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# Measuring the effect of irrigation on rate of technological change in crop production

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## ABSTRACT

A method for measuring technological advancement associated with irrigated agriculture is described and tested herein. The method was based upon the Solow Model of technical change which enables the computation of an index of technological change over time. The method involved derivation of aggregate production functions from time series data for selected irrigated and non-irrigated areas. Shifts in the production functions over time were then measured by computing indexes of technological change. The changes in the indexes for irrigated and non-irrigated agriculture over time were compared to determine the effect that irrigation had on the rate of adoption of new technology. The application of the method involved comparing irrigated with non-irrigated farming enterprise as a whole. The study area was Udumelpet Taluk in Coimbatore district of Tamil Nadu.

**Keywords:** Irrigation; technological change; crop production; irrigated agriculture; non-irrigated agriculture

## INTRODUCTION

When irrigation is initiated, wealth is generated at the local and national levels. With irrigation, semiarid deserts may be converted into farms, towns and cities. Not only does irrigated land produce crops and livestock but also the farming industry in turn supports factories, shops and professional services. In more humid areas where irrigation typically consists of providing supplemental water to increase production in favorable years and prevent crop failures in dry years, the results are less dramatic but still important.

Many researchers have attempted to estimate the value of irrigation water for a particular use; considerably less work has been done on measuring the total economic impact of irrigation on a specific area. Secondary and tertiary benefits must be appraised as well and efforts be made to relate irrigation to the general technology of agriculture. Golze (2013) suggested two indicators to measure the economic impact of irrigation on an area: the increase in value of irrigated land and the increase in amount of taxes collected from the area including the embedded towns and cities. However these are crude indicators at best. This study presents a method for measuring these advancements and describes the empirical results of a trial application. The study was conducted to measure technological advancement associated with irrigated agriculture, computation of an index of technological change over time and drive technology change index for paddy in specific for Coimbatore district of Tamil Nadu.

### Theoretical basis of the indexes

The technological change is regarded as a change over time in the combinations of inputs or management techniques technically feasible for production the usual effect of which is to make possible an increased level of output from a given set of inputs that is an upward shift in production functions (Davan et al 2004).

The estimation of a production curve from time series data can be readily accomplished. However such a curve will not directly reflect the shifts that have occurred over time may be pictured as a combination of movements along a production curve and of shifts

of the curve. In order to determine the rate of technological change it is necessary to disentangle these two movements.

Practicable separation of the variation in output due to movements along the production curve from that due to shifts of the curve itself requires three basic assumptions: 1) factors are paid their marginal products, 2) the shift is neutral (shifts leave marginal rates of substitution unchanged) and 3) the production function is homogeneous of degree one. The first is the usual assumption of perfect competition which is a characteristic, though not a completely accurate, description of agriculture. The homogeneity assumption is commonly made with respect to the aggregate production function. Shifts in technology may not always be neutral in the real world and this assumption is made to simplify the analysis. Results must be interpreted accordingly.

If Q represents output and K and L represent capital and labour inputs in physical units then the aggregate production function can be written as:

$$Q = F(K, L; t) \qquad \text{.....(1)}$$

The variable t for time allows for any kind of time-related shift in the production function. In a broad sense this shift can be called technological change. Assuming neutral technological change the production function can be expressed as:

$$Q = A(t)\, f(K, L) \qquad \text{.....(2)}$$

The multiplicative factor A (t) measures the cumulative effect of shift over time. Determining A (t) requires solving the relationship:

$$\frac{\Delta A}{A} = \frac{\Delta q}{q} - W_K \frac{\Delta k}{k}, \qquad \text{.....(3)}$$

where q= Q/L, k = K/L, $W_K$= Capital's share of income and ΔA/A is the percentage change in the production function (Meiburg 1962).

In equation (3) the change in output induced by changes in capital and labour inputs is subtracted from the total change in output. The residual change (positive, zero or negative) is a measure of the shift in the production function or technological change.

The technique as expressed thus far is the Solow Model of technical change (Solow 2007). However the model should alter on two points. It has been argued that the greatest increases in productivity come precisely at the time when the share of intermediate produce is increasing most rapidly (Solow 2007). In agricultural production intermediate products are usually referred to as purchased inputs (fertilizers, chemicals etc). To account for increased productivity due to purchased inputs equation (3) can be amended to equation (4):

$$\frac{\Delta A}{A} = \frac{\Delta q}{q} - W_K \frac{\Delta k}{k} - W_M \frac{\Delta m}{m}, \qquad \text{.....(4)}$$

where M= Purchased inputs, m= M/L and $W_M$ inputs' share of income

This has the effect of making output a function of capital, labour and purchased inputs. Therefore the change in output is determined and then the portion of the change caused by changes in capital, labour and purchased inputs is subtracted. The remainder is a measure of the shift in the production function (Lave 1966).

The second change is on the order of a mathematical refinement. The terms of equation (4), Δq/q, Δk/k and Δm/m are strictly correct only for infinitesimal changes. If there are large changes, q, k and m are incorrect divisors and introduce bias into the technological index. To minimize this bias, values of q, k and m are taken to be average value between two base periods. In other words equation (4) would be transformed into equation (5):

$$\frac{\Delta A}{A} = \frac{\Delta q}{\frac{q_{t1} + q_{t2}}{2}} - W_K \frac{\Delta k}{\frac{k_{t1} + k_{t2}}{2}} - W_M \frac{\Delta m}{\frac{m_{t1} + m_{t2}}{2}} \qquad \text{.....(5)}$$

where subscripts on q, k and m indicate time

Equation (5) results in an estimate of ΔA/A. By arbitrarily setting A(t)= 1 in the first period and making use of the fact that:

$$A(t+1) = A(t)\left[1 + \frac{\Delta A(t)}{A}\right], \qquad \text{.....(6)}$$

The A(t) time series can be successively constructed. Thus a technical change index or shift index is obtained.

**Empirical results of using the indexes**

Using the technique described above, an analysis was made of the impact of irrigation on the rate of technological change on irrigated farm as whole and non-irrigated farms of corresponding area. It was hypothesized that 1) output per unit of input was greater on the irrigated farms than on non-irrigated farms, 2) adoption of technological change occurred at a faster rate on the irrigated farms and 3) a higher level of purchased inputs was used on the irrigated farms.

If areas are identical except that one is irrigated and the other is not, any difference in the agricultural production process developing through time in the two areas is attributable to irrigation. When the rate of technological change has been determined for agriculture in an irrigated area, the part of that change which is attributable to the use of irrigation can be found by comparing the irrigated area with a similar non-irrigated area.

Those selected for comparison, one should have a high degree of irrigation and the other little or none. The general level of managerial ability should be the same in each area and prices should be equal or at least proportionally equal. If areas are compared which are different in these respects, the differences resulting from irrigation could be masked.

