water supplies and in financial resources, irrigated agriculture will have to meet 70 to 75 percent of the additional foodgrain requirements in many developing countries in order to avoid large scale hunger and malnutrition. Besides, irrigation will be needed for fibre and cash crops to meet the objectives of self-sufficiency, employment creation, poverty alleviation and development.

In view of the above, it is essential that water-use efficiency in irrigated agriculture should be improved with a view to producing "more food with less water." This would require inter alia, an understanding of the irrigation management practices, macro policy environments and institutional/organizational structures which enhance the productivity and environmental sustainability of irrigated agriculture in developing countries. This, in turn, requires in-depth analyses and evaluations of economic, financial and environmental sustainability of irrigated agriculture under a variety of agro-ecological conditions, management practices (e.g. rotational water supply vis-a-vis demand based systems), management structures (government department, agriculture corporation), policy environments (water charges, input/output prices).

This paper is based on ongoing studies in Malaysia under the Program of Assessing and Improving the Performance of Irrigated Agriculture being undertaken by the International Irrigation Management Institute (IIMI), Colombo. Under this Program, performance indicators are being estimated to quantify productivity, economic profitability and environmental sustainability of irrigated agriculture in Malaysia, Pakistan (Punjab), India (Gujarat), Sri Lanka, Sudan (Rahad), Morocco (Moulouya ORMVM) and Argentina (Tunyan)

This paper presents empirical evidence with regard to Muda irrigation scheme in Malaysia where substantial gains in productivity and profitability have been reported. This paper shows that high paddy yields can be achieved and sustained over time if adequate measures are undertaken to improve the utilization of irrigation water supplies during periods of water shortages.

The paper is divided into four sections. The first section presents an overview of IIMI's Performance Program goals and activities over the next 5 years. Section 2 presents an overview of Malaysian agriculture and major developments in the Muda irrigation scheme. This is followed by selected indicators of agricultural performance which include: Irrigated area; irrigated area per unit of water; trends in paddy production per unit of land and water; net value of output and cost of production at farmers' prices and at economic prices; and cost of production in relation to import costs during the last decade. The next section presents a preliminary analysis of selected interventions undertaken by the management of Muda irrigation scheme to improve the water-use efficiency and agricultural productivity over time. The last section presents conclusions and areas for further research.

1.0 PERFORMANCE PROGRAM GOALS AND ACTIVITIES¹

1.1 Performance Program Goals & Activities

The introduction of performance assessment methodologies is an effective and necessary first step in bringing about changes in irrigation management practices. Consistent use of performance indicators generates information which provides the basis for defining, monitoring and evaluating improved operational procedures for existing systems and for determining what further investment in irrigation, if any, are justified.

In view of the above, IIMI is implementing a Program on 'Assessing and Improving the Performance of Irrigated Agriculture.' It is anticipated that, over the next five years, the Program will :

- Assist irrigation agencies and policy makers to incorporate a Performance Assessment System as an integral part of the management process;

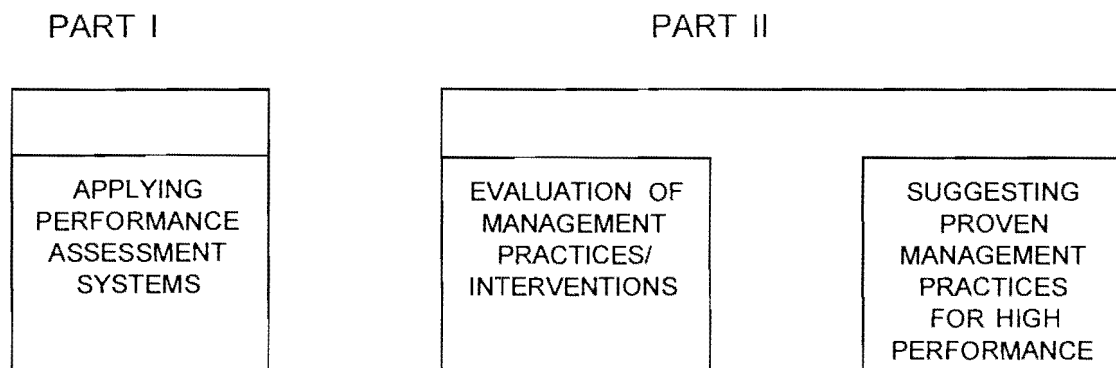
¹For details on methodological issues of measurement of indicators, quantification of assessment norms and evaluation of management interventions, see Bhatia (1994).

- Develop and disseminate methodologies to enable policy makers and irrigation managers to select appropriate indicator sets for evaluating productivity and sustainability of irrigated agriculture;
- Establish a database which can be used for comparative information on the performance of irrigated agriculture in varying agro-climatic and management situations;
- Identify proven management practices which are associated with high performance and assist in their adaption.

The proposed activities under this program will integrate and carry forward research presently underway on both performance assessment and decision support packages. Based on the framework developed earlier (Bos et al 1994) and other work (Small and Svendsen 1992, Abernethy 1991, Rao 1993 and Murray-Rust and Snellen 1993), a set of specific indicators will be identified that can be used by policy makers, irrigation managers and researchers. Performance indicators will be grouped into four types: (i) water supply performance; (ii) agricultural performance; and (iii) economic and social impacts, and (iv) environmental performance. These performance indicators will be applied and field-tested in selected irrigation schemes as discussed below.

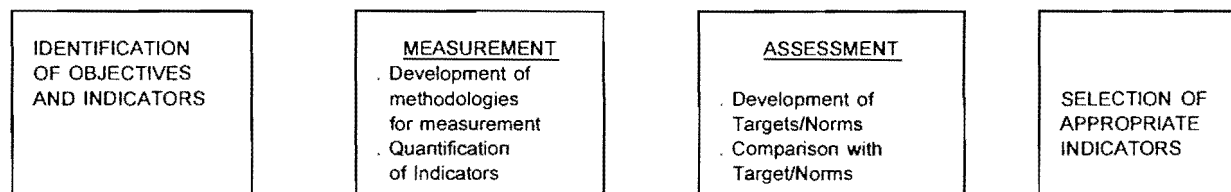
As outlined in Figure 1, the major activities of the Program are divided into two interrelated parts. Part I will focus on developing, applying and refining a comprehensive Performance Assessment System which will provide data regarding an irrigation scheme in terms of water supply, productivity, equity, financial viability, environmental sustainability and the degree to which the existing "scheme" meets current and further agricultural requirements. The outputs of these activities would be a package of practical and cost-effective performance indicators which will be used to assist policy makers and irrigation managers to assess and improve the performance of irrigated agriculture.

Figure 1
Major activities of the performance program



Part II of the program will concentrate on using the performance assessment system to evaluate the performance impacts of a set of management practices and interventions. The empirical studies will evaluate the impact of an existing management practice (e.g. fixed rotational water supply) in selected irrigation schemes or assess the performance improvements achieved as a consequence of a management intervention (e.g. use of a decision support system). The outputs of this part of the Program will be to generate and disseminate knowledge about proven management practices associated with high performance. These evaluations will generate empirical information about the "determinants" of performance-enhancing management practices and institutional changes.

Figure 2
Steps in performance assessment



For the **first phase (1994-1995)**, a comprehensive Performance Assessment System will be applied and field-tested in the following major irrigation schemes:

- (i) Chishtian Sub-division of the Fordwah-Eastern Sadiqia irrigation system, Punjab, Pakistan;
- (ii) Muda Irrigation Scheme in northern Malaysia.

1.2 Expected Outputs

At the end of 1995, the following outputs will be available :

- (i) A package of performance indicators which has been field-tested and modified on the basis of feedback from irrigation managers, policy makers and researchers;
- (ii) A methodology of selecting cost-effective and relevant performance parameters for a given irrigation scheme;
- (iii) Setting up a process within irrigation agencies under which data are routinely collected to apply a Performance Assessment System on a regular basis;
- (iv) Empirical estimates of "value of water" in irrigated agriculture under high rainfall rice systems and semi-arid multicrop schemes under a variety of management situations;

At the end of 1998, the following outputs will be available :

- (i) Empirical estimates of "value of water" in irrigation regimes under various conditions, such as rainfall, crop patterns, size of irrigated area, contributions from groundwater, type of surface water system (reservoir or diversion scheme) and management situations;
- (ii) Database for a number of country-wide irrigation schemes giving information on irrigated area; productivity per unit of land, water and labour; index of equitable distribution of benefits; financial viability; economic profitability and environmental impacts.
- (iii) An analysis of the "performance levels" of selected systems in terms of design and "potential performance" in their agro-ecological and infrastructural settings.
- (vi) Alternative methodologies for measurement of performance indicators along with the case of data collection, cost and statistical reliability.

2.0 INDICATORS OF AGRICULTURAL PERFORMANCE IN THE MUDA SCHEME

Water Resources for Irrigated Agriculture in Malaysia, the share of domestic and industrial demand in total will increase from 23 percent in 1990 to 32 percent in 2000. In the Muda irrigation system in Malaysia, urban and industrial water demand is estimated to increase from 228 million cubic meters (MCM) in 1990 to 477 MCM in 2000 (Table 1). In other words, if new sources of fresh water supplies are not found, irrigation supplies to farmers in the Muda area will have to be reduced from around 1700 MCM in 1990 to 1460 MCM in 2000, a reduction of 15 percent.²

Irrigation development in Malaysia has been exclusively devoted to the cultivation of wet paddy and about 52% or 342,000 ha of the total area under paddy has been provided with irrigation facilities. There are 8 granary areas totalling 211,850 ha while the non-granary irrigated areas are 924 schemes totalling 130,800 ha. Irrigation development is guided by the National Agricultural Policy (NAP) of 1984 which stipulates the rice self-sufficiency level should not be less than 65 percent. In 1990, rice imports were 0.33 million tons or an equivalent of 0.49 million tons of paddy. Thus, rice imports were about a quarter of the total rice consumption in 1990. However, these rice imports have doubled in the last ten years while domestic production of paddy has declined from about 2.0 million tons in 1981 to about 1.55 million tons in 1991.

The eight major granary areas occupying 32 percent of paddy lands produced more than 65 percent of the country's output in 1991. The Muda irrigation scheme is the largest among the eight granary areas and encompasses 96,000 ha of rice fields.

2.1 Significance of the Muda Scheme in Malaysian Agriculture

In 1990, the Muda irrigation scheme provided 0.76 million tons of paddy out of the total production of 1.65 million tons in Malaysia (Table 2). Further, the contribution of Muda scheme in meeting the self-sufficiency objective of the Malaysian economy has become more crucial over time. While total paddy production in Malaysia has declined from 2.0 million tons in 1981 to 1.55 million tons in 1991, total production in the Muda scheme increased from 0.73 million

²For details on conflicts in water use, conservation in water-use in urban and industrial sectors and sustainability of irrigation, see Bhatia and Falkenmark (1993), Bhatia et al (1994), Kijne and Bhatia (1994).

tons in 1981 to 0.80 million tons in 1991. Hence, paddy production in the Muda scheme accounted for about 50 percent of the total paddy production in the country in 1990, compared with its share of 26 percent in 1981. In 1991, rice imports would have been higher by about 50,000 tons (compared with 1980) in the absence of increased paddy production in the Muda scheme.

