WATER PRODUCTIVITY AND IMPLICATIONS FOR GROUNDWATER USE

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7.1 Overview

In the previous sections, the relationship of crops with groundwater extraction and water table depth in wells was established. The crops and cropping systems with significantly higher groundwater extraction were identified under normal and above normal rainfall scenarios. A natural extension of building the relationship of crops and groundwater extraction would be examining the productivity of water in general and groundwater in particular. In Antisar watershed, where groundwater is the only source of irrigation during *rabi* and *summer* season and supplementary source during *kharif* season, knowing the water productivity has direct implication for groundwater use. Further, knowledge of groundwater productivity in varying rainfall conditions would help suggest its redistribution not only intra-season, at different crop growth stages but also inter-season, between different crops.

Optimal use of water in crops warrants water allocation in crops with higher water productivity as compared to other crop with a comparatively lower productivity. Similarly, water is applied in the field at different stages of crop growth and therefore water productivities at different crop growth stages also need a closer examination. This is more so in the context of a watershed, where such agricultural production activities directly affect the stock of groundwater under a given rainfall scenario. Moreover, rainfall being uncertain in semi-arid tropical region, rational use of water in one season would ensure sufficient availability of groundwater for another season.

7.2 Review of past works

Several techniques have been employed for valuation of water. Renwick (2001) used a linear programming framework for valuing irrigated agriculture in Sri Lanka with water allocation constraint reflecting water-use rights or entitlements. Tsur and Dinar (1995) used this framework in assessing equity and efficiency considerations. Such an approach, however, has limitations in case of groundwater pumping where no water use entitlements are in place. In India, the groundwater use is indiscriminate The subsidized price of electricity has resulted into negligible cost of irrigation to groundwater users. The uncertainty in the supply of electricity to rural areas leads to the risk avoiding behaviour on their part. Hence, the tube well owners tend to extract water during the availability of electricity supply to minimize the risk of losing water availability in the field. The property rights to groundwater are not clearly defined. The rights belong to those owning land and are in possession of mechanism to tap it. There are no limitation on the volume of groundwater extraction to the tube well owners, which make them free to extract any quantum of ground water.

Wang and Lall (1999) used a translog production function to compute marginal value and price elasticity for water demand in industrial sector. However, studies on valuation in agriculture sector are very limited. Molden et al. (2001) used Standardized Gross Value Production (SGVP) in rice equivalent quantity in monetary values to compute water productivity in irrigated agriculture. The gross value production was computed in rice equivalent quantity based on the output prices of rice and other crops grown in irrigated agriculture and this was multiplied with the price of rice to convert into monetary values to define the water productivity. Scheierling et al. (1997) suggested that the correct specification of irrigation water use would be to consider irrigation decision as discrete irrigation event rather than modeling demand as a continuous variable. Pazvakawambwa and van der Zaag (2000) used a crop water production function for maize production in Eastern Zimbabwe. Nimah et al. (2006) used a mathematical model with an objective to maximize the water productivity. Randhir et al. (1989) used a Cobb-Douglas form of production function to examine the productivity of farm inputs including the supplemental irrigation. Singh and Srinivas (1989) also used Cobb-Douglas production function for rice farmers at head, middle and tail reaches of canal irrigation system of Vamsadhara Irrigation Project in Andhra Pradesh. The study reported negative coefficient of irrigation in head location and explained it in terms of excess water conditions. Somnathan and Ravindranath (2006) used seller's profit share divided by the volume of water delivered as the instrument of water price to examine the marginal water productivity in agriculture. Singh et al. (2004) measured water productivity as the ratio of crop output (kg) and total water (m^3) used in the production. Kumar et al. (2004) defined the economic value of groundwater as residual value obtained by subtracting market value of all the factors of production, labour, fertilizer, pesticide and irrigation water from the total value product. The production included livestock production and agricultural production.

Most of the studies reviewed have used sophisticated optimization techniques to evaluate agricultural water use and its productivity under varying geo-hydrologic situations. The complexities associated with the huge information database and large number of assumptions made for the unknown parameters lead to difficulties in application in developing countries, where majority of the groundwater users in agricultural production have little understanding of them. The extrapolated information leads to poor understanding of the economic implications of the model results and render the benefits limited in the field. Moreover, only a few attempts have been made in economic analysis to study the effect of moisture availability during different plant growth cycles and the resulting water response (Yaron, 1971). Therefore, attempt is made in this study by developing a simple analytical framework to estimate inter- and intra-seasonal marginal value productivity of water for the major crops and suggest diverting water use, particularly groundwater, to prospective crop enterprises with an implication of water saving, considering the sustainable use of groundwater stock, in the context of a semi arid watershed in India.

7.3 Technique used

A simple framework for modeling water application in crops is attempted in this section. The framework attempts to compute water productivity in crop. Unlike the general approach, where evapo-transpiration need of water is used to estimate water productivity, this approach uses water application for irrigation need in the field conditions by farmers.

7.3.1 Analytical framework

The productivity of water varies with the level of other input uses, with which it is used in the production process. In the context of agricultural use, the time of crop growth stage, the climatic factors etc. affect the level of input uses. The productivity of groundwater in agricultural use is derived from the crop water demand met by the groundwater. Groundwater is the only source for meeting deficit agricultural water demand in the Antisar watershed. The field observations indicate that during the drought years from 1999 to 2002, the area under irrigated crops, particularly during *rabi/* winter (October to January) and summer season (February to May) had drastically reduced. The watershed management programme helped in recharging groundwater and consequently the area under winter and summer irrigated crops increased significantly from 2003 onwards. Therefore, the agricultural use of groundwater and the productivity has been captured through its marginal value in crops produced in the watershed.

7.3.2 Production function approach

A production function approach, as a method of groundwater evaluation, has been suggested by a Committee on Valuing Groundwater (1997), constituted by Water Science and Technology Board of National Research Council of United States. This methodology is appropriate if the resources are input to a production process which has as an output with a well-defined market price. This measures the *in-situ* value of the resources and may be applicable for valuing groundwater that is not traded in the market.

The production theory describes relationship of an input applied in three stages of crop production with the output. As use of a particular input is increased with other factors remaining constant, output varies differently over a range of input use. In Stage I, the variable input is being used with increasing efficiency, reaching a maximum at point where the average physical product is at its maximum. Because the efficiency of variable inputs is improving throughout stage 1 a firm will always try to operate beyond this stage. In Stage II, output increases at a decreasing rate, and the average and marginal physical product is declining. In this stage, the employment of additional variable input decreases the efficiency of variable input. The optimum input/output combination will be in stage II. Maximum production efficiency must fall somewhere in this stage. In Stage III, too much variable input is being used relative to the available fixed inputs. The efficiency of variable inputs decline through out this stage.