Data used in this analysis were collected from CCPC reports on farm costs and returns on commercial farms. Gross farm income which reflects the total output of the farm was used as the measure of farm output (Goodsell 1961). Labour inputs included total operator and family labour and all hired labour in man hours.

Capital was defined as total farm capital which included land and buildings, machinery and equipment. An annual charge of 12 per cent for capital investment was used to compute capital's share of gross income (Walter 1943).

The value of purchased inputs was assumed to be indicated by cash operating expenses. This was not an exact measure but was the best approximation available. Cash operating expenses included cost of pesticides and other chemicals, cost of irrigation including maintenance of irrigation facilities, other crop expenses, cost of hiring machinery and machinery work.

## RESULTS and DISCUSSION

**Comparison of technological index change in irrigated and non-irrigated farms as a whole**

In this analysis irrigated and non-irrigated farms were compared. Climate was fairly uniform throughout the area. Over the period 2000-2020, non-irrigated farms averaged an annual gross revenue of Rs11,720.52 while irrigated farms averaged Rs 36,870.37, a difference of Rs 25,149.86. Non-irrigated farms used an average of 971.5037 man hours of labour per year, 355.1863 hours less than the 1,326.69 used on irrigated farms. Average value of capital stock was Rs 66,963.50 on non-irrigated farms and Rs 1,09,789.70 on irrigated farms, a difference of Rs 42,826.23. The value of purchased inputs averaged Rs 2,231.00 on non-irrigated farms and Rs 5,379.86 on irrigated farms, a difference of Rs 3,148.86.

The technological change indexes computed for the two types of farms are shown in the A(t) columns of Tables 1 and 2. The indexes exhibited the same general trend approximately in the same direction at the same time throughout the period studied. From a base of 1.000 in the 1981's the index rose to 3.893 by the 2000's for non-irrigated farms. This was a total increase of 289.3 per cent or an average increase of 14.46 per cent per year. For unirrigated farm it suffered severe drops reaching a low of -1.707 in the period 1985. This resulted in little net technological change over the 20 time periods. For irrigated farms the index increased from a base of 1.000 to 4.926 over the same number of years. This was a total increase of 392.6 per cent or an average increase of 19.63 per cent per year. In these terms technology can be said to have increased on an average of 5.17 per cent per year faster on irrigated farms than on non-irrigated farms.

Because of the similarities of the two types of farm areas the difference in the rates of technological change can virtually all be attributed to irrigation. This point should not be misinterpreted by confusing the rates of technological change over time with the difference between the production functions.

The rate of technological change reflects the shift of a particular production function over time. The

difference between the functions is a static measure of a different level of output for a given level of input resulting from the use of irrigation. The difference in the rate of technological change does not reflect this difference but does reflect the fact that irrigated farms may adopt new technology at a different rate than non-irrigated farms.

The three-dimensional diagram in Fig 1 illustrates the concept of technological change over time. The X-axis represents resources used to produce the output represented by the Y-axis. The T-axis represents time. ON is a production function for a non-irrigated farm and OI is a production function for an irrigated farm at a particular point of time. Over the time span from O to T, both production functions shift upwards because of technological change making possible a greater output from each given level of input. Technological change on irrigated farms for input level B is represented by the difference between $O_tA_t$ and OA. The slope of the line CCt represents the rate of technological change. On non-irrigated farms technological change for input level B is represented by the difference between $O_tA_t$' and OA' with the rate of technological change being the slope of the line $MM_t$. The difference between the respective slopes represents in concept the difference in the rate of technological change on irrigated and non-irrigated farms. The efficiency ratio is given in Figs 2 and 3.

Indexes of technological change were also constructed to exclude purchased inputs from the equations. This was done by simply dropping the last term of equation (5) and reconstructing the $\Delta A/A$ and A(t) series.

The indexes derived in this manner count the increased production caused by purchased inputs as technological change and therefore were higher than those originally calculated. The recomputed indexes for both non-irrigated and irrigated farms are shown in Table 3.

These indexes move in the same direction as the original indexes but exhibit a different magnitude. When purchased inputs were excluded from the equations (that is when they were counted as technological change), the index number of non-irrigated farms was 3.988 in the final period compared with 3.893 for the original index. Therefore extra production attributed to purchased inputs increased the index by 0.09 index points. For irrigated farms the revised index number for the last period was 5.189 while the original was 4.926; a much greater change than in the index for non-irrigated farms. Extra production attributed to purchased inputs shifted the index upward by 0.2633 index points. The size of these shifts shows the importance of purchased inputs.

To find which type of farm had the greater output per unit of input, efficiency ratios were also calculated (Table 4). This was done by dividing output by the sum of charge to capital, hours of labour and value of purchased inputs. With respect to paired time periods, irrigated farms produced more output per unit of input than non-irrigated farms. Thus the evidence supports the hypothesis that output per unit of input was greater on irrigated farms.

To summarize, irrigated farms adopted technology at a faster rate than did non-irrigated farms and had a greater output per unit of input than non-irrigated farms and as a result made greater use of purchased inputs to further increase output and efficiency. This suggests that irrigated farms in semiarid areas enjoyed both short run and long run advantages over non-irrigated farms in such areas.

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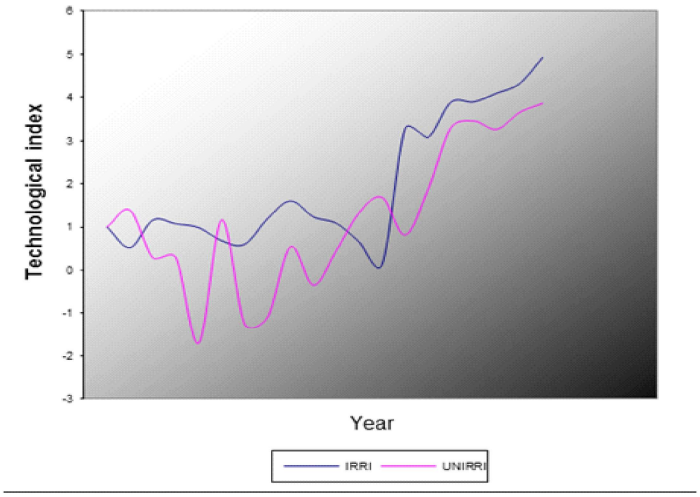