2.2 Major Developments in Malaysian Agriculture and in the Muda Scheme

Major developments in the Malaysian agriculture affecting the productivity of the Muda scheme are:

- . Guaranteed Minimum Price (GMP) for paddy and direct output price subsidy (since 1980);
- . Free fertilizer since 1979;
- . "Projectised Organization" for the management of large irrigated projects such as Muda, Kemubu etc since 1970;
- . Institutional support by establishing Federal Agricultural Marketing Authority (FAMA); Malaysian Agricultural Research and Development Institute (MARDI); National Paddy and Rice Authority for processing and marketing paddy and Agricultural Bank of Malaysia to extend agricultural credit.

The Malaysian government has fixed a guaranteed minimum price for paddy which has varied between RM (Malaysian Ringgit) 462 and RM 490 per ton during 1980-84 (1 U.S.\$ = RM 2.7 in 1994). The direct price subsidy has increased from RM 165 per ton up to 1990 (2nd season) to RM 248/ton since 1991. Since 1979, free fertilizers have been given by the government agencies to farmers up to a limit of 6 acres (2.4 ha). The amounts given were designed to enable farmers to apply 80 kg of nitrogen (N), 30 kg of phosphorous (P) and 20 kg of potassium (K) per ha. In 1991 (1st season), farmers in the Muda scheme, on average, applied 75 kgs of N, 30 kgs of P and 19 kgs of K per hectare. The cost of subsidized fertilizers have been estimated to be RM 125 (U.S.\$ 46) per ha in 1991.

Major Interventions in the Muda Irrigation Scheme

Shifts from Transplanting to Direct Sowing

Three methods of crop establishment used in the Muda area - transplantation, wet seeding and dry seeding - differ in terms of duration of irrigation period,

seasonal water requirements, crop yields and cost of production. Since its introduction into the Muda area in the early 1980's, the practice of direct seeding as a method of crop establishment has replaced traditional transplantation method.³ Coverage of direct seeding has increased from around 31 percent of the total area planted in 1985 to around 70 percent of the total area planted in 1988 and to about 95 percent in 1993. Direct seeding has three variations: wet seeding, dry seeding and voluntary seeding. Under wet seeding method, the fields need to be wet before pre-germinated seeds are sown. Under the dry seeding, paddy fields are ploughed under dry conditions and the seeds are sown after that. Water is introduced only after the germination of the seeds. This method is available only in the first season (or off-season) i.e. commencing in February-March and due for harvesting in July/August). The third method (voluntary seeding does not require new seeds being sown but depends on the shattered grains from the during previous harvests for crop establishment.

Table 3 provides data on these variables which show that dry seeding requires the least amount of water i.e. about 28 percent less than what is required under transplanting.

It has been estimated (Yashima 1994) that as a result of a major shift from wet sowing and transplanting (during the first season) to dry sowing (86 percent of total area in 1991) irrigation requirements in 1991 were 15 percent less than the irrigation requirements in 1988.

Dry seeding also has 10 percent lower yield compared with wet seeding. However, cost of production under dry seeding is about 17 percent lower than that under wet seeding, partly due to lower labour-use. The combined effect of lower yield and lower cost per ha is reflected in cost of production being RM 182 per ton under dry seeding compared with RM 200 per ton under wet seeding. (Table 4).

Tertiary Development

For management purposes, the Muda command area composed of 110 irrigation blocks is divided into four districts and 27 localities. Area under each block is 900 ha in average ranging between 110-1400 ha.

In 1978, MADA selected 38 irrigation blocks with water supply and drainage problems for improvement, under the tertiary development (so called Muda II project). These blocks were further divided into four to six Irrigation Service

³For details on the Muda Scheme, see Yashima (1994).

Areas (ISA), and each ISA was divided into approximately five Irrigation Service Units (ISU) (MADA, 1988). Area under each ISA varies between 100-150 ha, while area under an ISU varies between 20 to 30 ha approximately. Under tertiary development, tertiary canals and farm roads were constructed to increase canal density from 11 to 34 meters per hectare. Area under tertiary development increased from 2000 ha in 1984 to 23639 ha in 1992.

Farmers' Organizations

Under Muda II project, it was intended to organize all the farmers in each ISU into a ISU work group, and to form an ISA committee from the leaders of each ISU group. The ISA committee was expected to regulate the schedules, coordinate machinery and labor usage and regulate water supply by operating and maintaining all minor field structures. However, the response of the farmers to this intervention was not encouraging (MADA, 1988). As an alternative to water user groups as well as to serve as fore-runners to ISA organizations, MADA has organized the farmers into groups called Kelompoks. This system formally started in peninsular Malaysia in 1979. These groups consist of farmers who group together to carry out rice production. This method is expected to take over a part of the functions of the traditional form of family farm. In the areas under Muda II project, Kelompok are organized based on ISU area. There are about 400 Kelompoks in the project area according to the recent estimates. In 1990 there were 327 Kelompoks covering approximately 10,000 ha (10% of the area).

Mini estate is an advanced stage of group farming in terms of its independence and viability in group activities. Some mini estates operate tertiary canals. But they are not basically water user associations. There are about 90 mini estates in Muda area (16% of the total Kelompoks in 1990). The farmers in a mini estate are eligible to be given a government subsidy of RM 1000.00 per ha to improve their common infrastructure. They are also eligible to get RM 1000.00 soft loan from the government to be used for tractor ploughing and other inputs necessary for improving the production (Sivalingam, 1993).

Data Feedback System for Improved Canal Operations

MADA adopted a new water management and control scheme in 1988. Under this new system, water depth is measured daily at five locations in each irrigation block. In 1986 a telemetry system was installed by MADA to increase the efficiency and effectiveness of water management and flood routing. These systems consist of rainfall stations and rainfall-cum-water level stations. They are located at appropriate locations to monitor the rainfall distribution in paddy

fields, streamflow in uncontrolled flow catchment and rainfall and water level in Pedu reservoir (Teoh and Chua, 1989). Engineering section of MADA monitors the relevant hydraulic data required for the operation of the irrigation system. There are 20 telemetric rainfall stations in the command area from which data are relayed to the headquarters. In the uncontrolled flow catchment area, 5 telemetric rainfall-cum-water level stations monitor and supply uncontrolled flow data and rainfall. This Data Feedback System along with measurement of field water depth has enabled MADA to improve its canal operations to maximize the use of rainfall for paddy production.

MADA uses field water depth as an indicator of the water delivery and the target, discharge is formulated based on the field water depth. MADA adopts 3 water levels to evaluate water delivery; namely MWD (Minimum Water Depth of 5 cm, LCD (Lower Control Depth of 10 cm) and UCD (Upper Control Depth: maximum depth up to crest of dikes which depends on the field conditions). Criteria of irrigation management is as follows. (Teoh & Chua, 1989).

Above LCD:	No irrigation water is supplied
Below LCD:	Only uncontrolled river flow is supplied to retain LCD
Below MWD:	Dam storage is released to retain MWD if uncontrolled river flow is insufficient to retain LCD and water depth lowers MWD.

2.3 Indicators of Agricultural Productivity in the Muda Scheme

Productivity gains in the Muda scheme, over time, have been analyzed using the following indicators :

- . Gross irrigated area per year
- . Total production of paddy over time
- . Paddy output per hectare per year
- . Paddy output per million cubic meters of water released/supplied

Total area planted (and harvested) under the Muda scheme has increased over the period 1979-92 with the exception of 1983 and 1984 (which were relatively bad years on account of pest infestation and water shortages). Total area irrigated (Figure 3) was 184,479 ha per year (in both seasons) in 1979 which increased to 189,725 ha, in 1991 an increase of 3 percent over a 13-year period.

Total Paddy Production

As depicted in Figure 4, total paddy production average (for two years 1981 and 1982) was 0.67 million tons. Total paddy output increased to around 0.78 million tons (average of 1990 & 1991) indicating an increase of 16.5 percent over a decade. However, the total output shows a declining trend from 1979 (0.78 million tons) to 1983 (0.45 million tons); but this decline is reversed in 1984 (0.65 million tons), 1985 (0.71 million tons) and 1986 (0.72 million tons). The aggregate output fluctuates over the next four years before attaining a peak level of 0.80 million tons in 1991. However, aggregate output shows an increase of 25 percent if the average output of two years (1981-82) during the first period is compared with the average of two years (1990-91) during the latter phase.

Paddy Output Per Ha Per Year

Paddy production per ha per year (sum of both seasons) is quite high in the Muda scheme and has increased during 1979-92. Paddy production was 8.46 tons/ha/year in 1979; declined to 5.4 tons/ha/year in 1983 but increased to 8.37 tons/ha/year in 1991.

On account of high cropping intensity and high yields, the average annual output in the Muda scheme has been much higher than corresponding large-scale gravity-diversion irrigation schemes in Malaysia. For example, during 1975-76, annual paddy yield was 8.42 tons/ha in the Muda scheme was much higher than compared with other schemes/regions i.e. 6.10 tons/ha in Tg Karang in the West Central region and 4.77 tons/ha in Krian in the West Central region (Taylor 1981, pp 132, 133).

Output Per Unit of Water

Paddy output per unit of water has been estimated using the following indicators:

- . Paddy production per unit of water released from the reservoir (kilogram per cubic water);
- . Paddy production per unit of water supplied as estimated from the sum of discharged measured at secondary canals.

As may be noted from Figure 5, paddy output per cubic meter of dam release has fluctuated between 0.8 to 1.2 with an exception of two years. The average

figure for 1990-91 of 1.2 kilogram per cubic meter was 45 percent higher than the average figure for 1981-82 (0.827 kilograms per cubic meter). Average paddy production per unit of irrigation supply was around 1.0 kgs. per cubic meter in four out of five years for which data were available (Figure 4).

2.4 Economic Profitability of Paddy Production in the Muda Scheme

Economic profitability of paddy production in the Muda scheme has been analyzed using the following indicators :

- . Net value of output at farmers' prices
- . Net value of output at economic prices (without subsidies)
- . Cost of production at farmers' prices
- . Cost of production at economic prices (without subsidies)

Profitability of Paddy Production at Farmers' Prices

Net value of output has been estimated using output prices received by farmers and input prices paid by farmers. In 1991, average price (at current prices) received by farmers was Malaysian Ringgit (RM) 710 per ton which included RM 248 (RM 2.7 = 1 US\$ in 1994) as subsidy provided by the government. This output price support (or price subsidy) is on top of the Guaranteed Minimum Price (GMS) of paddy which has been fixed at RM 462 per ton since 1980. The price subsidy, however, has increased from RM 165 up to early 1990 to RM 248/ton since 1991.

Given an average annual output of 8.22 tons/ha, gross value of output was estimated at RM 4680 per year per ha. About one-third of this gross value was RM 1557 which was received as direct output subsidy given to the farmers. The corresponding figures for 1981 and 1982 were a gross value of output of RM 4509 per ha (including a subsidy of RM 1191). Thus, the gross value of paddy output in 1990-91 period which was 25 percent higher than that during 1981-82 when measured at current prices. However, when the adjustment is made for change in prices (by using GDP deflator), at constant prices, the gross value of output in 1990-91 was only 3 percent higher than that in 1981-82.