Examination of these stages of production, with corresponding amount of water applied, helps plan optimal use of a scarce resource like water, intra-season as well as inter-season. The value of marginal products across the crops grown in the different season can be used as good indicators to decide about the water / irrigation application. Irrigation is applied where value of marginal product of water use is higher as compared to the case with lower value of marginal product. Water application to crops in one season can thus be minimized so as to apply water to crops in another season.

7.3.3 Formulation of production function

Water is an intermediate public good utilized for agricultural production. It has a derived demand based on the output produced. A unit of water at the margin, therefore, can be valued based on the value of the marginal product in crop production.

The general form of production function was:

$$Y = f(\{X_s\}, TW) \tag{1}$$

where, Y is output (kg), $\{X_s\}$ is input variable vector comprising of land (ha), labour (man-days), machine (hp-hr), material inputs (kg), electrical energy consumed in groundwater withdrawal (KWh), and TW is water used (m^3). Further, machine variable was converted into Kwh and added with the variable electricity consumed and defined as a new input energy (Kwh). Thus, the relevant variables for the production function analysis were land, labour, material input, energy and water.

Water requirement of a crop is seasonal and differs during crop growth stages. Traditionally, initial, development, mid and late stages have been defined for crops (FAO, 2002). Hence, TW^k, the vector of water inputs at different crop growth stages was considered to estimate marginal productivity of water at 'k^{th}' crop growth stage.

The production function (Eq. 1) then becomes,

$$Y = f(\{X_s\}, \{TW^k\}) \tag{2}$$

where, X_s is vector of inputs other than water and TW^k is vector input of water (m^3) applied at stage 'k' of crop growth (k=1,2,3 & 4)

7.3.4 Marginal product and output elasticity

Marginal physical product of input $X_i(MP_i)$ is defined as the absolute change in the total product due to a unit change in the input X_i, keeping all other inputs constant at some prespecified levels (Sankhayan, 1988). Marginal physical product of water, δ (kg m^{-}

^{3}) at each crop growth stage 'k' in production is the first derivative with respect to water component and is expressed as:

$$\delta = \frac{\partial Y}{\partial TW^{k}} \tag{3}$$

Marginal value product, σ (Rs-m^{-3}) of water for crop production can be expressed as:

$$\sigma = \delta P_{Y} \tag{4}$$

where, P_{Y} is farm harvest price (Rs-kg^{-1}) of final output.

Elasticity of output

Elasticity of production or output elasticity with respect to an input can be given as the per cent change in the quantity of the output due to one per cent change in the quantity of the given input, keeping all the other inputs constant at some prespecified levels. Mathematically, the elasticity of production with respect to input X_i can be expressed as,

$$E_{pi} = \frac{Percent change in Y}{Percent change in X_i}$$

$$= \frac{\partial \ln Y}{\partial \ln X_i}$$

$$= \frac{\partial Y}{\partial X_i}\frac{X_i}{Y}$$

$$= \frac{\partial Y}{\partial X_i}\frac{1}{Y/X_i}$$

$$= \frac{MP_i}{AP_i}$$

Therefore, elasticity of production or output elasticity with respect to say water input at a certain level can be given as the ratio between its marginal and average products at that particular level of the water use. It has also been termed as the local measure of returns of scale (Sankhayan, 1988). Elasticity of production greater than one

($E_p > 1$) indicates increasing returns and a production elasticity of less than one ($E_p < 1$) indicates deceasing returns.

For fitting the production function, primary data on input, land, labour, machine, material inputs like seed, fertilizer, pesticide, energy consumed in groundwater withdrawal, water and the output of crops were collected from the tube well owners of the watershed through personal interview for three agricultural years, 2003-04 through 2005-06. The farm harvest prices for the produce and the local market prices for the inputs used in the production were used to convert the physical outputs into monetary units.

Multi-collinearity analysis was performed prior to fitting of the production function and the inputs found to be highly correlated were dropped prior to fitting of the function. Multi-collinearity is a problem when any two or more than two explanatory variables are so highly correlated that they change nearly in the same way. Therefore, the single equation model can not be estimated by using the conventional least square estimation technique.

7.3.5 Estimation of parameters

Total water applied to the crop was worked out as sum of rainwater retained in the field and supplemental irrigations from groundwater sources given at different stages of crop growth. It is presumed that the retained water is utilized for crop production and deep percolation is assumed to be negligible.

7.3.5.1 Water from rainfall component

The generic form of the equation which can be used to estimate the component of rainfall applied to the crop is given by:

Rain water retained on the field = $(P - R_o) * A_j / 1000$ (5)

Where,

A_j is area of the field under j^{th} crop (m^2), P = rainfall in (mm), R_0 is runoff from the field (mm).

R_o is estimated using SCS curve number method (SCS, 1972) on daily basis, modified for Indian conditions (Dhruvanarayana, 1993) as:

$$R_o = \frac{(P - 0.3S_T)^2}{(P + 0.7S_T)} \tag{6}$$

where, S_T is the maximum potential storage of the watershed (mm) given as

$$S_T = \frac{25400}{CN} - 254 \tag{7}$$

and CN is the weighted curve number for the watershed depending upon antecedent moisture conditions (SCS, 1972).

The volume of water retained is estimated on a daily basis using equation 5 and is aggregated over the individual crop growth stages, k and is, hereafter, denoted as V_{wi}^{k}.

7.3.5.2 Application of extracted groundwater to crops

Data on extraction of groundwater for a particular crop was collected from the tube well owners through primary surveys. Number of hours taken to irrigate a field in respect of the standing crop was collected from the farmers for all the irrigations given to the crop on different dates. This was multiplied with the average discharge of the tube wells.

For the information on tube well discharge, in absence of water meter, approximation was made by collecting information directly from farmers as to the time taken in filling a drum of 100 litres. This information was gathered at different times of the crop seasons and simply averaged. The data was converted into m^3/hr.

Therefore, the total water applied to any crop grown on a particular farm at growth stage 'k', TW^k is the sum of the water received from rainfall, and the groundwater extracted for irrigation.

7.4 Data base

7.4.1 Rainfall

The data on rainfall retained in the field was collected from the records of the experiment being conducted at Central Soil & Water Conservation Research & Training Institute, Research Centre, Vasad.

7.4.2 Agricultural water use

Data on groundwater use were collected for the agricultural years 2003-04, 2004-05 and 2005-06. The agricultural year was defined as period between June to May comprising of three seasons, namely *kharif* (June to September), *rabi* (October to January) and summer (February to April). The data was collected on crop-wise input details such as seeds, fertilizers, chemicals, human, bullock and machine use, yield of crops, and groundwater pumping details, such as schedule of irrigations (numbers, date of water application, bore well running hours during different irrigations). During *kharif* season, groundwater was applied only as supplemental irrigation and data collected include details of water applied at different crop growth stages both through rainfall as well as supplemental irrigations.