**Fig 1. Technological index in Tamil Nadu**

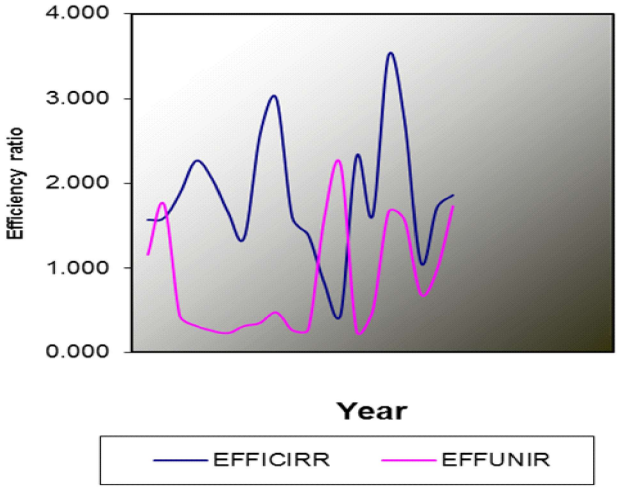


**Fig 2. Efficiency ratio**

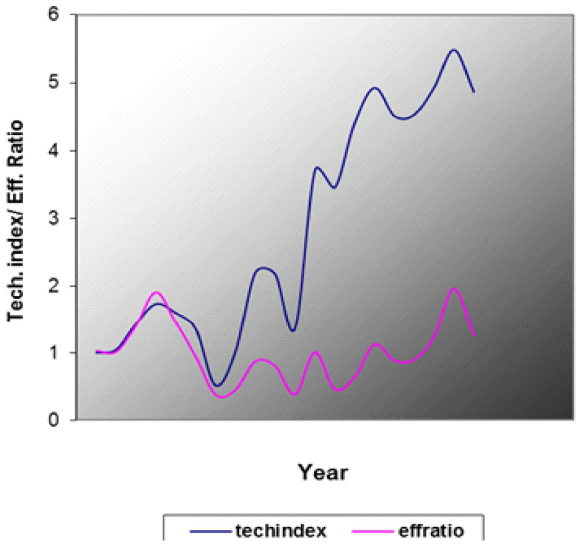


**Fig 3. Technological index and efficiency ratio for rice in Tamil Nadu**

Table 1a. Technological change index with purchase inputs– irrigated farm as a whole

| Year | Output Q (Rs) | Purchased inputs (Rs) | Labor L (h) | Capital K (Rs) | Charge for capital (Rs) | Output per unit of labour (q) (Rs) | Capital per unit of labour (k) (Rs) | Intermediate products per unit of labour (m) (Rs) | Capital share (wk) (%) | Intermediate product share (wm) (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 17,838.70 | 3,579.03 | 622.63 | 62,710.87 | 7,525.30 | 28.65 | 100.72 | 5.75 | 0.42 | 0.20 |
| 2001 | 3,718.79 | 1,244.70 | 715.96 | 7,121.43 | 854.57 | 5.19 | 9.95 | 1.74 | 0.23 | 0.33 |
| 2002 | 24,465.20 | 4,274.79 | 1,164.09 | 67,652.10 | 8,118.25 | 21.02 | 58.12 | 3.67 | 0.33 | 0.17 |
| 2003 | 1,8402.63 | 1696.56 | 1,416.48 | 43,332.75 | 5,199.93 | 12.99 | 30.59 | 1.20 | 0.28 | 0.09 |
| 2004 | 13,298.95 | 1,166.18 | 1,095.91 | 37,640.29 | 4,516.84 | 12.14 | 34.35 | 1.06 | 0.34 | 0.09 |
| 2005 | 19,648.69 | 2854.28 | 2,492.41 | 58,338.20 | 7,000.58 | 7.88 | 23.41 | 1.15 | 0.36 | 0.15 |
| 2006 | 11,131.12 | 1,507.32 | 1,259.98 | 51,142.75 | 6,137.13 | 8.83 | 40.59 | 1.20 | 0.55 | 0.14 |
| 2007 | 18,450.16 | 1,162.90 | 1,360.42 | 43,815.96 | 5,257.92 | 13.56 | 32.21 | 0.85 | 0.28 | 0.06 |
| 2008 | 23,768.59 | 2,044.17 | 1,105.68 | 35,264.57 | 4,231.75 | 21.50 | 31.89 | 1.85 | 0.18 | 0.09 |
| 2009 | 24,546.93 | 1,515.76 | 1,508.97 | 1,08,505.71 | 13,020.68 | 16.27 | 71.91 | 1.00 | 0.53 | 0.06 |
| 2010 | 1,6584.84 | 1,830.93 | 1,418.29 | 70,873.28 | 8,504.79 | 11.69 | 49.97 | 1.29 | 0.51 | 0.11 |
| 2011 | 12,804.17 | 2,535.19 | 1,292.21 | 1,00,642.93 | 12,077.15 | 9.91 | 77.88 | 1.96 | 0.94 | 0.20 |
| 2012 | 17,125.30 | 2,227.84 | 594.45 | 2,92,017.03 | 35,042.04 | 28.81 | 491.24 | 3.75 | 2.05 | 0.13 |
| 2013 | 64,869.39 | 5,024.71 | 2,765.89 | 1,54,825.63 | 18,579.08 | 23.45 | 55.98 | 1.82 | 0.29 | 0.08 |
| 2014 | 65,588.11 | 7,876.49 | 2,939.53 | 2,54,191.36 | 30,502.96 | 22.31 | 86.47 | 2.68 | 0.47 | 0.12 |
| 2015 | 12,9281.29 | 9,868.82 | 1,929.25 | 2,11,396.56 | 25,367.59 | 67.01 | 109.57 | 5.12 | 0.20 | 0.08 |
| 2016 | 95,733.97 | 14,129.08 | 1,323.12 | 1,56,216.75 | 18,746.01 | 72.35 | 118.07 | 10.68 | 0.20 | 0.15 |
| 2017 | 32,478.22 | 8,539.77 | 229.13 | 1,69,543.23 | 20,345.19 | 141.74 | 739.93 | 37.27 | 0.63 | 0.26 |
| 2018 | 4,7613.59 | 11,052.19 | 934.58 | 1,16,873.74 | 14,024.85 | 50.95 | 125.05 | 11.83 | 0.29 | 0.23 |
| 2019-20 | 80,058.85 | 2,3466.54 | 364.81 | 1,53,689.54 | 18,442.74 | 219.45 | 421.29 | 64.33 | 0.23 | 0.29 |