Profitability of Paddy Production at Economic Prices

Profitability of paddy production has been estimated by valuing outputs and inputs at 'economic prices' instead of using prices received/paid by farmers. This has been done by:

- (i) valuing paddy output at prices received by farmers i.e. without adding the benefits of subsidy received by farmers plus adding the estimated cost of fertilizers which are supplied free to farmers by MADA;
- (ii) valuing paddy output at 'economic price' which is equated to an estimated value of imported rice (adjusted for quality and transport cost);

On account of lack of data on O&M costs and capital costs of irrigation and the opportunity cost of water in other user sectors it has not been possible to calculate 'economic price' of irrigation water. Hence, these estimates of profitability would have to be modified to take account of 'economic cost' of using water for irrigation. Similarly, no adjustment has been made for the impact of irrigation on water quality and its impact of public health.

If output subsidy is not taken into account, the gross value of paddy production was RM 3797 per ha during 1990-91 (four seasons) which was about 20 percent higher than that in 1980-81. However, when adjustment is made for price changes, gross value of output is over by 6 percent over the decade. The estimated cost of production at economic prices during 1990-91 was RM 2557 per ha if the cost of free fertilizers (RM 206/ha) are added. Hence, the estimated net value of output was RM 1240 per ha during 1990-91 (at current prices). This figure for 1990-91 is much higher than the corresponding figure for 1981-82 which was only RM 183/ha. The difference is mainly because, during 1990-91, (i) crop yield is 13 percent higher than in 1981-82; (ii) cost of production was RM 411 lower than in 1981-82.

3.0 FACTORS AFFECTING CHANGES IN PRODUCTIVITY AND COST OF PRODUCTION

3.1 Analysis of Output-reducing and Output-enhancing Factors

Productivity gains and changes in cost of production described in Section 2 were influenced by a complex set of factors including rainfall, water management, cropping systems, input costs, fertilizer subsidies and output price subsidies. It is difficult to "isolate" the impact of various factors in a quantitative way and evaluate the contribution of each factor. In this preliminary analysis of

available data, an attempt has been made to identify factors which would have resulted in increased yields; farm practices which would have reduced yields (but also reduced costs and hence were adopted by farmers) and interventions by management which were expected to improve water-use efficiency and to reduce cost of production.

These factors influencing paddy crop yields are classified as follows:

1. Output-depressing factors such as lower rainfall, lower releases from the dam, direct seeding in place of transplanting and effects of pests/weeds, etc.;
2. Output-enhancing factors such as improved efficiency of water-use as a result of tertiary development, dry sowing and improved data-feedback system in operations;
3. Cost-reducing factors such as tertiary development, direct seeding, mechanization, reduced labour input, etc.

Output-depressing Factors

Among the significant factors which could have serious effects on paddy output is a reduction in average rainfall and reduced releases from the reservoir. Average annual rainfall (1867 mm) for three recent years (1990, 91, 92) was 20 percent less than the average (2350) for the years 1980-81 and 82. Similarly, the average of the releases from the dam (686 MCM) in 1990-92 period was also lower by 15 percent when compared with the total releases (804 MCM) during the three years 1981-83.

Output-enhancing Factors

Output-enhancing factors included improved water-use efficiency as a result of better access to and management of water by farmers as a result of tertiary development. The tertiary development activities which were started in 1978 in 38 of the total of 118 irrigation blocks in the Muda scheme included construction of tertiary canals and farm roads to increase the canal density from 11 to 34 meters per hectare. The area under tertiary development increased from 2000 ha in 1984 to 23639 ha in 1992.

Tertiary development which aims to improve irrigation, drainage and road conditions will be effective in shortened presaturation period in main fields by 20 to 30 days (Yashima 1994). It has been estimated that water volume saved is

3200 cubic meter/ha/year as a result of shortened presaturation period in the two seasons (10 mm/day in first season and 6 mm/day in second). This is estimated to have reduced water consumption by about 20 percent per hectare.

Similarly, direct sowing practices were adopted to meet water shortage problems and area under direct sowing in the dry season (first season) increased rapidly from 53 percent in 1984 to more than 90 percent in the early 90's. In response to this, the Muda Agricultural Development Agency (MADA) reduced the irrigation period in the dry season from 197 days to 152 days after 1992.

Cost-reducing Factors

Direct sowing was also adopted in response to labour shortages and rising costs of labour. Studies show that direct sowing reduces labour demand by 30 percent and reduces production costs by 40 percent (Wong 1993, Ho et al 1993, Wong 1992). In addition to direct sowing, construction of farm road (as part of tertiary development) reduced the costs of input transportation, paddy transport, ploughing and harvesting. Membership of farmers' organizations (Kelompoks) and mini-estates has also helped in reducing costs of production.

3.2. Analysis of Impact of Interventions on Productivity and Production Costs

In this section an analysis of post trends in various performance indicators has been presented. An attempt has also been made to evaluate the impacts of various interventions using time series intervention analysis models (Box & Tio, 1975).

The Trend Analyses, Time Series Regression Analysis and Intervention Analysis

Trend Analyses.

The number of years of available data is not adequate for a long term trend analysis on the performance indicators. However the attempt in this section is to identify the short term trends of indicators for the two seasons during the period from 1979 to 1992. This period nonetheless includes the pre and post tertiary development, the increasing direct sowing practices in the Muda agriculture. Therefore, though the trends are short term, these may perhaps indicate the directions of indicators which were expected to affect significantly

by these interventions. The technique used here to identify the trend lines is from non-parametric regression (Eubank, 1988). Our choice here is the nonparametric polynomial regression. The parameter estimates of the final trend line were obtained using the weighted regression, where the weights are the robust weights generated in Robust regression techniques [SOLO, 1991]. The estimated parameters of the fitted polynomial weighted regression equations for the two seasons are given in the table 5.

The figures 6 through 12 show the trends of the different indicators for both the first and second seasons. The land productivity and the total production in the first season show a sharp declining trend from 79 to 84 period and followed by an increasing trend after 1985. The trends of these two indicators in the second season show a slightly declining trend in the 79 to 83 period and an increasing trend there after. The farmers basic production cost per ha and the total basic production cost show similar trends in both season. The basic production cost has a declining trend during the 81-83 period and then have an increasing trend until 1889. The period after 1989 again show declining trends. The irrigation intensity in MUDA is very high and are over 90% for both seasons except in the first season of 1983 and in the second season of 1984. The first season trend of the irrigation intensity is an increasing one through out the period except in 1983. In the second season, though non-linear the trend is generally an increasing one. The trend analysis shows that most of the indicators have different trend patterns before and after the tertiary developed area came into operations. Therefore in the next section an attempt has been made to explain the variations of these indicators from the exogenous and endogenous variables that may have caused the indicators to have these different types of trend patterns.

Multiple Regression Analysis.

In this section the project level time series indicators are regressed with different endogenous and exogenous variables for identifying the factors which can be used for explaining the increase or/and decrease of output and cost. The exogenous variables that are available for the study are approximate determinant indices of interventions such as tertiary development and of different cropping practices such as direct seedling, dry seedling etc and rainfall. The endogenous variables that are considered in the analysis are the yield, the total production, the farmers basic production cost, the cost per ha and per ton, the dam release etc. The land productivity in the Muda area may expected to be affected by the efficient water delivery through tertiary development, by the amount of fertilizer input, the rain fall and the different cropping practices such as direct seedling, dry seedling etc. The production cost per ton may be affected by the water delivery performance, the rainfall, the tertiary developed area, the dry seedling

area and the land productivity etc. The time period considered for the multiple regression analysis is from 1984 first season to 1991 second season. The tertiary developed area first came into operation in 1984 and the period after 1984 showed a significant increase in direct seedling practices. Therefore our attempt here is to explain as much as we can of the variations of production and production cost in this period due to tertiary development and increased direct seedling practices. First we define the following variables.

PROD	-	Total paddy output (,00000 Ton) ,
YLD	-	Out put per ha (Ton/Ha) ,
FCOST	-	Farmers basic Production cost ('000000 MR),
FCHA	-	Farmers basic Production cost per ha (MR/Ha),
FCTO	-	Farmers basic production cost per Ton (MR/Ton),
CCA	-	Cultivated area (Ha),
TDA	-	Tertiary developed area (Ha),
DISA	-	Direct(dry and wet) seedling area (Ha),
DSA	-	Dry seedling area (Ha),
%TDA	-	Percentage of tertiary developed area (%),
%DISA	-	Percentage of direct seedling area (%),
%DSA	-	Percentage of dry seedling area (%),
RF	-	Rainfall (MM),
DRMCM	-	Dam release (MCM)
DR	-	Dam release (MM),
T	-	Time.

The multiple regression results for dependent variables, the paddy production, the basic cost of production (Farmers prices) and the dam releases are given in tables 6, 7 and 8. The parameters of the regressors are estimated using single equation models. The values within the parenthesis indicate the t-statistics value of the parameter estimate. The extent of the residual autocorrelation in the fitted models are explained by the Durbin-Watson test statistic values. None of the Durbin-Watson statistics values in the tables show that the null hypothesis of no autocorrelation can be rejected at .05 level. The residual diagnostics of all the models did not indicate any obvious inadequacies in the fitted models.

The models in table 6 show that the tertiary developed area, the direct seedling area, the rainfall and the dam release (volume) are statistically significant in explaining the variations of the total production and the production cost per ha. The tertiary development has positively contributed towards the production growth while the increasing direct seedling area has contributed

negatively to the production during this period. The estimated equation suggest that an increase of one ha of tertiary developed area had helped increased the production by 14.6 tons. Similarly the one ha increase in direct seedling area amounted to a production loss of 4.8 tons.

Table 7 shows that both increased tertiary developed area and dry seedling area have had positive contribution for cost reductions. An increase of one ha of tertiary developed area amounts to a reduction of 1.8 MR (=1752 MR/Ha / 972Ha) from farmers cost per ha. Similarly, a dry seedling increase in one percent of the cultivated area would reduce the production cost by 211MR per ha. i.e, an increase of dry sowing area by one ha would reduce the production cost per ha by .25MR (=211 MR/HA / 900ha, assuming a one percent of cultivated area is roughly 900 ha). Table 8 shows that with increased direct seedling area and increased rainfall would contributed significantly for reducing the dam release. The increased tertiary developed area would indicate an increase in dam release. However the fitted model show a negative coefficient for the cultivated area which in generally would be expected to be positive. In the next section the type of impact of the intervention, the tertiary development and its contribution to the Muda agriculture production will be studied using a time series intervention models.

Intervention Analysis.

The trend analysis and the regression analysis suggest that there may be positive impacts from the tertiary development and increasing direct sowing practices on the productivity, production cost of the Muda agriculture. The type of impact of an intervention on a time series indicator may some times be an abrupt or gradual permanent increase in the mean level or an abrupt but temporary increase in the mean level (see Figure 13). The types of impacts of these interventions, whether they are abrupt or gradual and permanent or temporary, on the performance of the Muda agriculture can be assessed using time series intervention analysis models [Box & Tio (1975), Hipel et al., (1975)]. The basic form of the intervention model is, $Y_t = N_t + I_t$, where Y_t is the time series observed at equal time intervals, N_t is the noise component and the I_t is the dynamic part of the model that contains the intervention components and other deterministic inputs. The noise component in the intervention analysis is modelled by the Seasonal Auto Regressive Integrated Moving Average (Box-Jenkins) models.