The crop growth stages defined for different crops (FAO, 2002) were modified in consultation with agronomic experts and farmers in the area (Table 7.1). Crop growth stages were computed based on individual sowing dates on farms and crop growth stage duration. The water use under different crop growth stages was computed by temporal mapping of the individual dates of sowing of crops in the crop growth calendar. The crop growth stage durations have been computed based on the sowing dates. Since the seasonal crop growth period and growth stage durations of individual crops are different, computations of water used by the crops were based on the quantity of water available during that period from either rainfall or groundwater, or both.

7.5 RESULTS AND DISCUSSION

7.5.1 Crops and groundwater use in the area

The major crops utilizing groundwater were cotton, castor, fennel, cumin wheat and summer pearl millet. Maximum number of irrigations was applied to cotton crop followed by fennel, castor, cumin, and wheat.

Area under different crops along with the number of irrigations provided in different years is presented in table 7.2. Not only the area under crops but also the number of irrigations given increased over the period. The number of total irrigations increased from 556 (2003-04) to 1215 (2005-06), indicating increased used of groundwater during this period. In cotton alone, the number of irrigations roughly doubled between 2003-04 and 2005-06. In other crops, higher irrigations could be attributed to increased area under the crop.

7.5.2 Production function

A linear production function does not define the interactions between various other inputs and water, hence was not considered. The quadratic form of the function could not be fitted well because of the limitations of sufficient data points. A translog production function in restricted form was tried along with the Cobb-Douglas production function as these are the most widely used production functions in agriculture for economic analysis of production. The Cobb-Douglas production function was retained for the purpose of analysis because of its simplicity in use and also it was at par in performance with the translog form of the production function (Tables 7.3 through 7.15). The mathematical form of the fitted relationship is given as,

$$Y = aX_1^{b1}X_2^{b2}X_3^{b3}X_4^{b4}W_1^{b5}W_2^{b6}W_3^{b7}W_4^{b8}$$

Where, X_1 = land, X_2 = labour, X_3 = material input (seed, fertilizer etc), X_4 = energy used in crop production and W_1 = water applied at crop growth stage I, W_2 =

water applied at growth stage II, W_3 = water applied at growth stage III, W_4 = water applied at growth stage IV.

Thus the form of fitted production functions can be given as,

i) Translog production function

$$\ln Y = a + \sum_{i=1}^{n} b_i \ln X_i + \sum_{i=1}^{n} c_i \frac{\ln^2 X_i}{2} + \sum_{i,j=1}^{n} d_i \ln X_i \ln X_j \qquad i \neq j$$

ii) Cobb-Douglas production function

$$\ln Y = \ln a + \sum_{i=1}^{n} b_i \ln X_i$$

where,

Y= Crop Output

X_i = ith Crop Input (i = 1...7)

X_1 = Energy (KWh), X_2 = Land (acres), X_3 = Input (kg), X4 = Land (ha), W_1 = water applied at crop growth stage I (m^3), W_2 = water applied at crop growth stage II (m^3), W_3 = water applied at crop growth stage III (m^3), W_4 = water applied at crop growth stage IV (m^3)

a = Constant term

b_i = Coefficient of parameters associated with log value of the variable 'i'

c_i = Coefficient of parameters associated with the squared log value of the variable 'i'

d_i = Coefficient of parameters associated with the interaction of log values of the variables 'i' and 'j'

Tests were performed to examine the heteroscedasticity, spatial autocorrelation and multicollinearity in the data. While spearman's rank correlation tests indicated it to be a less serious problem, the test based on Durbin-Watson statistic resulted in indecision about presence of spatial correlation. Also as there was no strong economic interest or logic in ordering of data to make any sense of its determination (Gujarati, 2006), further probing was not pursued. The collinearity diagnostics tests, however, indicated presence of multicollinearity. The remedial measure such as dropping of some highly correlated variable could not be taken as it was against the basic nature of production function analysis, where the various inputs interact with each other to produce output. Dropping variable could also lead to specification bias. Therefore, all the variables were retained for the analysis.

7.5.3 Production function and regression coefficient

. The regression analysis was performed separately for the agricultural years 2003-04, 2004-045 and 2005-06 to examine the water productivity in different scenarios as rainfall and groundwater withdrawal varied during these years.

The regression summary for different crops in the three years is presented in Table 7.16. The coefficients of water applied in different stages turned out to be significant at various levels of significance. In the agricultural year 2005-06, no groundwater was applied at stage IV (late crop growth stage) during rabi, 2005 and summer, 2006. Some of the water coefficients which were negative turned out to be insignificant statistically and hence, these were dropped from further analysis. The functions fitted quite well in most of the cases as suggested by the F-statistics (Tables 7.3 through 7.12). Those crops for which the results turned out to be inconsistent were not considered for the analysis. Further, the adjusted R^2 value and significance values of the independent variables suggested that the form of the fitted function satisfactorily explained large variation in output by the selected inputs in respect of the major crops. Incidentally, these were also the crops accounting for the maximum groundwater withdrawal.

In castor crop, water applied during crop growth stage I (crop development stage) was significant in all the years. Incidentally, during the year 2005-06 water coefficient applied to the crop during all the four crop growth stages were significant at 5% level.

In fennel crop none of the water coefficients at any of the crop growth stages in the three years turned out to be significant. Cumin was not sown in the year 2003-04. While the crop was sown in the two years 2004-05 and 2005-06, its water coefficients were not significant in any crop growth stage. Summer pearl millet was sown only during the year 2005-06 as enough groundwater was available to sow the crop during summer season. Higher rainfall resulted into higher groundwater recharge and therefore, availability of groundwater during summer 2006. In this crop, water coefficient was significant in crop growth stages II and III, while no groundwater was applied during crop growth stage IV (late stage).

7.5.4 Marginal productivity of groundwater use among crops

The marginal physical product of water applied at different crop growth stages was examined with a view to draw implications for groundwater redistribution in different crops. The marginal physical product of water applied at different stages of crop growth was computed at the mean level of other input use. In semi-arid watershed under study, where groundwater is the only source of crop production in rabi and summer seasons and supplementary irrigation source in kharif season, marginal productivity of water can be useful indicator of its potential use and therefore, a decision variable regarding groundwater application in the relevant crop - inter season as well as intra season. For the analysis, the marginal physical products were computed for only two years 20045-05 and 2005-06 as the water coefficients for the year 2003-04 were found inconsistent.

Inter season

The marginal physical product in cotton crop (2004-05) ranged from 0.03 to 1.00 at different crop growth stages in different seasons. The higher marginal productivities in development (1.00 in stage II) crop growth stage as compared to other stage indicated that an additional application of 1 m^3 of water yielded more output in the crop development stage (1.00 kg) as compared to the output in other stages of crop growth (Table 7.17). Any further groundwater application in the crop growth stage II is, therefore, justified rather that its use in crop growth stages I, III, IV. Similarly, in castor, the marginal productivity of water varied from 0.03 to 1.00. The marginal productivity in stages I and II worked out to be higher than the marginal productivity at crop growth stages III and IV. In cumin, similarly, the marginal productivities ranged between 0.67 to 1.00 in the year 2005-06. The marginal productivity of water in summer pearl millet ranged from 0.17 to 0.56.