Given values are average per ha

Source: CCPC, Department of Agricultural Economics

Table 1b. Technology change work sheet for irrigated farm

| Δq | q1 + q2/2 | Δq/ q1 + q2/2 | Δk | k1 + k2/2 | Δk/ k1 + k2/2 | wk*Δ k/ k1 + k2/2 | Δm | m1 + m2/2 | Δm/ m1 + m2/2 | wm*Δ/ m1 + m2/2 | Change in production function (ΔA/A) (%) | Technological change index [A(t)] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -23.46 | 16.92 | -1.39 | -90.77 | 55.33 | -1.64 | -0.69 | -4.01 | 3.74 | -1.07 | -0.21 | -0.48 | 1.00 |
| 15.82 | 13.11 | 1.21 | 48.17 | 34.03 | 1.42 | 0.33 | 1.93 | 2.71 | 0.71 | 0.24 | 0.64 | 0.52 |
| -8.02 | 17.00 | -0.47 | -27.52 | 44.35 | -0.62 | -0.21 | -2.47 | 2.43 | -1.02 | -0.18 | -0.09 | 1.16 |
| -0.86 | 12.56 | -0.07 | 3.75 | 32.47 | 0.12 | 0.03 | -0.13 | 1.13 | -0.12 | -0.01 | -0.09 | 1.08 |
| -4.25 | 10.01 | -0.42 | -10.94 | 28.88 | -0.38 | -0.13 | 0.08 | 1.10 | 0.07 | 0.01 | -0.30 | 0.99 |
| 0.95 | 8.36 | 0.11 | 17.18 | 32.00 | 0.54 | 0.19 | 0.05 | 1.17 | 0.04 | 0.01 | -0.08 | 0.68 |
| 4.73 | 11.20 | 0.42 | -8.38 | 36.40 | -0.23 | -0.13 | -0.34 | 1.03 | -0.33 | -0.05 | 0.59 | 0.60 |
| 7.93 | 17.53 | 0.45 | -0.31 | 32.05 | -0.01 | 0.00 | 0.99 | 1.35 | 0.74 | 0.05 | 0.41 | 1.19 |
| -5.23 | 18.88 | -0.28 | 40.01 | 51.90 | 0.77 | 0.14 | -0.84 | 1.43 | -0.59 | -0.05 | -0.36 | 1.60 |
| -4.57 | 13.98 | -0.33 | -21.94 | 60.94 | -0.36 | -0.19 | 0.29 | 1.15 | 0.25 | 0.02 | -0.15 | 1.24 |
| -1.78 | 10.80 | -0.17 | 27.91 | 63.93 | 0.44 | 0.22 | 0.67 | 1.63 | 0.41 | 0.05 | -0.43 | 1.09 |
| 18.90 | 19.36 | 0.98 | 413.35 | 284.56 | 1.45 | 1.37 | 1.79 | 2.85 | 0.63 | 0.12 | -0.52 | 0.65 |
| -5.36 | 26.13 | -0.20 | -435.26 | 273.61 | -1.59 | -3.26 | -1.93 | 2.78 | -0.69 | -0.09 | 3.14 | 0.13 |
| -1.14 | 22.88 | -0.05 | 30.50 | 71.23 | 0.43 | 0.12 | 0.86 | 2.25 | 0.38 | 0.03 | -0.20 | 3.28 |
| 44.70 | 44.66 | 1.00 | 23.10 | 98.02 | 0.24 | 0.11 | 2.44 | 3.90 | 0.62 | 0.08 | 0.82 | 3.07 |
| 5.34 | 69.68 | 0.08 | 8.49 | 113.82 | 0.07 | 0.01 | 5.56 | 7.90 | 0.70 | 0.05 | 0.01 | 3.89 |
| 69.39 | 107.05 | 0.65 | 621.86 | 429.00 | 1.45 | 0.28 | 26.59 | 23.97 | 1.11 | 0.16 | 0.20 | 3.90 |
| -90.80 | 96.34 | -0.94 | -614.88 | 432.49 | -1.42 | -0.89 | -25.44 | 24.55 | -1.04 | -0.27 | 0.22 | 4.10 |
| 168.5 | 135.20 | 1.25 | 296.23 | 273.17 | 1.08 | 0.32 | 52.50 | 38.08 | 1.38 | 0.32 | 0.61 | 4.32 |
| | | | | | | | | | | | - | 4.93 |

Table 2a. Technological change index with purchase inputs– unirrigated farm as a whole

| Year | Output Q (Rs) | Purchased inputs (Rs) | Labor L (h) | Capital K (Rs) | Charge for capital (Rs) | Output per unit of labour (q) (Rs) | Capital per unit of labour (k) (Rs) | Intermediate products per unit of labour (m) (Rs) | Capital share (wk) (%) | Intermediate product share (wm) (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 5528.39 | 1191.15 | 1154.30 | 20883.16 | 2505.98 | 4.79 | 18.09 | 1.03 | 0.45 | 0.22 |
| 2001 | 2792.89 | 223.94 | 370.46 | 9806.77 | 1176.81 | 7.54 | 26.47 | 0.60 | 0.42 | 0.08 |
| 2002 | 1694.14 | 505.40 | 565.26 | 24772.41 | 2972.69 | 3.00 | 43.83 | 0.89 | 1.75 | 0.30 |
| 2003 | 7934.43 | 4437.70 | 5813.11 | 168827.87 | 20259.34 | 1.36 | 29.04 | 0.76 | 2.55 | 0.56 |
| 2004 | 1487.26 | 230.93 | 365.85 | 43595.20 | 5231.42 | 4.07 | 119.16 | 0.63 | 3.52 | 0.16 |
| 2005 | 1556.27 | 870.42 | 1140.19 | 38998.39 | 4679.81 | 1.36 | 34.20 | 0.76 | 3.01 | 0.56 |
| 2006 | 1880.09 | 940.80 | 422.02 | 41871.56 | 5024.59 | 4.45 | 99.22 | 2.23 | 2.67 | 0.50 |
| 2007 | 1836.98 | 501.46 | 358.64 | 38558.53 | 4627.02 | 5.12 | 107.51 | 1.40 | 2.52 | 0.27 |
| 2008 | 2939.79 | 326.70 | 637.17 | 37263.25 | 4471.59 | 4.61 | 58.48 | 0.51 | 1.52 | 0.11 |
| 2009 | 1669.79 | 174.71 | 436.22 | 41603.51 | 4992.42 | 3.83 | 95.37 | 0.40 | 2.99 | 0.10 |
| 2010 | 2362.74 | 297.05 | 531.85 | 40269.00 | 4832.28 | 4.44 | 75.72 | 0.56 | 2.05 | 0.13 |
| 2011 | 14148.45 | 482.50 | 546.00 | 52320.65 | 6278.48 | 25.91 | 95.82 | 0.88 | 0.44 | 0.03 |
| 2012 | 49006.21 | 6602.48 | 1533.07 | 95322.98 | 11438.76 | 31.97 | 62.18 | 4.31 | 0.23 | 0.13 |
| 2013 | 6361.99 | 947.07 | 385.87 | 113222.38 | 13586.69 | 16.49 | 293.42 | 2.45 | 2.14 | 0.15 |
| 2014 | 11685.44 | 1910.21 | 588.45 | 112461.83 | 13495.42 | 19.86 | 191.11 | 3.25 | 1.15 | 0.16 |
| 2015 | 18264.37 | 3204.46 | 1165.62 | 37673.33 | 4520.80 | 15.67 | 32.32 | 2.75 | 0.25 | 0.18 |
| 2016 | 25052.04 | 5831.03 | 1107.42 | 52859.60 | 6343.15 | 22.62 | 47.73 | 5.27 | 0.25 | 0.23 |
| 2017 | 16396.04 | 3443.25 | 623.19 | 141788.88 | 17014.67 | 26.31 | 227.52 | 5.53 | 1.04 | 0.21 |
| 2018 | 25856.00 | 4585.13 | 510.43 | 133088.73 | 15970.65 | 50.66 | 260.74 | 8.98 | 0.62 | 0.18 |
| 2019-20 | 35957.04 | 7913.64 | 1074.93 | 94081.98 | 11289.84 | 33.45 | 87.52 | 7.36 | 0.31 | 0.22 |