The analysis in this part only assesses the impact of tertiary development on the performance indicators in the Muda agriculture. The analyses use seasonal data from 1979 first (dry) season to 1991 second (wet) season. Even though the number of data points available (at most 26) for an ARIMA analysis

is rather small (suggested at least 50), our attempt here is to explain as much about the types of impact of tertiary development on the agricultural performance of the Muda system. The increased irrigation and drainage canal density through increased tertiary developed area may have contributed for higher land productivity through better water management. The increased farm road density through increased tertiary developed area may have contributed for reduction of production cost. The effect of tertiary development on production and production cost can be better described if the tertiary developed irrigation and drainage canal densities and farm road density are available for the analysis. However these data are not available for the current analysis. Therefore the impact of tertiary development on these indicators are explained in the following manner. Since the tertiary developed area first came into operation in 1984 (about 1990 ha) and increased gradually in succeeding years, the impact of tertiary development after 1984 is hypothesized to have a gradually increasing trend. That is that the form of the intervention component in the model is

$$I_t = \frac{w}{1 - \delta B^2} \zeta_t$$

where B is the backward shift operator, i.e, $B^j X_t = X_{t-j}$ for $j=0,1,2,3...$ and

$$\zeta_t = \begin{cases} 0, & \text{if } t < 1984 \\ 1, & \text{if } t \geq 1984. \end{cases}$$

Since the new tertiary developed area was introduced into operation in a yearly schedule and not in a seasonal schedule, the denominator in the intervention component is assumed to have only a second degree backward shift

operator. The fitted intervention models for the indicators, the total production and the land productivity are given below.

$$YLD_t = a_t / (1 - .4705 B^2) + 1.0232 / (1 - .5645 B^2) \zeta_t - 2.917 DISA_t +$$

(3.0)(3.8) (5.4) (4.5)

$$+ (-.00018 + .00076) RF_t$$

(0.75) (5.5)

$$PROD_t = a_t / (1 - .4727 B^2) + 1.1136 / (1 - .5799 B^2) \zeta_t - 3.1209 DISA_t +$$

(2.8) (3.9)(5.6) (4.2)

$$+ (-.0002 + .00072) RF_t$$

(-0.74) (4.6)

All the endogenous and exogenous variables in the above two equations represents the original variables minus their respective mean values. The numbers within the parenthesis are the t statistics values for each parameter estimate. The estimated intervention models show that the impact of tertiary development as hypothesized is statistically significant for the indicators of total production and land productivity. This suggest that the impact of tertiary development on the total output is indeed a gradual permanent impact. Infact the production loss due to increased direct seedling was more than off set by the production increase due to tertiary development. The statistically significant lagged rainfall variable in the intervention model perhaps can be taken as a proxy to the dam release in a given season as the dam releases in a given season depend on the dam storage prior to the season and this in turn depends on the rainfall in the previous season. Since $\zeta_t = 0$ before 1984 and $=1$ after 1984, the expected value of the total production (PROD) before and after the tertiary developed area came into operation respectively are

$$E (PROD_{t<84}) = C + E \left(\frac{a_t}{1 - .4727 B^2} \right) - 3.1136 E (DISA_{t<84}) - (.0002 - .0007 B) E (RF_{T<84})$$

and

$$E (PROD_{t \geq 84}) = C + E \left(\frac{a_t}{1 - .4727 B} \right) + \frac{1.1136 \zeta_{t \geq 84}}{1 - .5799 B^2} - 3.1209 E (DISA_{T \geq 84}) - (.0002 + .0007 B) E (RF_{t \geq 84})$$

The constant C is the sum of the terms involving mean values of variables. Then the difference between the expected production of the periods before and after the tertiary development is

$$E(PROD_{t \geq 84}) - E(PROD_{t < 84}) = E \left(\frac{1.1136}{1 - .5799B^2} \zeta_{t \geq 84} \right) - 3.1209(E(DISA_{t \geq 84}) - E(DISA_{t < 84})) \\ - (.0002 - .0007B)(E(RF_{t \geq 84}) - E(RF_{t < 84}))$$

The table 9 describe the contribution from the tertiary development, the increased direct seedling practices and the rainfall on the changes of the mean level of the total production from the period before 84 period to the period after 84. The contributions from the explanatory variables for the mean levels of the total production shows that the tertiary development has significantly contributed towards the increase of total production. The production loss due to increased direct seedling practices and decrease in rainfall is more than offset by the production increase due to increased tertiary developed area.

The net contribution from the tertiary development, the direct seedling practices and the rainfall for change in mean production level has increased by almost 135% ($= .3039 / .2242 * 100$) from the period before 84 to the period after 84. Table 10 shows the contribution from the tertiary development, the direct seedling practice and the rainfall towards the mean level changes of the land productivity. It can be seen that the net contribution from the above three factors towards the change in land productivity level has increased by 74% ($= .203 / .2759$) from the pre tertiary period to the post tertiary period. From the intervention analysis an important conclusion is that, a component that has contributed very significantly towards the production increase in the MUDA agriculture was the increased tertiary development. With out this it would have been a significant production loss from the period before 1984 to the period after 1984 due to increased direct seedling practices.

4.0 CONCLUSIONS AND AREAS FOR FURTHER RESEARCH

The conclusions of the paper are :

- (i) In the Muda irrigation scheme, there have been significant increases in paddy output per ha and per cubic meter of water, particularly after 1984;

- (ii) Production of paddy per ha as well as per cubic meter of water is quite high in the Muda scheme when compared with other large scale irrigation schemes in Malaysia.
- (iii) Cost of paddy production has declined over time such that domestic cost of production of excluding land rent is lower than the cost of importing rice from Thailand.
- (iv) Higher yields as well as reduction in costs have resulted in higher incomes for farmers in the Muda area in the early nineties compared with those in the early eighties.

A number of research questions are being addressed now and it is hoped that the results of these analyses will be available in the next few months. These are:

- (i) How to decompose the changes in crop yields in terms of the yield-enhancing factors and yield-reducing factors?
- (ii) How to quantify the relationship between changes in land productivity and cost of production in terms of their determinants such as increase in tertiary development (area), changes in direct sown area and changes in rainfall?
- (iii) What methodologies can be used to "isolate" the effect of individual interventions (tertiary development, direct seeding) and to estimate the effects of interaction of these interventions.

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TABLE 1.**Competing Uses of Water in the Muda area in Malaysia***

(Million Cubic Meters)

Estimated Demand	1990	2000
Irrigation	1701	1709
Domestic	124	192
Industrial	104	285
Total domestic and industrial demand	228	477
Availability for Irrigation if domestic and industrial demand is fully met in 2000		1460

* The data relate to Kedah, Perlis and Penang areas.

Source: Sivalingam, G. (1994)

TABLE 2.**Production and imports of rice in Malaysia and the Contribution of the Muda Scheme**

	1981	1990	1991
<u>MALAYSIA</u>			
1. Paddy Area (1000 ha)	711	639	635
2. Paddy Production (1000 tons)	2020	1655	1550
3. Rice Imports (1000 tons)	168	330	-
4. Rice Imports in Equivalent Paddy Terms (1000 tons)	252	495	-
<u>Muda Irrigation Scheme</u>			
1. Paddy Area (1000 ha)	186	190	190
2. Paddy Production (1000 tons)	729	762	797
3. Paddy Production in Muda as Percent of Total production in Malaysia	36%	46%	51%
4. Rice imports (paddy equivalent) as Percent of Paddy production in Muda	35%	65%	-
* Figures are for 1980			

Source: F.A.O. Regional Office for Asia and the Pacific, Bangkok, 1992, MADA offices.

TABLE 3

Irrigation Period and Water Requirements for Wet-Seeding, Dry Seeding and Transplanting

	Transplanting			Wet Seeding			Dry Seeding (1st Season) Plus Wet Seeding (2nd Season)		
	1st Season	2nd Season	Total	1st Season	2nd Season	Total	1st Season	2nd Season	Total
1. Duration of Irrigation Period (Days)	125	115	240	135	120	255	90	120	210
2. Water Requirements (mm)	1330	850	2180	1490	1010	2500	960	1010	1970
3. Total labour Use (Man hours (1986) Per Ha)	260 (1986)			212 (1991)			158 (1991)		

Sources: 1. S. Yashima: Water Use Performance Paper prepared for Internal Program Review, 1994, IIMI, Cambodia
 2. Wong Hin soon (1992), P30

TABLE 4

Paddy Yields and Cost of Production for Wet Seeding and Dry Seeding (1991; 1st Season)

	Wet Seeding	Dry Seeding
1. Net Paddy Yield Tons/ha	3.47 (.30)*	3.17 (.30)
2. Cost of Production (excluding land rent, water rates/land tax)		
- RM Per Ha	695	575
- RM Per Ton	200	182
3. Total Labour Utilization** (Manhour Per Ha)	212	158

* Figures in parenthesis are coefficient of variation

** Out of total labour use, 27 percent is by hired labour

Source: Wong Hin Soon: Farm Management and Socio Economic Series, Report 2, MADA, October 1992.

TABLE 5.**Results of Trend Analysis for different Indicators.**

Dependent Variable	Season	Constant Term	Coefficients of (where applicable)			Adjusted R ²
			T	T ²	T ³	
Irrigation Intensity	1	.912*	.045*	-	-	.800*
	2	.987*	-.072*	.212*	-.128*	.979*
Land Productivity	1	4.386*	-5.375*	4.904*	-	.796*
	2	4.117**	-1.336	2.044**	-	.438**
Production	1	389865*	-543295*	534425*	-	.672*
	2	394851*	-131037**	206175**	-	.566*
Cost per Ha	1	624.5*	-1779.9*	4978.9*	-3470.2*	.638**
	2	603.3*	-857.3*	3236.8*	-2492.8*	.897**
Cost per Ton	1	182.9*	-438.9	1470.6***	-1143.5***	.255
	2	150.2*	-213.7**	945.1*	-812.7*	.804*
Production Cost	1	56.38*	-170.7*	481.6*	-334.9*	.632**
	2	57.79*	-93.7*	342.3*	-259.0*	.851*

* - Statistically significant at .01 level

** - Statistically Significant at .05 level

*** - Statistically Significant at .1 level

TABLE 6.

Results of Multiple Regression Analysis to Explain Variations in Paddy Output in the Muda Scheme: 1984-1991.

Depende-net Var-iable	Term Coefficients of Independent Variables				Adjus- ted D-W Statistics	No. of Observation s
	Constant	TDA	DISA	RF	DRMCM	
PROD	6.13096 (7.08)*	.146e-03 (4.74)*	-.480e-04 (-4.68)*	-.118e-02 (-2.36)*	-.174e-02 (-2.39)*	16
					.578* 2.27 ^a	
NYLD	5.8585 (8.39)*	10.317 (4.71)*	-3.573 (-5.09)*	-.881e-03 (-2.11)**	-.122e-02 (-2.21)*	16
		%TDA	%DISA	RF	DR	
					.615* 1.85 ^a	

* - Statistically significant at 1% level

** - Statistically significant at 5% level

*** - Statistically significant at 10% level

a - If the Durbin-Watson statistics is less than .74 reject the null hypothesis of no autocorrelation, if greater than 1.93 do not reject the null hypothesis of no autocorrelation and if between .74 and 1.93 the test is inconclusive.