The higher marginal productivity of water in crops like castor and even summer pearl millet make them stronger candidate for application of groundwater. This has serious implications for the groundwater use in the watershed. The cotton based cropping systems were found to extract maximum groundwater with an implication for water saving, particularly groundwater. Cotton is long duration, high water requiring crop. This makes it a weak contender for groundwater from resource sustainability view point. This crop need partial replacement by other crops with higher marginal productivity of water in the cropping system being practiced in the watershed such as castor and summer pearl millet. In addition, cumin is highly remunerative crop and castor is at par with cotton in terms of remuneration. Among these crops, castor is better recommended as replacement of cotton. Firstly, castor occupies less time in field as compared to cotton, and therefore, leaves scope for sowing another crop till the time of cotton harvest. Secondly, its lower water requirement and disease free nature make it survive as good as cotton with water saving. This again has implications for groundwater use in the watershed in terms of its sustainability.

Intra season

With a crop season, the water productivity at different crop growth stages, similarly, could be an indicator for groundwater application with further implications on saving groundwater use particularly during rabi and summer season. In cotton, though groundwater is used as supplemental irrigation during kharif season, yet groundwater is the only source beyond kharif season as this is a long duration crop. The water productivity during stage II (crop development stage) is high. Therefore, groundwater application at stage II is preferred over other crop growth stages in situation of scarce water availability. If cotton is a preference with farmers, application of groundwater in crop development stage alone makes sense. Any additional application of groundwater in growth stage III and IV should be made cautiously.

In castor crop, water productivities in all crop growth stages except for crop growth stage IV is high. During the year 2004-05, water productivity was higher in crop growth stages I and II, the productivity was high in crop growth stages I, II and also somewhat in III during the year 2005-06. It can be inferred that any application of groundwater in these stages make sense and application of groundwater, if any, in stages III and IV should only be decided, in terms of crop stress conditions, cautiously. Similarly, in cumin, crop growth stage III (water productivity 1.00), in wheat crop growth stage I (water productivity 0.57) and in summer pearl millet, crop growth stage II (water productivities 0.56) are the crop growth stages, where groundwater application make sense. In general, the implications for groundwater use warrant that in a situation of groundwater scarcity, such as situation of drought, groundwater application at different crop growth stages in the study area would be governed by higher marginal productivity of water. A rational application of water such as this (crop growth stages I and II in most crops) could ensure groundwater sustainability. In a high rainfall - high groundwater availability situation, application of groundwater in crop growth stage III might be considered judiciously, observing the water stress conditions.

7.5.5 Marginal value product and output elasticity of water

Marginal value products of water were computed considering the local farm harvest prices prevailing in the area. During the *kharif* season, cotton had inelastic output elasticity of water in stages I, III and IV (0.03, 0.05 and 0.007), with marginal value product of water ranging from 0.50 to 1.80 Rs./m^3 to (Table 7.19). However, during crop growth stage II, not only the output elasticity was quite elastic but also the marginal value product of water being high (16.00 Rs./m^3), which implied that use of groundwater as supplementary irrigation in development stage of crop growth is, the output elasticity of water restricts further scope of water.

In case of castor, which had equally high marginal value product of water (2.40 to 15.00 Rs./m^3), the output elasticity varied from 0.02 to 0.43. Thus, while taking decision about the allocation of groundwater, the castor crop must get priority over the cotton crop. However, caution should be exercised to avoid excess application of groundwater. The *rabi* crops exhibited similar trend. Fennel realized inelastic output elasticity of water (0.13 to 0.24) and had marginal value product of water (3.96 Rs./m^3 to 7.50 Rs./m^3). In case of cumin, the crop had high marginal value product in crop growth stage III (40.00 Rs./m^3), the water output elasticity worked out to be 0.05 during the agricultural year 2005-06. Further application of groundwater at the crop development is economically justified. In wheat and summer pearl millet, not only the output elasticity was inelastic but marginal value of water use was also comparatively low.

In general the fennel and cumin crops realized higher marginal value of groundwater. The higher local harvest prices realized by rabi crops in addition to the high productivity obtained with groundwater use explained the higher marginal value of water. During the previous four successive drought years up to 2002, the rabi crop failed for want of water use. The availability of groundwater subsequently enhanced the use of other inputs, resulting into higher productivity, particularly in castor. This trend was quite visible during 2004-05 and 2005-06, when groundwater availability as well as its application was higher as compared to the year 2003-04 as evident from increase in number of irrigations in the former two years as compared to the latter year (Table 7.2).

In competition with other crops like castor and cumin, cotton, which is a long duration crop and require high amount of water loses out as castor and cumin crops have comparatively higher marginal value of water and low water consumption. More area under castor and cumin cultivation is, therefore, desirable from resource sustainability viewpoint. This trend was visible in the area as castor cultivation under irrigated conditions increased from 9 ha (2003-04) to 23 ha (2004-05) and 18 ha (2005-06) during the study period. Similarly area under cumin crop increased from 10 ha in 2004-05 to 15 ha in 2005-06. This trend is welcome and should be encouraged further in the watershed.

7.6 CONCLUSIONS

The marginal productivity approach was used to examine inter- and intra-season marginal value of groundwater use in the semi-arid watershed, Antisar. Water has different productivity in different crops over different seasons as well as at different crop growth stages in a given crop because of different level of water use and use of other relevant inputs.

The *kharif* crop cotton realized marginal water values, ranging from 1.76 Rs./m^3 to 16 Rs./m^3 in cotton. The marginal water values in castor were at par, rather slightly higher (2.40 Rs./m^3 to 150 Rs./m^3). Among *rabi* crops, cumin fared better than wheat and summer pearl millet crops. The marginal values of water in cumin varied from 26.8 to 40.0 Rs./m^3 and in summer pearl millet from 1.02 to 3.36 Rs./m^3 at different crop growth stages in different seasons.

This framework can be used to suggest inter crop and the intra crop redistribution of the groundwater with implication for groundwater saving. This analysis along with the analysis done in the previous section can be summarized as under,

a) The marginal productivity of water revealed castor as against cotton to be a better competitor for groundwater use.

b) The strong relationship between cropping systems practiced in tube well command and the marginal productivity of water use in crops clearly make a strong case of gradually shifting area under crop like cotton to other remunerative crops like castor and cumin. In the later crops marginal water values indicated that groundwater use not only made economic sense and could effect substantial saving in groundwater use.