Given values are average per ha

Source: CCPC, Department of Agricultural Economics

Table 2b. Technology change work sheet for unirrigated farm

| Δq | q1 + q2/2 | Δq/ q1 + q2/2 | Δk | k1 + k2/2 | vk/ k1 + k2/2 | wk* Δk/ k1 + k2/2 | Δm | m1 + m2/2 | Δm/ m2/2 | m1 + | wm* Δm/m1 + m2/2 | Change in production function ( ΔA/A) (%) | Technological change index [A(t)] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.75 | 6.16 | 0.45 | 8.38 | 22.28 | 0.38 | 0.17 | -0.43 | 0.82 | -0.52 | | -0.11 | 0.39 | 1.00 |
| -4.54 | 5.27 | -0.86 | 17.35 | 35.15 | 0.49 | 0.21 | 0.29 | 0.75 | 0.39 | | 0.03 | -1.10 | 1.39 |
| -1.63 | 2.18 | -0.75 | -14.78 | 36.43 | -0.41 | -0.71 | -0.13 | 0.83 | -0.16 | | -0.05 | 0.01 | 0.29 |
| 2.70 | 2.72 | 0.99 | 90.12 | 74.10 | 1.22 | 3.11 | -0.13 | 0.70 | -0.19 | | -0.11 | -2.00 | 0.30 |
| -2.70 | 2.72 | -0.99 | -84.96 | 76.68 | -1.11 | -3.90 | 0.13 | 0.70 | 0.19 | | 0.03 | 2.87 | -1.71 |
| 3.09 | 2.91 | 1.06 | 65.01 | 66.71 | 0.97 | 2.93 | 1.47 | 1.50 | 0.98 | | 0.55 | -2.42 | 1.17 |
| 0.67 | 4.79 | 0.14 | 8.30 | 103.37 | 0.08 | 0.21 | -0.83 | 1.81 | -0.46 | | -0.23 | 0.15 | -1.25 |
| -0.51 | 4.87 | -0.10 | -49.03 | 83.00 | -0.59 | -1.49 | -0.89 | 0.96 | -0.93 | | -0.25 | 1.64 | -1.10 |
| -0.79 | 4.22 | -0.19 | 36.89 | 76.93 | 0.48 | 0.73 | -0.11 | 0.46 | -0.25 | | -0.03 | -0.89 | 0.54 |
| 0.61 | 4.14 | 0.15 | -19.66 | 85.54 | -0.23 | -0.69 | 0.16 | 0.48 | 0.33 | | 0.03 | 0.80 | -0.35 |
| 21.47 | 15.18 | 1.41 | 20.11 | 85.77 | 0.23 | 0.48 | 0.33 | 0.72 | 0.45 | | 0.06 | 0.88 | 0.45 |
| 6.05 | 28.94 | 0.21 | -33.65 | 79.00 | -0.43 | -0.19 | 3.42 | 2.60 | 1.32 | | 0.04 | 0.35 | 1.33 |
| -15.48 | 24.23 | -0.64 | 231.24 | 177.80 | 1.30 | 0.30 | -1.85 | 3.38 | -0.55 | | -0.07 | -0.87 | 1.68 |
| 3.37 | 18.17 | 0.19 | -102.30 | 242.27 | -0.42 | -0.90 | 0.79 | 2.85 | 0.28 | | 0.04 | 1.05 | 0.82 |
| -4.19 | 17.76 | -0.24 | -158.79 | 111.72 | -1.42 | -1.64 | -0.50 | 3.00 | -0.17 | | -0.03 | 1.43 | 1.86 |
| 6.95 | 19.15 | 0.36 | 15.41 | 40.03 | 0.39 | 0.10 | 2.52 | 4.01 | 0.63 | | 0.11 | 0.16 | 3.29 |
| 3.69 | 24.47 | 0.15 | 179.79 | 137.63 | 1.31 | 0.33 | 0.26 | 5.40 | 0.05 | | 0.01 | -0.19 | 3.45 |
| 24.35 | 38.48 | 0.63 | 33.22 | 244.13 | 0.14 | 0.14 | 3.46 | 7.25 | 0.48 | | 0.10 | 0.39 | 3.26 |
| -17.20 | 42.05 | -0.41 | -173.21 | 174.13 | -0.99 | -0.61 | -1.62 | 8.17 | -0.20 | | -0.04 | 0.24 | 3.65 |
| | | | | | | | | | | | | - | 3.89 |

Table 3. Technological change index-excluded purchased inputs

| Year | Irrigated farm | | Unirrigated farm | |
|---|---|---|---|---|
| | Change in production function (ΔA/A) | Exclude purchase inputs A(t) | Change in production function (ΔA/A) | Exclude purchase inputs A(t) |
| 2000 | -0.694 | 1.000 | 0.276 | 1.000 |
| 2001 | 0.882 | 0.306 | -1.070 | 1.276 |
| 2002 | -0.266 | 1.188 | -0.036 | 0.205 |
| 2003 | -0.101 | 0.922 | -2.111 | 0.169 |
| 2004 | -0.296 | 0.821 | 2.903 | -1.942 |
| 2005 | -0.078 | 0.525 | -1.869 | 0.961 |
| 2006 | 0.549 | 0.447 | -0.075 | -0.908 |
| 2007 | 0.455 | 0.997 | 1.384 | -0.983 |
| 2008 | -0.414 | 1.452 | -0.916 | 0.401 |
| 2009 | -0.136 | 1.038 | 0.836 | -0.515 |
| 2010 | -0.389 | 0.902 | 0.935 | 0.321 |
| 2011 | -0.394 | 0.512 | 0.398 | 1.256 |
| 2012 | 3.050 | 0.119 | -0.942 | 1.654 |
| 2013 | -0.172 | 3.169 | 1.087 | 0.711 |
| 2014 | 0.891 | 2.996 | 1.406 | 1.799 |
| 2015 | 0.062 | 3.888 | 0.268 | 3.204 |
| 2016 | 0.364 | 3.950 | -0.180 | 3.472 |
| 2017 | -0.052 | 4.314 | 0.491 | 3.292 |
| 2018 | 0.927 | 4.262 | 0.205 | 3.784 |
| 2019-20 | - | 5.189 | - | 3.989 |