TABLE 7.

**Results of Multiple Regression Analysis to Explain Variations
in Cost of Productions of Paddy in the Muda Scheme: 1984-1991.**

Depende-net Var-iable	Term Coefficients of Independent Variables				Adjus-ted D-W Statistics		No. of Observation s
	%TDA	%DSA	T	T*T	R ²	1.50 ^a	
FCOST					.899*	1.50 ^a	16
	49.4320 (17.1)*	-190.634 (-3.50)*	-24.656 (-7.79)*	18.856 (6.43)*	-1.465 (-6.39)*		
FCHA					.878*	1.20 ^a	16
	526.94 (18.09)*	-1752.23 (-3.19)*	-211.148 (-6.62)*	179.846 (6.09)*	-14.401 (-6.24)*		
FCTO					.827*	2.03 ^b	16
	348.198 (5.24)*	-588.117 (2.76)**	-63.777 (2.17)**	-54.88 (3.58)*	54.73 (5.08)*	-4.081 (-4.29)*	

* - Statistically significant at 1% level

a - If the Durbin-Watson statistics is less than .74 reject the null hypothesis of no autocorrelation, if greater than 1.93 do not reject the null hypothesis of no autocorrelation and if between .74 and 1.93 the test is inconclusive.

b - If the Durbin-Watson statistics is less than .62 reject the null hypothesis of no autocorrelation, if greater than 2.15 do not reject the null hypothesis of no autocorrelation and if between .62 and 2.15 the test is inconclusive.

TABLE 8.

**Results of Multiple Regression Analysis to Explain Variations
in the Dam Releases in the Muda scheme: 1984-1991.**

Dependent Variable	Constant Term Coefficients of Independent Variables				Adjusted D-W Statistics		No. of Observations
	Constant	TDA	DISA	CCA	RF	R ²	
DRMCM	4072.08 (2.73)**	.375e-01 (2.68)**	-.12e-03 (2.98)**	-.34e-01 (3.64)**	-.364 (-2.22)**	.301**	1.87 ^a
DRMCM	3722.73 (2.67)**	.366e-01 (2.71)**	-.12e-03 (-3.09)**	-.295e-01 (-2.04)**	-.390.329 (-2.41)**	.341**	1.76

** - Statistically significant at 5% level

a - If the Durbin-Watson statistics is less than .74 reject the null hypothesis of no autocorrelation, if greater than 1.93 do not reject the null hypothesis of no autocorrelation and if between .74 and 1.93 the test is inconclusive.

1 - The variable MRF is the actual seasonal rainfall as a ratio of average rainfall of the corresponding season.

TABLE 9.

Contribution of Tertiary Development, Direct Seedling and Rainfall
for the Change in the Mean Level of Total Production.

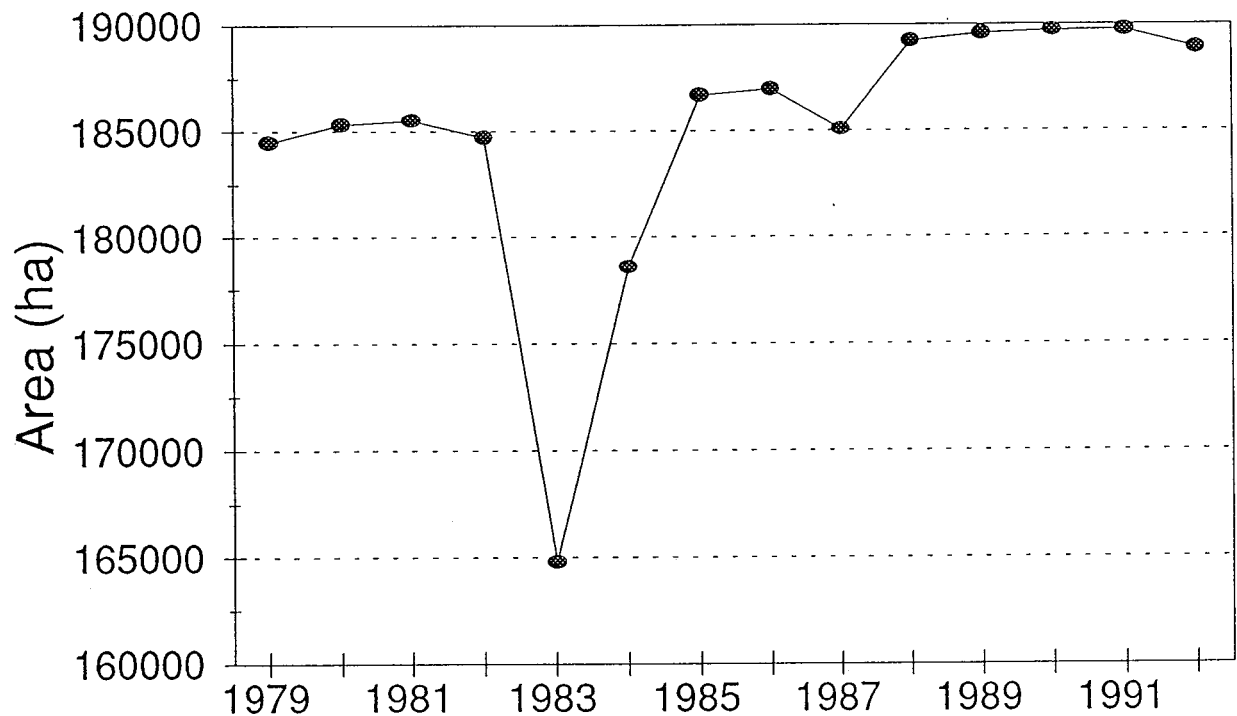
Variable	Contribution from Explanatory variables		Production Change
	T < 1984	T ≥ 1984	
Tertiary development(ζ_t)	0	2.21	2.21
Direct Seedling(DISA _t)	-3.1209*.1293 (= -.4035)	-3.1209*.7016 (= -2.1896)	-1.7861
Rainfall(RF _t)	-.0002*1267.1 (= - .2534)	-.0002*989.44 (= - .1979)	0.0555
Lagged Rainfall (RF _t)	.0007*1258.77 (=.8811)	.0007*1008 (= .7056)	-0.1755
Total	.2242	.5281	0.3039

Table 10.

Contribution of Tertiary Development, Direct Seedling and Rainfall for the Change in the Mean Level of Land Productivity(ton/ha).

Variable	Contribution from Explanatory variables		Productivity Change
	T < 1984	T ≥ 1984	
Tertiary development(ζ_t)	0	1.9980	1.9980
Direct Seedling(DISA _t)	-2.917*.1293 (= -.3771)	-2.917*.7016 (= -2.0466)	-1.6695
Rainfall(RF _t)	-.00018*1267.1 (= - .2281)	-.00018*989.44 (= - .1781)	0.0500
Lagged Rainfall (RF _t)	.0007*1258.77 (=.8811)	.0007*1008 (= .7056)	-0.1755
Total	.2759	.4789	0.203

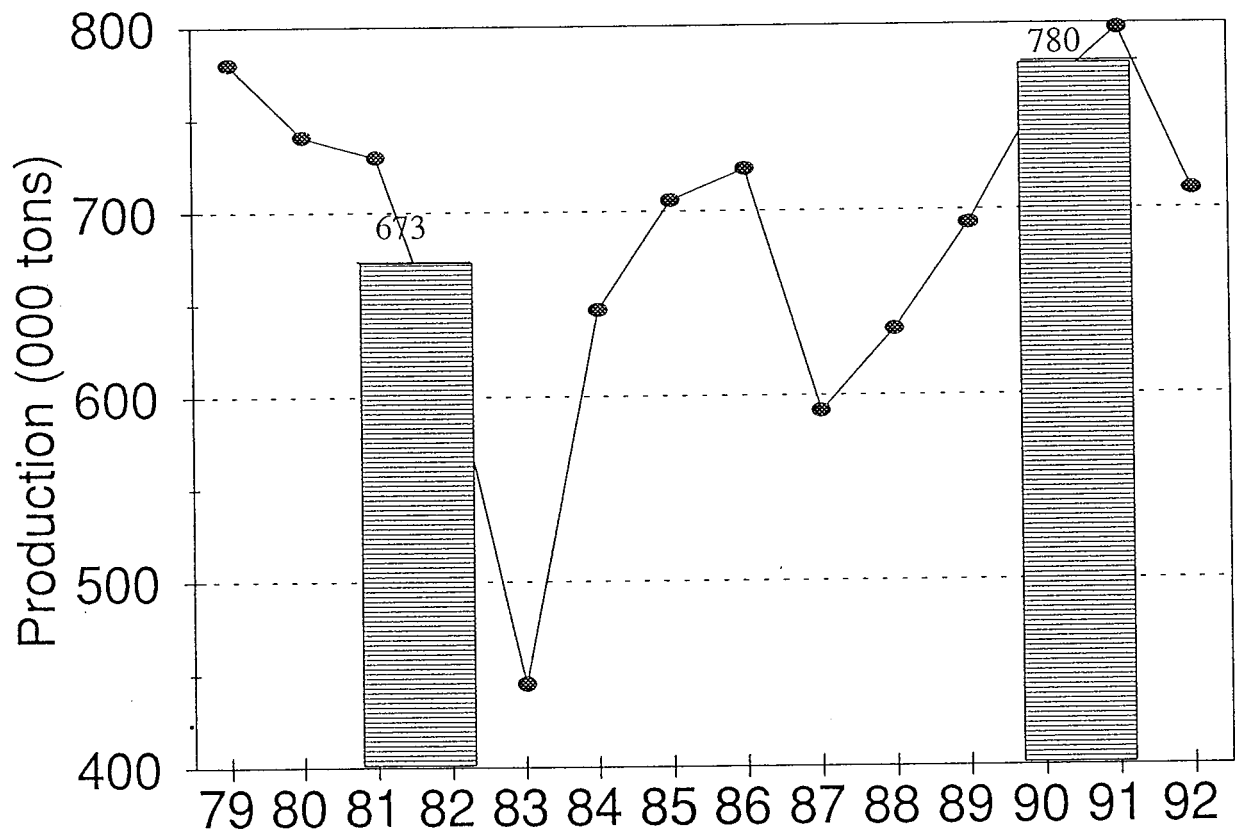
Figure 3. Trends in Irrigated Area in the Muda Scheme :1979-92