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Table. 7.1. *Crop growth stage duration (days) for production function analysis*

Crop growth stages						*Planting date*	*References*
Crop	*Initial*	*Crop development*	*Mid-season*	*Late*	*Total*		
Cotton	30	50	60	55	195	May-June	*http://www.fao.org/ag/agl/aglw/ cropwater/ cwinform.stm*
Maize	20	35	40	30	125	June-July	*http://www.fao.org/ag/agl/aglw/ cropwater/ cwinform.stm*
Cumin	10	30	60	30	130	Oct-Nov	*Discussion with farmers*
Castor	30	40	60	50	180	Oct-Nov	*Discussion with farmers*
Fennel	10	30	60	30	130	Oct-Nov	*Discussion with farmers*
Wheat	10	20	70	25	125	Nov-Dec	*Discussion with farmers*

Table 7.2. *Crop-wise irrigation details of farms in the study area.*

S.No	*Crop*	*Farms (Nos.)*	*Irrigation (Nos.)*	*Area irrigated by wells (ha)*
Agricultural year 2003-04				
1	Cotton	50	206	76.23
2	Fennel	9	72	7.76
3	Castor	9	49	6.46
4	Paddy	6	35	3.84
5	Sunflower	5	37	8.91
6	Other crops	23	108	10.46
		Total	556	113.66
Agricultural year 2004-05				
1	Cotton	66	382	103.87
2	Castor	23	203	29.84
3	Fennel	12	110	17.12
4	Wheat	12	82	17.35
5	Cumin	10	54	12.84
6	Paddy	6	36	9.02
7	Other crops	1	10	2.31
		Total	877	192.35
Agricultural year 2005-06				
1	Cotton	52	419	122
2	Fennel	39	339	48
3	Summer pearl millet	19	110	21.6
4	Castor	18	148	21
5	Cumin	15	81	17.1
6	Wheat	7	51	6.7
7	Summer sorghum	4	23	3.9
8	Paddy	2	7	2.5
9	Other crops	3	37	2.2
		Total	1215	245

Table 7.3. Summary results of Cobb-Douglas production function (ridge function), cotton 2003-04

Variables Entered/Removed [b]

Model	Variables Entered	Variables Removed	Method
1	W4, W1, Energy, W3, Labour, Input, W2, Land [a]	.	Enter

a All requested variables entered.
b Dependent Variable: Output

Model Summary [b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.912(a)	0.832	0.800	0.400

a Predictors: (Constant), W4, W1, Energy, W3, Labour, Input, W2, Land
b Dependent Variable: Output

ANOVA [b]

Model		Sum of Squares	df	Mean Square	F	p-level
1	Regression	32.740	8	4.092	25.540	1.33E-13
	Residual	6.569	41	0.160		
	Total	39.309	49			

a Predictors: (Constant), W4, W1, Energy, W3, Labour, Input, W2, Land
b Dependent Variable: Output

Ridge regression summary, lambda = 0.60
Coefficients

	BETA	St. Err. of BETA	B	St. Err. of B	t(41)	p-level
Intercept			3.529372	0.714758	4.937855	1.37E-05
AREA	0.17978	0.073807	0.197822	0.081214	2.435809	0.019292
HUMAN	0.12361	0.068257	0.094266	0.052053	1.810956	0.077479
INPUT	0.147739	0.072309	0.079199	0.038763	2.043169	0.047499
ENERGY	0.047684	0.065832	0.022099	0.03051	0.724333	0.472974
W1	0.164582	0.072243	0.181692	0.079754	2.278161	0.027997
W2	0.162359	0.073848	0.180468	0.082085	2.198543	0.033611
W3	0.092316	0.067747	0.067879	0.049814	1.362659	0.180428
W4	0.009786	0.056087	0.002270	0.013034	0.174483	0.862344

Collinearity Diagnostics[a]

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions								
				(Constant)	Land	Labour	Input	Energy	W1	W2	W3	W4
1	1	6.930	1.000	.00	.00	.00	.00	.00	.00	.00	.00	.00
	2	1.049	2.570	.00	.02	.00	.00	.00	.05	.00	.00	.00
	3	.958	2.689	.00	.02	.00	.00	.00	.05	.00	.00	.00
	4	.052	11.592	.00	.00	.00	.00	.00	.52	.00	.00	.32
	5	.005	38.252	.00	.01	.00	.71	.00	.02	.09	.03	.01
	6	.003	45.037	.03	.00	.04	.13	.01	.00	.31	.01	.03
	7	.001	69.175	.00	.03	.40	.08	.01	.01	.23	.33	.12
	8	.001	89.292	.09	.16	.52	.01	.03	.00	.35	.46	.03
	9	.000	194.053	.88	.76	.04	.07	.95	.36	.01	.16	.49

a. Dependent Variable: Output

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	6.2361	8.9875	7.3897	.76982	18
Residual	-.24465	.23515	.00000	.14168	18
Std. Predicted Value	-1.498	2.076	.000	1.000	18
Std. Residual	-1.256	1.208	.000	.728	18

a. Dependent Variable: Output

Table 7.4. Summary results of Cobb-Douglas production function, fennel 2003-04

Variables Entered/Removed [b]

Model	Variables Entered	Variables Removed	Method
1	W4, W1, Energy, W3, Labour, Input, W2 [a]	.	Enter

a Tolerance = 0.00 limits reached
b Dependent variable: Output

Model Summary [b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	0.986 [a]	0.976	0.811	0.27558	3.161

a Predictors: (Constant), W4, W1, Energy, W3, Labour, Input, W2
b Dependent Variable: Output

ANOVA [b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.137	7	0.448	5.902	0.307 [a]
	Residual	0.76	1	0.076		
	Total	3.213	8			

a Predictors: (Constant), W4, W1, Energy, W3, Labour, Input, W2
b Dependent Variable: Output

Coefficients [a]

Parameters	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	0.767	4.685		0.164	0.897		
Labour	2.113	1.696	1.986	1.246	1.246	0.009	107.528
Input	-0.467	1.290	-0.781	-0.362	-0.362	0.005	196.759
Energy	-0.808	0.888	-0.654	-0.909	-0.909	0.046	21.912
W1	-0.038	0.229	-0.191	-0.165	-0.165	0.181	57.068
W2	-0.104	0.659	-0.119	-0.167	-0.157	0.041	24.259
W3	1.505	1.462	1.517	1.029	1.029	0.011	91.888
W4	-0.570	0.529	-0.839	-0.1077	-1.077	0.039	25.682

a Dependent Variable: Output

Excluded variable [b]

Model		Beta In	Partial correlation	Collinearity startistics		
				Tolerance	VIF	Minimum tolerance
1	Land	-31.856 [a]	-1.000	2.33E-0.005	42938.595	2.33E-0.005

Collinearity Diagnostics[a]