Table 4. Efficiency ratio for irrigated and unirrigated farms

| Year | Labour charges/ha | Input/ha | Capital charge | Output/ha | Total inputs | Efficiency ratio |
|---|---|---|---|---|---|---|
| **Irrigated farm** | | | | | | |
| 2000 | 245.86 | 3,579.03 | 7,525.30 | 17,838.70 | 11,350.19 | 1.57 |
| 2001 | 234.75 | 1,244.70 | 854.57 | 3,718.79 | 2,334.02 | 1.59 |
| 2002 | 609.86 | 4,274.79 | 8,118.25 | 24,465.20 | 13,002.90 | 1.88 |
| 2003 | 1,222.98 | 1,696.56 | 5,199.93 | 18,402.63 | 8,119.47 | 2.27 |
| 2004 | 778.05 | 1,166.18 | 4,516.84 | 13,298.95 | 6,461.06 | 2.06 |
| 2005 | 1,991.53 | 2,854.28 | 7,000.58 | 19,648.69 | 11,846.39 | 1.66 |
| 2006 | 524.38 | 1,507.32 | 6,137.13 | 11,131.12 | 8,168.83 | 1.36 |
| 2007 | 719.64 | 1,162.90 | 5,257.92 | 18,450.16 | 7,140.46 | 2.58 |
| 2008 | 1,634.22 | 2,044.17 | 4,231.75 | 23,768.59 | 7,910.15 | 3.00 |
| 2009 | 760.37 | 1,515.76 | 13,020.68 | 24,546.93 | 15,296.82 | 1.60 |
| 2010 | 1,547.76 | 1,830.93 | 8,504.79 | 16,584.84 | 11,883.48 | 1.40 |
| 2011 | 1,002.96 | 2,535.19 | 12,077.15 | 12,804.17 | 15,615.30 | 0.82 |
| 2012 | 1,032.48 | 2,227.84 | 35,042.04 | 17,125.30 | 38,302.37 | 0.45 |
| 2013 | 4,362.41 | 5,024.71 | 18,579.08 | 64,869.39 | 27,966.20 | 2.32 |
| 2014 | 2,123.14 | 7,876.49 | 30,502.96 | 65,588.11 | 40,502.60 | 1.62 |
| 2015 | 1,621.51 | 9,868.82 | 25,367.59 | 1,29,281.29 | 36,857.91 | 3.51 |
| 2016 | 2,088.00 | 14,129.08 | 18,746.01 | 95,733.97 | 34,963.09 | 2.74 |
| 2017 | 1,478.26 | 8,539.77 | 20,345.19 | 32,478.22 | 30,363.22 | 1.07 |
| 2018 | 2,709.42 | 11,052.19 | 14,024.85 | 47,613.59 | 27,786.46 | 1.71 |
| 2019-20 | 1,078.63 | 23,466.54 | 18,442.74 | 80,058.85 | 42,987.92 | 1.86 |
| **Unirrigated farm** | | | | | | |
| 2000 | 1,191.15 | 1,059.66 | 2,505.98 | 5,528.39 | 4,756.79 | 1.16 |
| 2001 | 223.94 | 187.77 | 1,176.81 | 2,792.89 | 1,588.52 | 1.76 |
| 2002 | 505.40 | 412.26 | 2,972.69 | 1,694.14 | 3,890.35 | 0.44 |
| 2003 | 4,437.70 | 534.43 | 20,259.34 | 7,934.43 | 25,231.48 | 0.31 |
| 2004 | 230.93 | 346.26 | 5,231.42 | 1,487.26 | 5,808.61 | 0.26 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2005 | 870.42 | 1,279.74 | 4,679.81 | 1,556.27 | 6,829.97 | 0.23 |
| 2006 | 940.80 | 64.10 | 5,024.59 | 1,880.09 | 6,029.49 | 0.31 |
| 2007 | 501.46 | 155.72 | 4,627.02 | 1,836.98 | 5,284.20 | 0.35 |
| 2008 | 326.70 | 1,296.34 | 4,471.59 | 2,939.79 | 6,094.63 | 0.48 |
| 2009 | 174.71 | 1,189.98 | 4,992.42 | 1,669.79 | 6,357.12 | 0.26 |
| 2010 | 297.05 | 3,630.33 | 4,832.28 | 2,362.74 | 8,759.67 | 0.27 |
| 2011 | 482.50 | 2,032.79 | 6,278.48 | 14,148.45 | 8,793.77 | 1.61 |
| 2012 | 6,602.48 | 3,992.55 | 11,438.76 | 49,006.21 | 22,033.79 | 2.22 |
| 2013 | 947.07 | 10,465.36 | 13,586.69 | 6,361.99 | 24,999.12 | 0.25 |
| 2014 | 1,910.21 | 8,122.02 | 13,495.42 | 11,685.44 | 23,527.65 | 0.50 |
| 2015 | 3,204.46 | 3,250.59 | 4,520.80 | 18,264.37 | 10,975.85 | 1.66 |
| 2016 | 5,831.03 | 3,782.45 | 6,343.15 | 25,052.04 | 15,956.63 | 1.57 |
| 2017 | 3,443.25 | 3,082.57 | 17,014.67 | 16,396.04 | 23,540.48 | 0.70 |
| 2018 | 4,585.13 | 5,822.61 | 15,970.65 | 25,856.00 | 26,378.38 | 0.98 |
| 2019-20 | 7,913.64 | 1,555.28 | 11,289.84 | 35,957.04 | 20,758.76 | 1.73 |

Values in Rs

severe drops reaching a low of -1.707 in the period 2005. This resulted in little net technological change over the 20 time periods. For irrigated farms the index increased from a base of 1.000 to 4.926 over the same number of years. This was a total increase of 392.6 per cent or an average increase of 19.63 per cent per year. In these terms technology can be said to have increased on an average of 5.17 per cent per year faster on irrigated farms than on non-irrigated farm.

So far technological change index for farms as a whole was studied; then technological change index for specific crop cultivating farms was constructed. In the study area paddy crop was cultivated more predominantly. Hence paddy farms were selected and technological change index for it was constructed.

**Technological change index for irrigated paddy farm**

Over the period 2000-2020, irrigated farms averaged annual gross revenue of Rs 19,577.27. Irrigated farms used an average of 2,071.769 man hours of labour per year. Average value of capital stock was Rs 1,48,310.60 on irrigated farms. The value of purchased inputs averaged Rs 3,473.594 on irrigated farms.