Note: Area is the sum of the area irrigated in two seasons

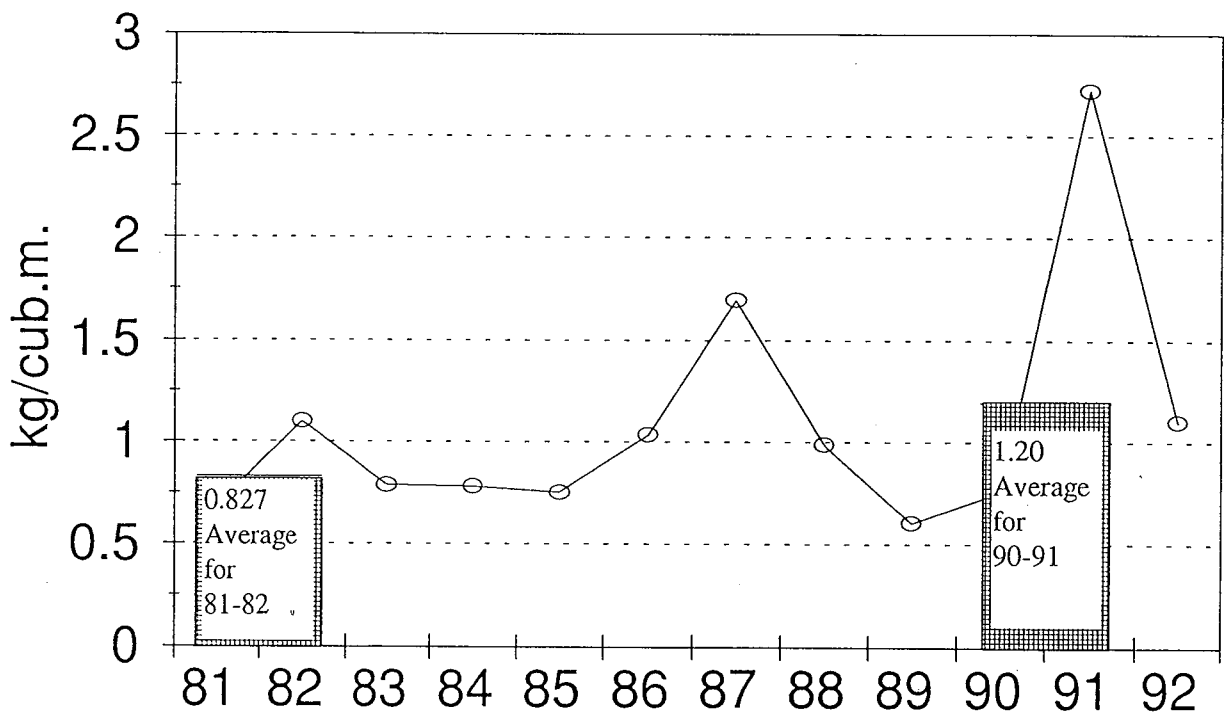
Source: MADA

Figure 4. Annual Paddy Production



Source: MADA Agriculture Division

Figure 5. Paddy Production per Unit of Water (Dam Release)



Source: MADA Engineering and Agriculture Divisions

Figure 6. Irrigation Intensity
First and Second Season(1979-1991)

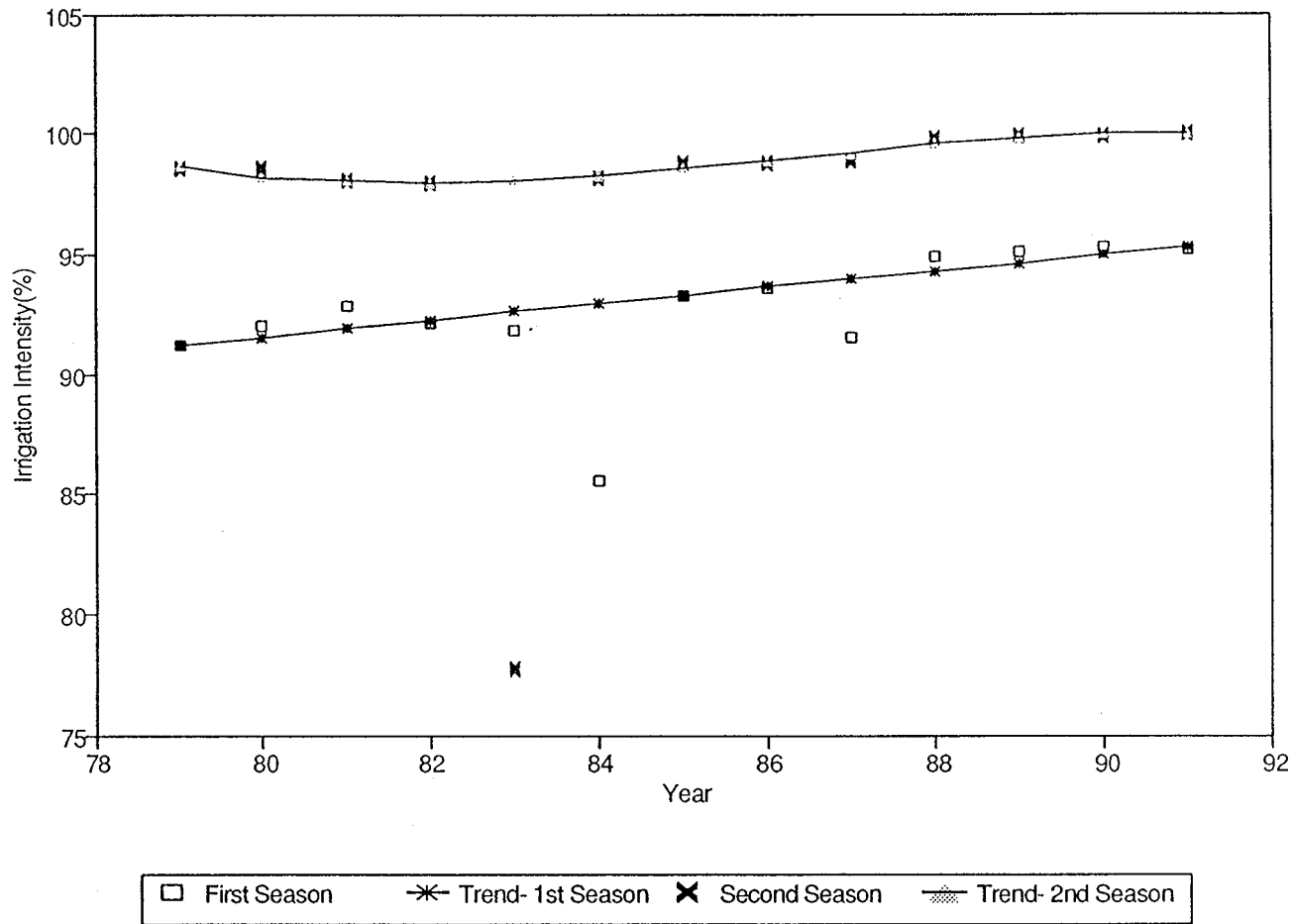


Figure 7. Land Productivity
First and Second Season(1979-1991)

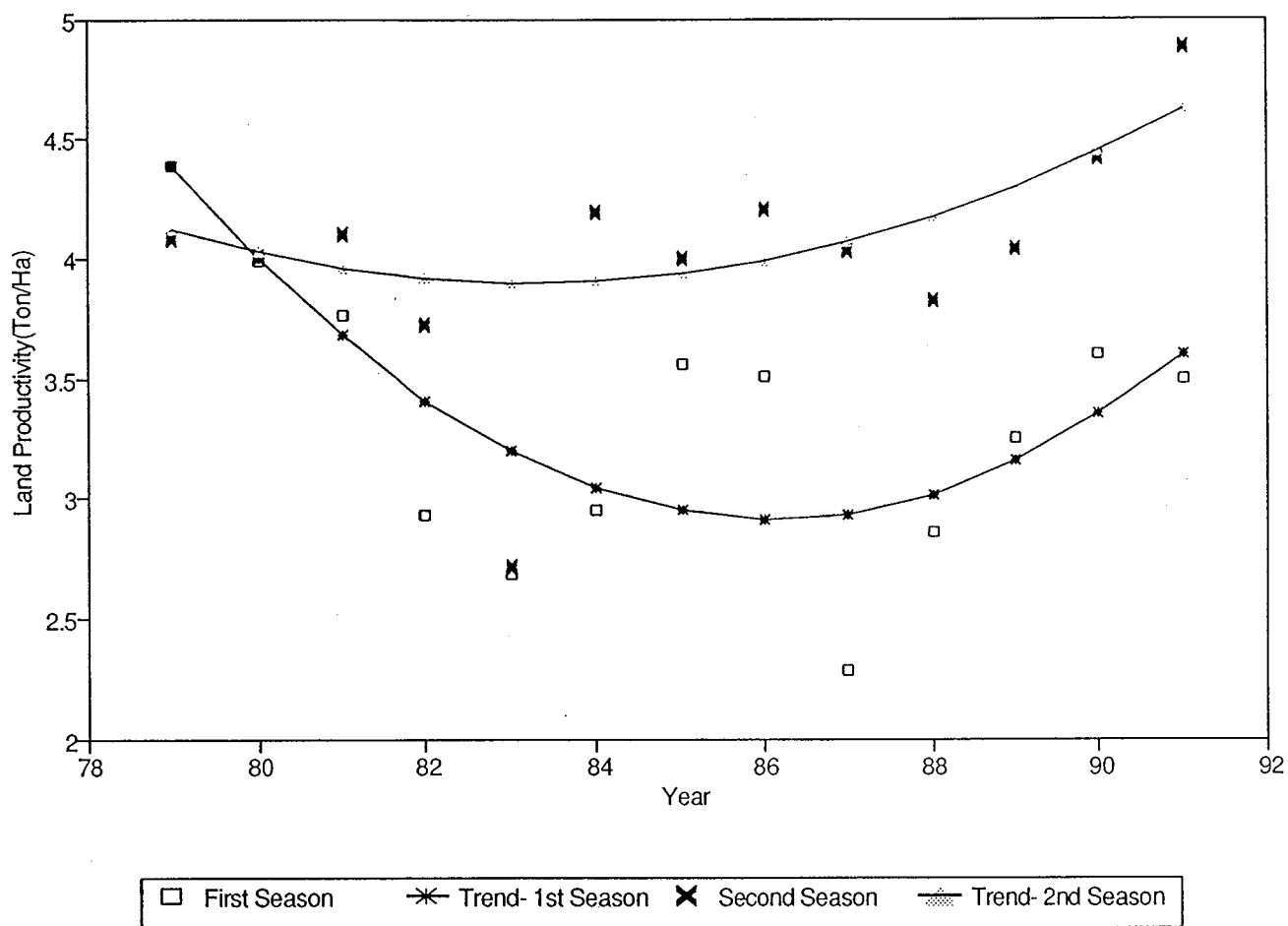


Figure 8. Total Production
First and Second Season(1979-1991)