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions							
				(Constant)	Labour	Input	Energy	W1	W2	W3	W4
1	1	7.659	1.000	.00	.00	.00	.00	.00	.00	.00	.00
	2	.311	4.962	.00	.00	.00	.00	.02	.00	.00	.00
	3	.019	19.940	.00	.00	.00	.00	.01	.00	.00	.00
	4	.007	33.188	.04	.00	.00	.00	.00	.00	.00	.02
	5	.002	55.620	.01	.00	.00	.00	.01	.10	.00	.09
	6	.001	77.702	.00	.02	.06	.02	.24	.00	.02	.02
	7	.000	227.356	.22	.07	.01	.88	.10	.37	.01	.06
	8	3.59E-005	462.140	.74	.91	.92	.10	.62	.53	.97	.81

a. Dependent Variable: Output

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	7.2437	9.1299	8.0775	.62625	9
Residual	-.12352	.15322	.00000	.09743	9
Std. Predicted Value	-1.331	1.681	.000	1.000	9
Std. Residual	-.448	.556	.000	.354	9

a. Dependent Variable: Output

Table 7.5. Summary results of Cobb-Douglas production function, cotton 2004-05

Variables Entered/Removed [b]

Model	Variables Entered	Variables Removed	Method
1	W4, W1, Energy, W3, Labour, Input, W2, Land [a]	.	Enter

a All requested variables entered
b Dependent variable: Output

Model Summary [b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	0.947 [a]	0.896	0.881	0.33847	1.575

a Predictors: (Constant), W4, W1, Energy, W3, Labour, Input, W2, Land
b Dependent Variable: Output

ANOVA [b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	56.230	8	7.029	61.352	0.000 [a]
	Residual	6.530	57	0.115		
	Total	62.760	65			

a Predictors: (Constant), W4, W1, Energy, W3, Labour, Input, W2, Land
b Dependent Variable: Output

Coefficients [a]

Parameters	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	2.54	11.175		0.227	0.270		
Land	2.692	1.293	2.009	2.08	0.042	0.002	510.642
Labour	0.324	0.245	0.269	1.323	0.191	0.044	22.580
Input	0.097	0.136	0.081	0.710	0.481	0.139	7.215
Energy	0.002	0.119	0.002	0.016	0.987	0.099	10.095
W1	0.028	0.086	0.028	0.321	0.749	0.238	4.205
W2	3.388	1.238	2.521	2.737	0.008	0.002	464.609
W3	0.047	0.079	0.064	0.593	0.555	0.159	6.306
W4	0.007	0.025	0.027	0.294	0.770	0.212	4.707

a Dependent Variable: Output

Collinearity Diagnostics[a]

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions								
				(Constant)	Land	Labour	Input	Energy	W1	W2	W3	W4
1	1	8.547	1.000	.00	.00	.00	.00	.00	.00	.00	.00	.00
	2	.303	5.310	.00	.00	.00	.00	.00	.00	.00	.00	.00
	3	.137	7.911	.00	.00	.00	.00	.00	.00	.00	.00	.26
	4	.005	40.799	.00	.00	.00	.03	.04	.06	.00	.64	.07
	5	.004	47.132	.00	.00	.00	.02	.04	.52	.00	.27	.29
	6	.002	68.082	.00	.00	.02	.69	.33	.00	.00	.00	.14
	7	.001	81.490	.00	.00	.28	.10	.53	.20	.00	.01	.21
	8	.001	114.065	.00	.03	.65	.12	.05	.17	.00	.08	.04
	9	6.36E-006	1159.410	.99	.97	.04	.03	.00	.04	1.00	.01	.00

a. Dependent Variable: Output

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	6.1862	10.3910	8.3609	.93009	66
Residual	-.80669	.69472	.00000	.31696	66
Std. Predicted Value	-2.338	2.183	.000	1.000	66
Std. Residual	-2.383	2.053	.000	.936	66

a. Dependent Variable: Output

Table 7.6. Summary results of Cobb-Douglas production function, fennel 2004-05

Variables Entered/Removed [b]

Model	Variables Entered	Variables Removed	Method
1	W4, W1, Energy, W3, Labour, Input, W2, Land [a]	.	Enter

a All requested variables entered
b Dependent variable: Output

Model Summary [b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	0.997 [a]	0.994	0.977	0.12065	1.843

a Predictors: (Constant), W4, W1, Energy, W3, Labour, Input, W2, Land
b Dependent Variable: Output

ANOVA [b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.785	8	0.848	58.262	0.003 [a]
	Residual	0.044	3	0.015		
	Total	6.828	11			

a Predictors: (Constant), W4, W1, Energy, W3, Labour, Input, W2, Land
b Dependent Variable: Output

Coefficients [a]

Parameters	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	3.852	4.126		0.934	0.419		
Land	0.205	0.735	0.191	0.280	0.798	0.005	219.97
Labour	0.819	0.460	0.724	1.782	0.173	0.013	77.466
Input	0.139	0.143	0.143	0.973	0.402	0.098	10.195
Energy	0.053	0.373	0.057	0.143	0.896	0.013	74.231
W1	-0.005	0.026	-0.013	-0.200	0.854	0.417	2.125
W2	-0.008	0.032	-0.023	-0.264	0.809	0.288	3.477
W3	-0.062	0.088	-0.065	-0.708	0.530	0.253	3.958
W4	-0.024	0.027	-0.085	-0.896	0.436	0.239	4.183

a Dependent Variable: Output

Collinearity Diagnostics [a]

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions								
				(Constant)	Land	Labour	Input	Energy	W1	W2	W3	W4
1	1	7.820	1.000	.00	.00	.00	.00	.00	.00	.00	.00	.00
	2	.905	2.939	.00	.00	.00	.00	.00	.00	.00	.00	.00
	3	.157	7.066	.00	.00	.00	.00	.00	.05	.01	.00	.20
	4	.076	10.116	.00	.00	.00	.00	.00	.38	.11	.00	.02
	5	.036	14.752	.00	.00	.00	.00	.00	.13	.34	.00	.11
	6	.003	48.155	.00	.00	.01	.10	.00	.00	.08	.53	.05
	7	.001	77.174	.01	.00	.03	.70	.01	.00	.22	.16	.02
	8	.001	106.263	.00	.01	.21	.00	.10	.15	.01	.19	.09
	9	4.45E-005	419.093	.99	.98	.75	.19	.89	.29	.23	.12	.52

a. Dependent Variable: Output

Residuals Statistics [a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	6.0331	8.9076	7.8791	.78537	12
Residual	-.09942	.12836	.00000	.06301	12
Std. Predicted Value	-2.350	1.310	.000	1.000	12
Std. Residual	-.824	1.064	.000	.522	12

a. Dependent Variable: Output

Table 7.7. Summary results of Cobb-Douglas production function, wheat 2004-05

Variables Entered/Removed [b]