The technological change indexes computed for the paddy farms are shown in the A(t) columns of Table 5. The indexes exhibited the same general trend approximately in the same direction at the same time throughout the period studied. From a base of 1.000 in the 1981's, the index rose to 4.8629 by the 2000's. This was a total increase of 486.26 per cent or an average increase of 24.31 per cent per year.

Indexes of technological change were also constructed to exclude purchased inputs from the equations. This was done by simply dropping the last term of equation (5) and reconstructing the $\Delta A/A$ and A(t) series.

When purchased inputs were excluded from the equations, the index number was 5.1498 in the final period compared with 4.8629 for the original index (Table 6). Therefore extra production attributed to purchased inputs increased the index by 0.29 index points. The size of these shifts shows the importance of purchased inputs. To find the greater output per unit of input, efficiency ratios were also calculated (Table 7).

## SUMMARY

Efficiency as measured by output per unit of input was clearly greater on the irrigated farms. Time period by time period, both farms as a whole and specific crop activity the irrigated farms maintained a higher efficiency ratio than non-irrigated farms.

Technological changes measured by shifts in production functions occurred at a faster rate on the irrigated farming enterprise studied than the non-irrigated area farms. Over the period 2000 through 2020, technology increased on an average of 5.17 per cent per year faster on irrigated farms than on non-irrigated farms as a whole and in paddy it was 24.31.

Purchased inputs used for the 20 years farm as a whole and in specific irrigated farm increased continuously.

Table 5a. Irrigated rice technological change index

| Year | Output Q (Rs) | Purchased inputs (Rs) | Labor L (h) | Capital K (Rs) | Charge for capital (Rs) | Output per unit of labour (q) (Rs) | Capital per unit of labour (k) (Rs) | Intermediate products per unit of labour (m) (Rs) | Capital share (wk) (%) | Intermediate product share (wm) (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 5642.86 | 785.25 | 1750.63 | 34300.00 | 4116.00 | | | | | |
| 2001 | 6625.00 | 246.43 | 1978.57 | 47571.43 | 5708.57 | 3.22 | 19.59 | 0.45 | 0.73 | 0.14 |
| 2002 | 6903.98 | 567.88 | 1833.45 | 31001.77 | 3720.21 | 3.35 | 24.04 | 0.12 | 0.86 | 0.04 |
| 2003 | 12100.47 | 1487.64 | 2199.85 | 38084.67 | 4570.16 | 3.77 | 16.91 | 0.31 | 0.54 | 0.08 |
| 2004 | 10265.14 | 1331.52 | 1966.10 | 42416.02 | 5089.92 | 5.50 | 17.31 | 0.68 | 0.38 | 0.12 |
| 2005 | 9196.31 | 910.46 | 1694.97 | 69744.97 | 8369.40 | 5.22 | 21.57 | 0.68 | 0.50 | 0.13 |
| 2006 | 16887.30 | 2616.60 | 3090.98 | 328819.67 | 39458.36 | 5.43 | 41.15 | 0.54 | 0.91 | 0.10 |
| 2007 | 15370.83 | 2045.31 | 2842.22 | 245733.33 | 29488.00 | 5.46 | 106.38 | 0.85 | 2.34 | 0.15 |
| 2008 | 13425.00 | 1451.14 | 1809.44 | 97893.62 | 11747.23 | 5.41 | 86.46 | 0.72 | 1.92 | 0.13 |
| 2009 | 15808.33 | 2204.17 | 2214.58 | 114333.33 | 13720.00 | 7.42 | 54.10 | 0.80 | 0.88 | 0.11 |
| 2010 | 8780.00 | 1664.67 | 1840.00 | 156586.67 | 18790.40 | 7.14 | 51.63 | 1.00 | 0.87 | 0.14 |
| 2011 | 14184.40 | 4863.12 | 2463.59 | 63224.59 | 7586.95 | 4.77 | 85.10 | 0.90 | 2.14 | 0.19 |
| 2012 | 17543.86 | 4878.07 | 1348.07 | 269192.98 | 32303.16 | 5.76 | 25.66 | 1.97 | 0.53 | 0.34 |
| 2013 | 31465.13 | 4778.85 | 2838.46 | 342871.79 | 41144.62 | 13.01 | 199.69 | 3.62 | 1.84 | 0.28 |
| 2014 | 35923.91 | 4263.04 | 1382.61 | 193797.10 | 23255.65 | 11.09 | 120.79 | 1.68 | 1.31 | 0.15 |
| 2015 | 35810.85 | 7205.32 | 2892.06 | 265317.46 | 31838.10 | 25.98 | 140.17 | 3.08 | 0.65 | 0.12 |
| 2016 | 35028.17 | 8183.77 | 3268.28 | 249373.13 | 29924.78 | 12.38 | 91.74 | 2.49 | 0.89 | 0.20 |
| 2017 | 34175.00 | 7302.67 | 1878.85 | 146110.43 | 17533.25 | 10.72 | 76.30 | 2.50 | 0.85 | 0.23 |
| 2018 | 34992.33 | 6618.71 | 687.15 | 80848.14 | 9701.78 | 18.19 | 77.77 | 3.89 | 0.51 | 0.21 |
| 2019-20 | 31416.57 | 6067.27 | 1455.50 | 148991.64 | 18531.24 | 50.92 | 117.66 | 9.63 | 0.28 | 0.19 |