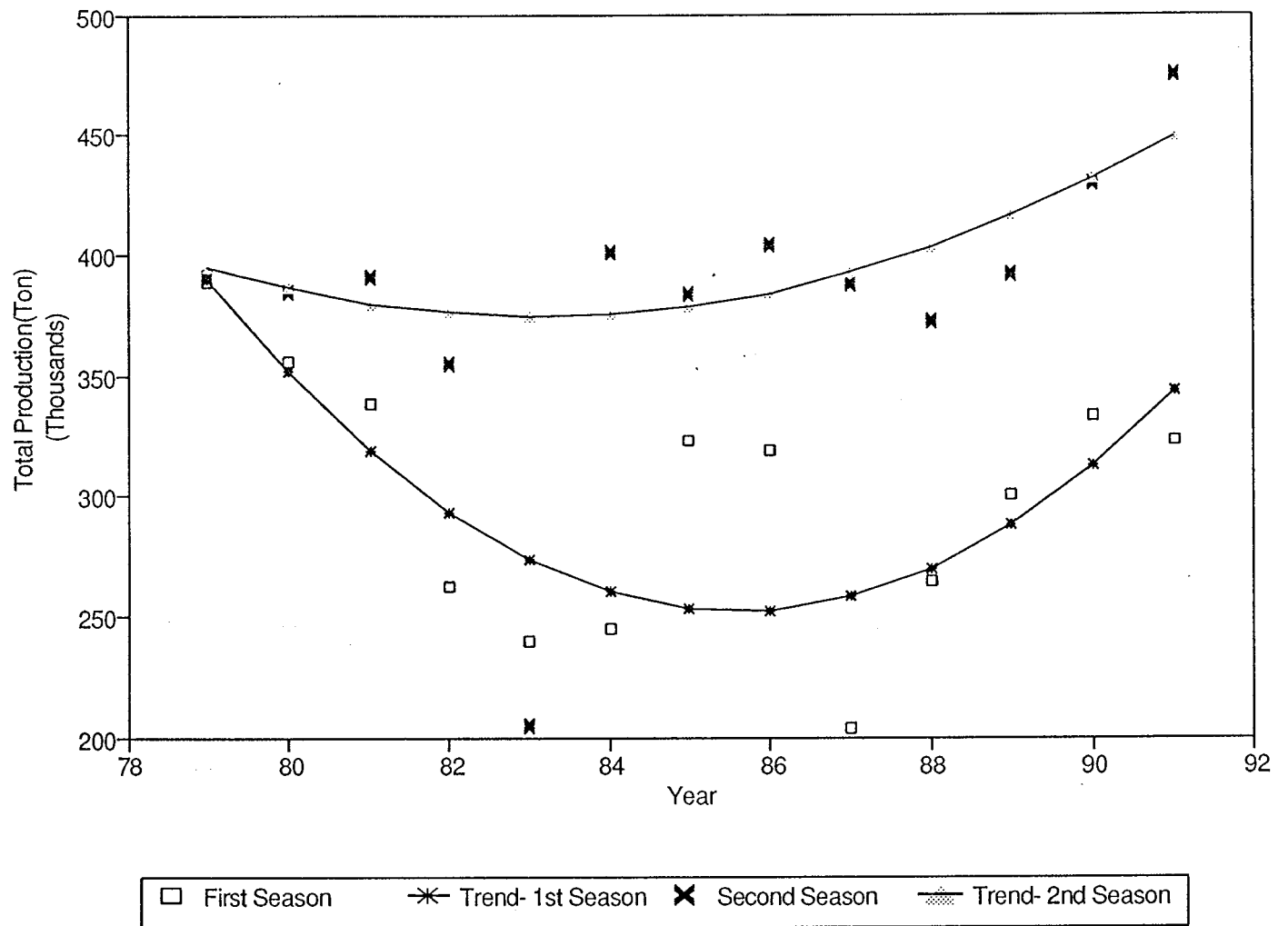


Figure 8. Total Production
First and Second Season(1979-1991)

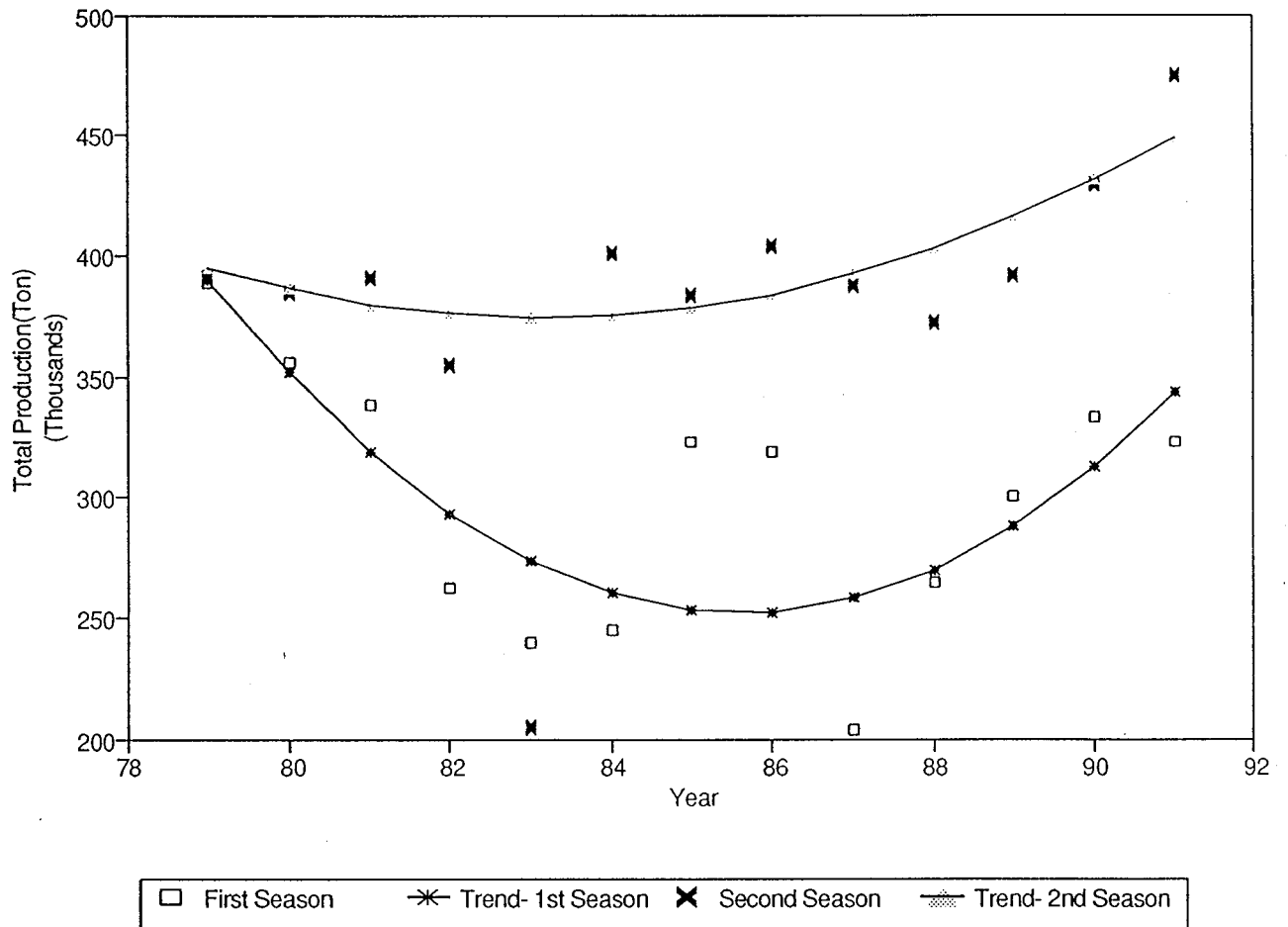


Figure 9. Basic Production Cost per Ha
First and Second Season(1979-1991)

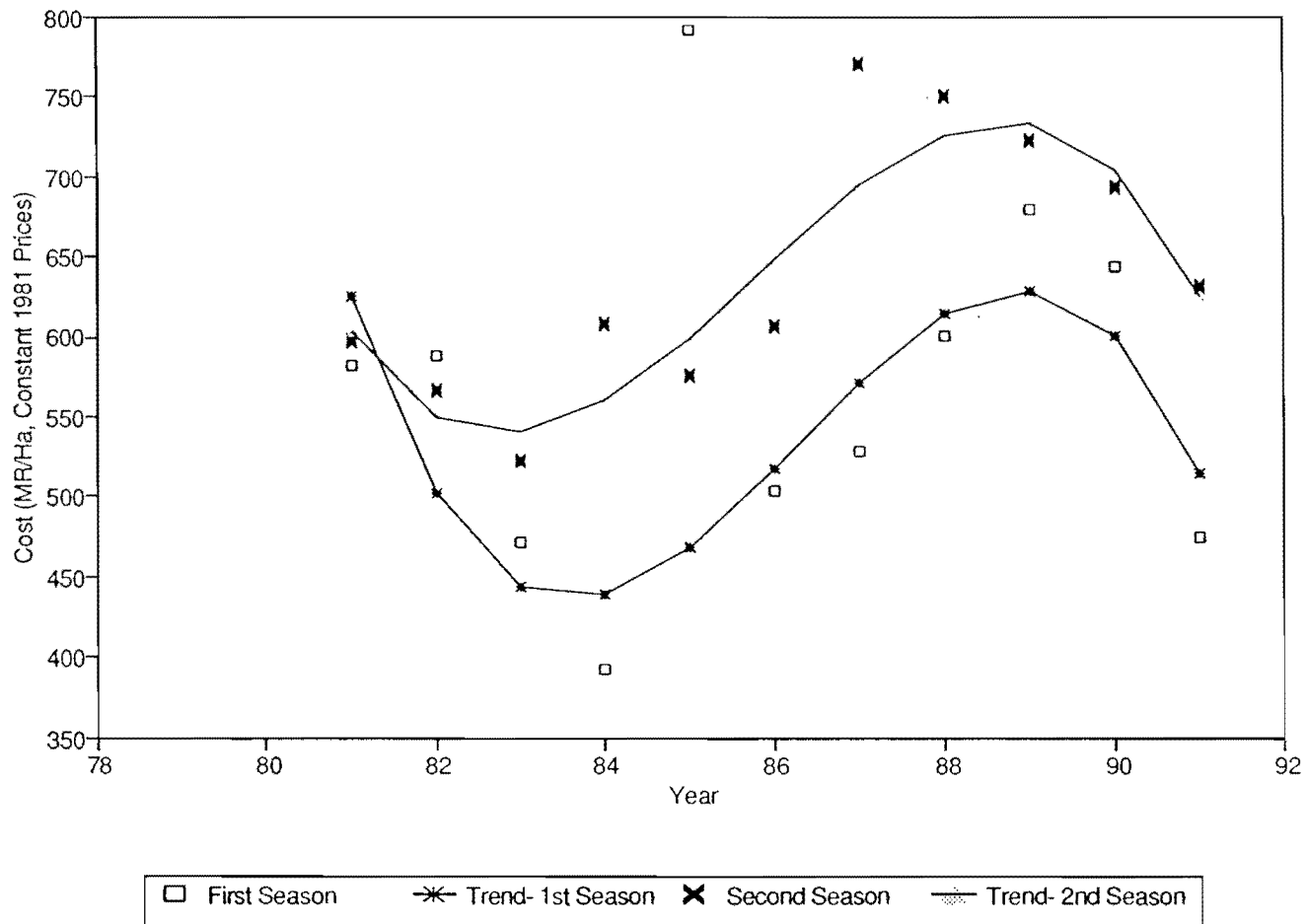


Figure 10. Basic Production Cost/Ton
First and Second Season(1979-1991)