Model	Variables Entered	Variables Removed	Method
1	W4, W1, Energy, W3, Labour, , Land W2, Input [a]	.	Enter

a All requested variables entered
b Dependent variable: Output

Model Summary [b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	0.991 [a]	0.982	0.935	0.18566	1.472

a Predictors: (Constant), W4, W1, Energy, W3, Labour, Input, W2, Land
b Dependent Variable: Output

ANOVA [b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	5.711	8	0.714	20.708	0.015 [a]
	Residual	0.103	3	0.034		
	Total	5.814	11			

a Predictors: (Constant), W4, W1, Energy, W3, Labour, Input, W2, Land
b Dependent Variable: Output

Coefficients [a]

Parameters	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	4.081	3.908		1.044	0.373		
Land	0.371	0.638	0.352	0.581	0.602	0.016	62.039
Labour	-0.386	0.347	-0.329	-1.111	0.348	0.068	14.754
Input	0.945	0.680	0.896	1.390	0.259	0.014	70.078
Energy	-0.187	0.330	-0.190	-0.565	0.611	0.052	19.075
W1	0.053	0.041	0.245	1.309	0.282	0.170	5.893
W2	0.019	0.036	0.053	0.531	0.632	0.585	1.709
W3	0.083	0.123	0.140	0.677	0.547	0.138	7.249
W4	0.020	0.028	0.092	0.715	0.526	0.355	2.819

a Dependent Variable: Output

Collinearity Diagnostics [a]

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions								
				(Constant)	Land	Labour	Input	Energy	W1	W2	W3	W4
1	1	7.314	1.000	.00	.00	.00	.00	.00	.00	.00	.00	.00
	2	.984	2.726	.00	.01	.00	.00	.00	.00	.00	.00	.01
	3	.376	4.410	.00	.00	.00	.00	.00	.10	.00	.00	.12
	4	.267	5.238	.00	.00	.00	.00	.00	.08	.03	.00	.22
	5	.051	11.957	.00	.00	.00	.00	.00	.06	.80	.00	.02
	6	.006	34.590	.00	.00	.00	.00	.00	.03	.10	.46	.07
	7	.001	81.203	.01	.03	.83	.00	.06	.02	.03	.06	.07
	8	.000	139.079	.14	.06	.06	.03	.81	.43	.03	.06	.20
	9	8.67E-005	290.440	.85	.88	.11	.97	.13	.27	.02	.41	.29

a. Dependent Variable: Output

Residuals Statistics [a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	7.1971	9.6960	8.1389	.72052	12
Residual	-.17103	.10213	.00000	.09696	12
Std. Predicted Value	-1.307	2.161	.000	1.000	12
Std. Residual	-.921	.550	.000	.522	12

a. Dependent Variable: Output

Table 7.8. Summary results of Cobb-Douglas production function, castor 2004-05

Variables Entered/Removed [b]

Model	Variables Entered	Variables Removed	Method
1	W4, W1, W3, Energy, Labour, , Land W2, Input [a]	.	Enter

a All requested variables entered
b Dependent variable: Output

Model Summary [b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	0.949 [a]	0.901	0.844	0.25198	2.461

a Predictors: (Constant), W4, W1, Energy, W3, Labour, Input, W2, Land
b Dependent Variable: Output

ANOVA [b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	8.075	8	1.009	15.898	0.000 [a]
	Residual	0.889	14	0.063		
	Total	8.964	22			

a Predictors: (Constant), W4, W1, Energy, W3, Labour, Input, W2, Land
b Dependent Variable: Output

Coefficients [a]

Parameters	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	5.194	2.587		2.008	0.064		
Land	0.747	0.482	0.676	1.549	0.144	0.037	26.912
Labour	-0.100	0.403	-0.102	-0.249	0.807	0.042	23.807
Input	-0.115	0.114	-0.141	-1.016	0.327	0.367	2.725
Energy	0.067	0.152	0.063	0.445	0.663	0.356	2.812
W1	0.138	0.049	0.343	2.845	0.013	0.487	2.055
W2	0.284	0.210	0.275	1.354	0.197	0.172	5.821
W3	0.022	0.044	0.057	0.511	0.617	0.579	1.726
W4	-0.019	0.028	-0.095	-0.681	0.507	0.363	2.752

a Dependent Variable: Output

Collinearity Diagnostics [a]

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions								
				(Constant)	Land	Labour	Input	Energy	W1	W2	W3	W4
1	1	7.512	1.000	.00	.00	.00	.00	.00	.00	.00	.00	.00
	2	1.174	2.530	.00	.02	.00	.00	.00	.00	.00	.00	.03
	3	.224	5.786	.00	.04	.00	.00	.00	.00	.00	.00	.49
	4	.055	11.684	.00	.00	.00	.00	.00	.31	.00	.16	.00
	5	.026	16.994	.00	.00	.00	.00	.00	.15	.01	.55	.06
	6	.006	36.442	.00	.01	.00	.84	.01	.43	.01	.10	.20
	7	.002	55.821	.00	.01	.07	.00	.63	.00	.04	.01	.02
	8	.001	93.063	.02	.00	.34	.07	.03	.08	.83	.02	.15
	9	.000	159.711	.98	.92	.59	.09	.33	.03	.11	.16	.05

a. Dependent Variable: Output

Residuals Statistics [a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	6.5576	8.4581	7.6179	.60585	23
Residual	-.35247	.37329	.00000	.20101	23
Std. Predicted Value	-1.750	1.387	.000	1.000	23
Std. Residual	-1.399	1.481	.000	.798	23

a Dependent Variable: Output

Table 7.9. Summary results of Cobb-Douglas production function, cotton 2005-06

Variables Entered/Removed [b]

Model	Variables Entered	Variables Removed	Method
1	W4, W1, W3, Energy, Labour, , Land W2, Input [a]	.	Enter

a All requested variables entered
b Dependent variable: Output

Model Summary [b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	0.978 [a]	0.956	0.947	0.20546	1.947

a Predictors: (Constant), W4, W1, Energy, W3, Labour, Input, W2, Land
b Dependent Variable: Output

ANOVA [b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	39.176	8	4.897	116.004	0.000 [a]
	Residual	1.815	43	0.042		
	Total	40.991	51			

a Predictors: (Constant), W4, W1, Energy, W3, Labour, Input, W2, Land
b Dependent Variable: Output

Coefficients [a]

Parameters	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	0.928	3.148		0.295	0.770		
Land	0.213	0.414	0.166	0.515	0.609	0.010	100.975
Labour	0.280	0.175	0.245	1.599	0.117	0.044	22.700
Input	0.158	0.103	0.139	1.543	0.130	0.128	7.834
Energy	0.212	0.249	0.193	0.852	0.399	0.020	49.850
W1	-0.013	0.080	-0.015	-0.162	0.872	0.125	8.007
W2	0.306	0.393	0.239	0.778	0.441	0.011	91.487
W3	0.037	0.053	0.039	0.698	0.489	0.329	3.043
W4	0.002	0.116	0.002	0.014	0.989	0.075	13.405

a Dependent Variable: Output

Collinearity Diagnostics [a]