Given values are average per ha

Source: CCPC, Department of Agricultural Economics

Table 5b. Technology work sheet for irrigated rice technological change index

| Year | Δq | Δq/ q1 + q2/2 | Δk | k1 + k2/2 | Δk/k1 + k2/2 | wk* Δk/k1 + k2/2 | Δm | Δm/ m1 + m2/2 | wm* Δm/ m1 + m2/2 | Change in production function ( ΔA/A) (%) | Technological change (A(t) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 0.13 | 0.04 | 4.45 | 21.82 | 0.20 | 0.15 | -0.324 | -1.131 | -0.157 | 0.047 | 1.000 |
| 2001 | 0.42 | 0.12 | -7.13 | 20.48 | -0.35 | -0.30 | 0.185 | 0.853 | 0.032 | 0.386 | 1.047 |
| 2002 | 1.74 | 0.37 | 0.40 | 17.11 | 0.02 | 0.01 | 0.367 | 0.743 | 0.061 | 0.301 | 1.432 |
| 2003 | -0.28 | -0.05 | 4.26 | 19.44 | 0.22 | 0.08 | 0.001 | 0.001 | 0.000 | -0.135 | 1.733 |
| 2004 | 0.20 | 0.04 | 19.57 | 31.36 | 0.62 | 0.31 | -0.140 | -0.231 | -0.030 | -0.241 | 1.598 |
| 2005 | 0.04 | 0.01 | 65.23 | 73.76 | 0.88 | 0.80 | 0.309 | 0.447 | 0.044 | -0.842 | 1.357 |
| 2006 | -0.06 | -0.01 | -19.92 | 96.42 | -0.21 | -0.48 | -0.127 | -0.162 | -0.025 | 0.498 | 0.515 |
| 2007 | 2.01 | 0.31 | -32.36 | 70.28 | -0.46 | -0.88 | 0.082 | 0.108 | 0.014 | 1.182 | 1.012 |
| 2008 | -0.28 | -0.04 | -2.47 | 52.86 | -0.05 | -0.04 | 0.193 | 0.215 | 0.023 | -0.021 | 2.195 |
| 2009 | -2.37 | -0.40 | 33.47 | 68.36 | 0.49 | 0.42 | -0.091 | -0.095 | -0.013 | -0.809 | 2.174 |
| 2010 | 0.99 | 0.19 | -59.44 | 55.38 | -1.07 | -2.30 | 1.069 | 0.743 | 0.141 | 2.343 | 1.365 |
| 2011 | 7.26 | 0.77 | 174.02 | 112.68 | 1.54 | 0.83 | 1.645 | 0.588 | 0.202 | -0.255 | 3.708 |
| 2012 | -1.93 | -0.16 | -78.89 | 160.24 | -0.49 | -0.91 | -1.935 | -0.730 | -0.203 | 0.949 | 3.453 |
| 2013 | 14.90 | 0.80 | 19.37 | 130.48 | 0.15 | 0.19 | 1.400 | 0.587 | 0.089 | 0.520 | 4.403 |
| 2014 | -13.60 | -0.71 | -48.43 | 115.95 | -0.42 | -0.27 | -0.592 | -0.212 | -0.025 | -0.413 | 4.923 |
| 2015 | -1.66 | -0.14 | -15.44 | 84.02 | -0.18 | -0.16 | 0.013 | 0.005 | 0.001 | 0.018 | 4.510 |
| 2016 | 7.47 | 0.52 | 1.47 | 77.03 | 0.02 | 0.02 | 1.383 | 0.433 | 0.101 | 0.400 | 4.528 |
| 2017 | 32.73 | 0.95 | 39.89 | 97.71 | 0.41 | 0.21 | 5.745 | 0.850 | 0.182 | 0.556 | 4.928 |
| 2018 | -29.34 | -0.81 | -15.29 | 110.01 | -0.14 | -0.04 | -5.464 | -0.792 | -0.150 | -0.621 | 5.484 |
| 2019-20 | | | | | | | | | | - | 4.863 |

Table 6. Technological change index excluded purchased inputs

| Year | ΔA/A | [A(t)] | Year | ΔA/A | [(A(t)] | Year | ΔA/A | [(A(t)] | Year | ΔA/A | [(A(t)] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | -0.111 | 1.000 | 2005 | -0.798 | 1.263 | 2010 | 2.484 | 1.314 | 2015 | 0.019 | 4.663 |
| 2001 | 0.418 | 0.889 | 2006 | 0.473 | 0.465 | 2011 | -0.053 | 3.798 | 2016 | 0.501 | 4.682 |
| 2002 | 0.362 | 1.307 | 2007 | 1.197 | 0.937 | 2012 | 0.746 | 3.745 | 2017 | 0.738 | 5.183 |
| 2003 | -0.135 | 1.669 | 2008 | 0.002 | 2.134 | 2013 | 0.610 | 4.492 | 2018 | -0.771 | 5.920 |
| 2004 | -0.271 | 1.534 | 2009 | -0.822 | 2.136 | 2014 | -0.439 | 5.101 | 2019-20 | 0.000 | 5.150 |

Table 7. Efficiency ratio

| Year | Input/ha (q) | Labour charges (Rs) | Capital charges (Rs) | Output/ha (q) | Total inputs (Rs) | Efficiency ratio |
|---|---|---|---|---|---|---|
| 2000 | 785.25 | 580.00 | 4,116.00 | 5,642.86 | 5,481.25 | 1.03 |
| 2001 | 246.43 | 567.86 | 5,708.57 | 6,625.00 | 6,522.86 | 1.02 |
| 2002 | 567.88 | 615.84 | 3,720.21 | 6,903.98 | 4,903.93 | 1.41 |
| 2003 | 1,487.64 | 285.77 | 4,570.16 | 12,100.47 | 6,343.57 | 1.91 |
| 2004 | 1,331.52 | 633.43 | 5,089.92 | 10,265.14 | 7,054.87 | 1.46 |
| 2005 | 910.46 | 464.23 | 8,369.40 | 9,196.31 | 9,744.08 | 0.94 |
| 2006 | 2,616.60 | 2,475.41 | 39,458.36 | 16,887.30 | 44,550.37 | 0.38 |
| 2007 | 2,045.31 | 2,867.78 | 29,488.00 | 15,370.83 | 34,401.08 | 0.45 |
| 2008 | 1,451.14 | 2,227.39 | 11,747.23 | 13,425.00 | 15,425.77 | 0.87 |
| 2009 | 2,204.17 | 3,791.67 | 13,720.00 | 15,808.33 | 19,715.83 | 0.80 |
| 2010 | 1,664.67 | 2,548.00 | 18,790.40 | 8,780.00 | 23,003.07 | 0.38 |
| 2011 | 4,863.12 | 1,644.68 | 7,586.95 | 14,184.40 | 14,094.75 | 1.01 |
| 2012 | 4,878.07 | 1,043.86 | 32,303.16 | 17,543.86 | 38,225.09 | 0.46 |
| 2013 | 4,778.85 | 3,256.41 | 41,144.62 | 31,465.13 | 49,179.87 | 0.64 |
| 2014 | 4,263.04 | 4,523.19 | 23,255.65 | 35,923.91 | 32,041.88 | 1.12 |
| 2015 | 7,205.32 | 1,435.52 | 31,838.10 | 35,810.85 | 40,478.93 | 0.88 |
| 2016 | 8,183.77 | 1,011.19 | 29,924.78 | 35,028.17 | 39,119.74 | 0.90 |
| 2017 | 7,302.67 | 2,677.91 | 17,533.25 | 34,175.00 | 27,513.83 | 1.24 |
| 2018 | 6,618.71 | 1,513.04 | 9,701.78 | 34,992.33 | 17,833.53 | 1.96 |
| 2019-20 | 6,067.27 | 986.63 | 17879.00 | 31,416.57 | 24,932.90 | 1.26 |

In these 20 years, labour hours were exchanged by machine hours and labour hours continuously declined.

Since irrigated farm had shown comparatively higher technical change it is important to concentrate on introduction of new irrigation techniques in irrigated agriculture. The gap in technical adoption should be bridged up appropriately so that the impact of technological change could be felt uniformly. Such adoption will also bring down the cost of technology transfer and adoption.

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