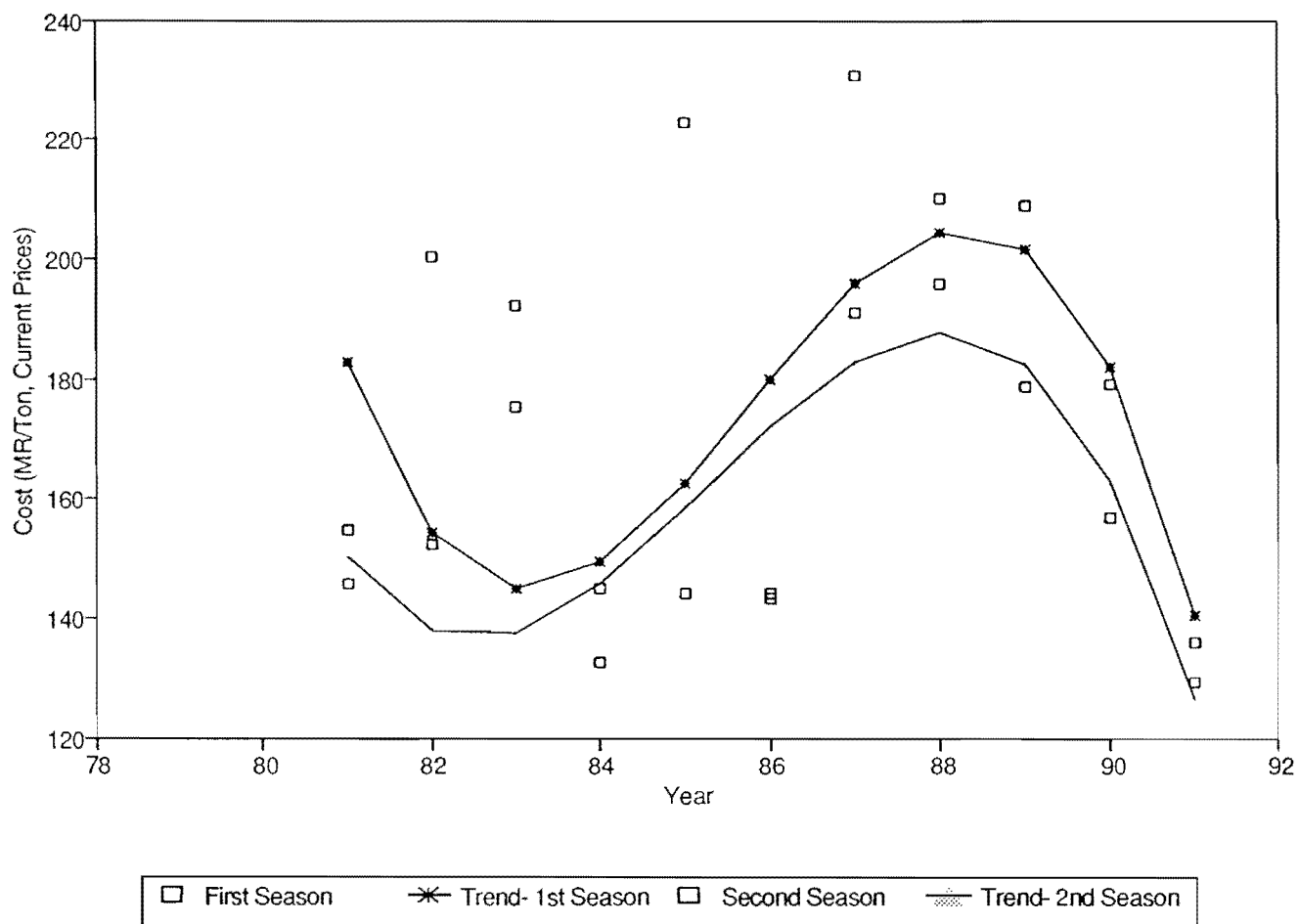


Figure 11. Total Basic Production Cost
First and Second Season(1979-1991)

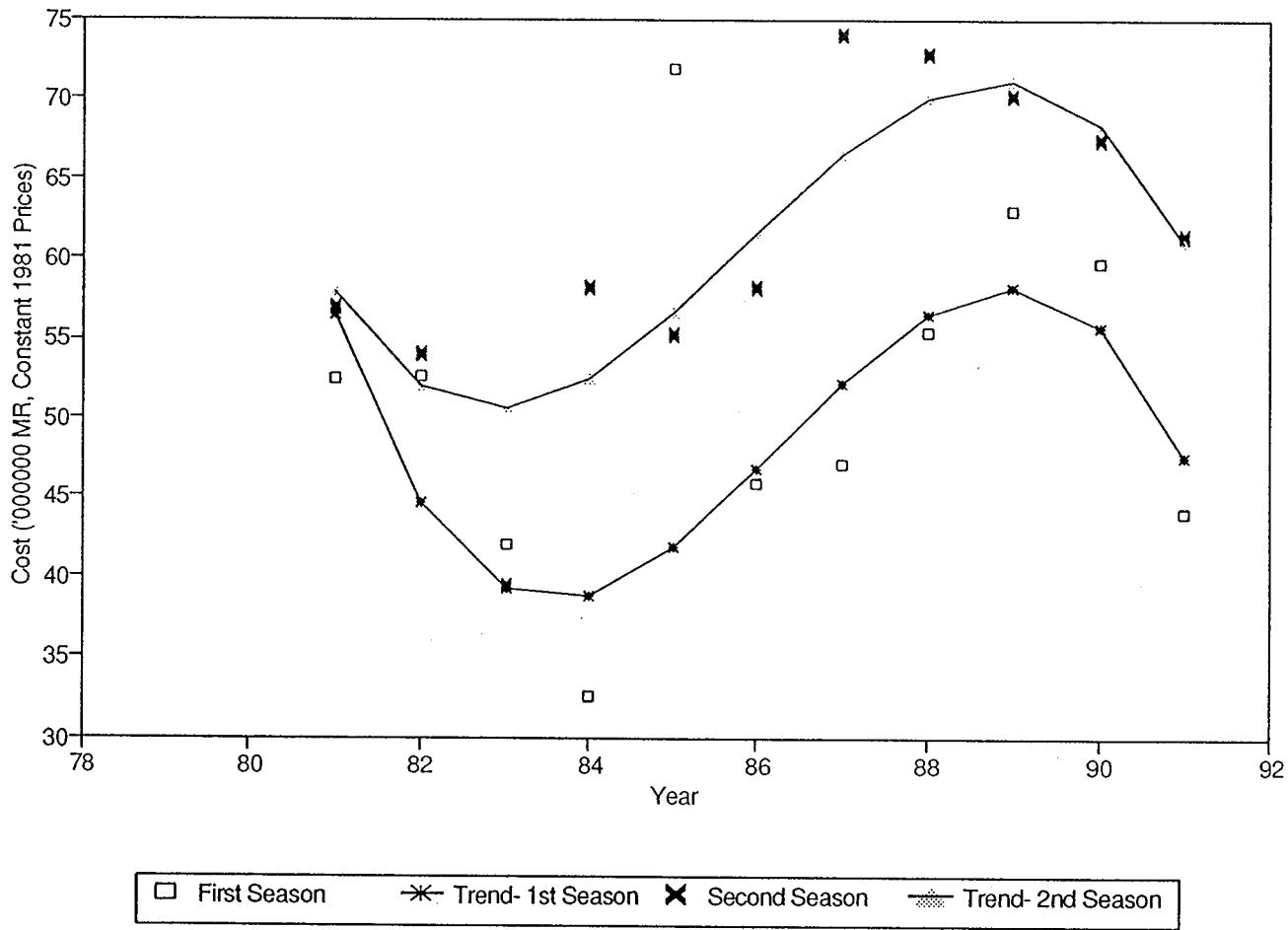


Figure 12 . Water Productivity
First and Second Season(1979-1991)

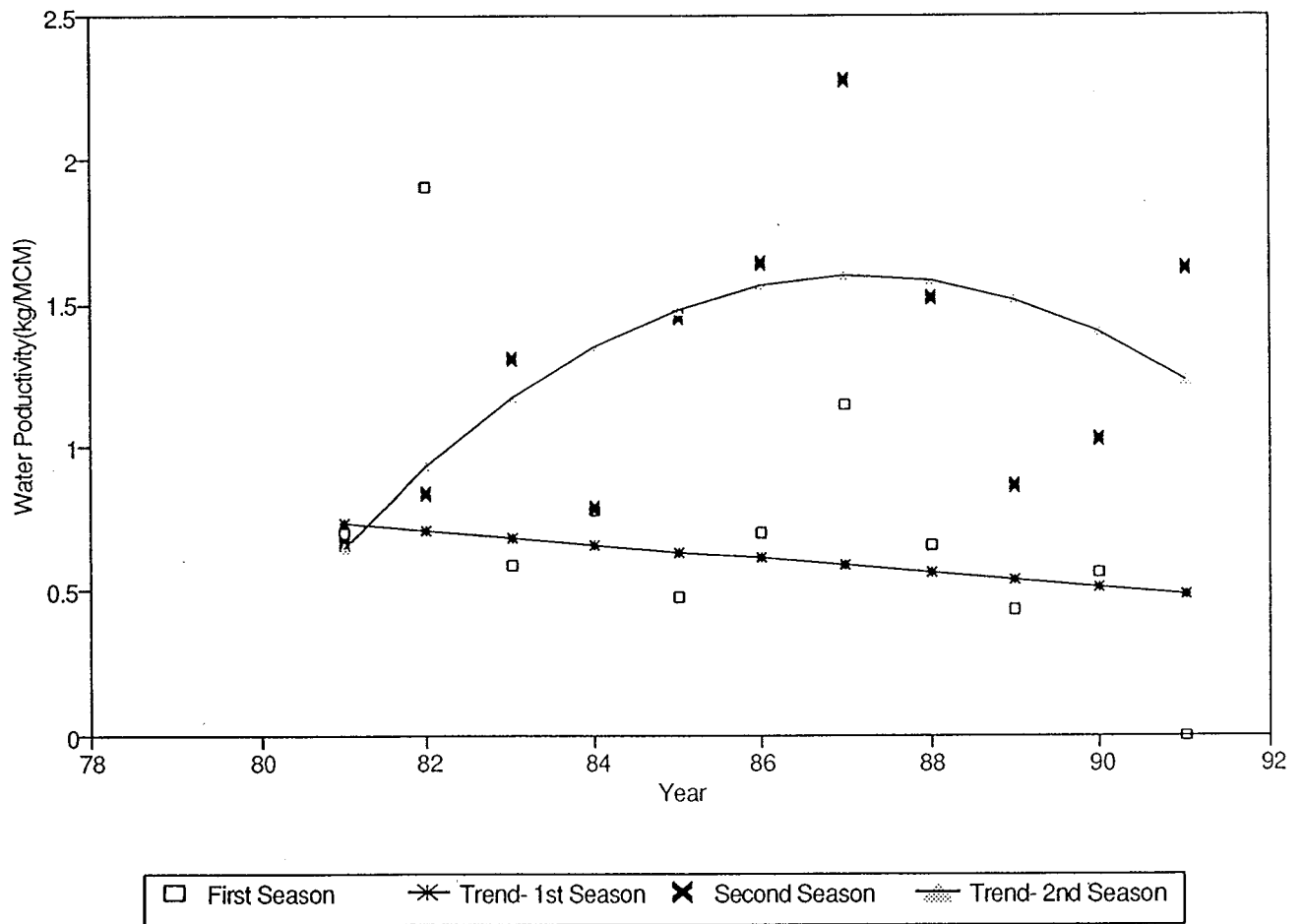


Figure 13. Types of Impacts of Interventions