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions								
				(Constant)	Land	Labour	Input	Energy	W1	W2	W3	W4
1	1	8.530	1.000	.00	.00	.00	.00	.00	.00	.00	.00	.00
	2	.452	4.346	.00	.01	.00	.00	.00	.00	.00	.00	.00
	3	.009	30.522	.00	.00	.00	.00	.00	.13	.00	.28	.00
	4	.005	42.411	.00	.00	.00	.02	.01	.03	.00	.29	.09
	5	.003	56.006	.00	.00	.01	.31	.00	.24	.00	.34	.01
	6	.001	89.720	.01	.01	.18	.61	.00	.14	.01	.02	.08
	7	.001	123.376	.03	.12	.81	.02	.01	.00	.02	.04	.02
	8	.000	215.799	.01	.06	.00	.02	.93	.00	.03	.03	.74
	9	3.81E-005	473.215	.95	.80	.00	.01	.06	.45	.95	.00	.05

a. Dependent Variable: Output

Residuals Statistics [a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	6.3963	9.8493	8.1634	.87644	52
Residual	-.40481	.55589	.00000	.18866	52
Std. Predicted Value	-2.016	1.924	.000	1.000	52
Std. Residual	-1.970	2.706	.000	.918	52

a Dependent Variable: Output

Table 7.10. Summary results of Cobb-Douglas production function, castor 2005-06

Variables Entered/Removed [b]

Model	Variables Entered	Variables Removed	Method
1	W4, W1, W3, Energy, Labour, , Land W2, Input [a]	.	Enter

a All requested variables entered
b Dependent variable: Output

Model Summary [b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	0.983 [a]	0.967	0.938	0.19472	3.058

a Predictors: (Constant), W4, W1, Energy, W3, Labour, Input, W2, Land
b Dependent Variable: Output

ANOVA [b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	10.075	8	1.259	33.213	0.000 [a]
	Residual	0.341	9	0.038		
	Total	10.416	17			

a Predictors: (Constant), W4, W1, Energy, W3, Labour, Input, W2, Land
b Dependent Variable: Output

Coefficients [a]

Parameters	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	3.027	2.199		3.650	0.005		
Land	1.353	0.400	0.921	3.383	0.008	0.049	20.336
Labour	0.243	0.245	0.184	0.993	0.347	0.106	9.427
Input	0.022	0.116	0.014	0.186	0.857	0.639	1.564
Energy	-0.519	0.388	-0.396	-1.337	0.214	0.042	24.070
W1	0.209	0.043	0.723	4.843	0.001	0.163	6.119
W2	0.371	0.136	-0.347	2.718	0.024	0.223	4.479
W3	0.435	0.174	0.383	2.505	0.034	0.156	6.417
W4	0.104	0.044	0.468	2.354	0.043	0.092	10.787

a Dependent Variable: Output

Collinearity Diagnostics[a]

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions								
				(Constant)	Land	Labour	Input	Energy	W1	W2	W3	W4
1	1	6.930	1.000	.00	.00	.00	.00	.00	.00	.00	.00	.00
	2	1.049	2.570	.00	.02	.00	.00	.00	.05	.00	.00	.00
	3	.958	2.689	.00	.02	.00	.00	.00	.05	.00	.00	.00
	4	.052	11.592	.00	.00	.00	.00	.00	.52	.00	.00	.32
	5	.005	38.252	.00	.01	.00	.71	.00	.02	.09	.03	.01
	6	.003	45.037	.03	.00	.04	.13	.01	.00	.31	.01	.03
	7	.001	69.175	.00	.03	.40	.08	.01	.01	.23	.33	.12
	8	.001	89.292	.09	.16	.52	.01	.03	.00	.35	.46	.03
	9	.000	194.053	.88	.76	.04	.07	.95	.36	.01	.16	.49

a. Dependent Variable: Output

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	6.2361	8.9875	7.3897	.76982	18
Residual	-.24465	.23515	.00000	.14168	18
Std. Predicted Value	-1.498	2.076	.000	1.000	18
Std. Residual	-1.256	1.208	.000	.728	18

a Dependent Variable: Output

Table 7.11. Summary results of Cobb-Douglas production function, fennel 2005-06

Variables Entered/Removed [b]

Model	Variables Entered	Variables Removed	Method
1	W4, W1, W3, Energy, Labour, , Land W2, Input [a]	.	Enter

a All requested variables entered
b Dependent variable: Output

Model Summary [b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	0.919 [a]	0.844	0.803	0.29562	1.798

a Predictors: (Constant), W4, W1, Energy, W3, Labour, Input, W2, Land
b Dependent Variable: Output

ANOVA [b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	14.196	8	1.774	20.305	0.000 [a]
	Residual	2.622	30	0.087		
	Total	16.818	38			

a Predictors: (Constant), W4, W1, Energy, W3, Labour, Input, W2, Land
b Dependent Variable: Output

Coefficients [a]

Parameters	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	3.100	1.829		1.695	0.100		
Land	0.414	0.314	0.323	1.319	0.197	0.087	11.509
Labour	0.588	0.273	0.522	2.157	0.039	0.089	11.278
Input	0.137	0.181	0.124	0.758	0.455	0.194	5.148
Energy	-0.339	0.367	-0.286	-0.926	0.362	0.054	18.387
W1	-0.007	0.042	-0.018	-0.177	0.860	0.494	2.025
W2	0.240	0.186	0.211	1.285	0.209	0.193	5.189
W3	0.125	0.160	0.122	0.779	0.442	0.212	4.706
W4	0.006	0.040	0.015	0.161	0.873	0.579	1.726

a Dependent Variable: Output

Collinearity Diagnostics[a]

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions								
				(Constant)	Land	Labour	Input	Energy	W1	W2	W3	W4
1	1	7.046	1.000	.00	.00	.00	.00	.00	.00	.00	.00	.00
	2	1.082	2.552	.00	.04	.00	.00	.00	.00	.00	.00	.25
	3	.832	2.910	.00	.05	.00	.00	.00	.00	.00	.00	.32
	4	.033	14.709	.00	.00	.00	.00	.00	.74	.00	.00	.26
	5	.004	42.741	.00	.01	.09	.04	.00	.02	.02	.21	.00
	6	.002	67.068	.03	.01	.12	.67	.02	.01	.07	.02	.00
	7	.001	80.831	.03	.06	.01	.21	.00	.07	.61	.39	.02
	8	.001	110.186	.66	.68	.55	.04	.00	.10	.22	.05	.00
	9	.000	163.220	.28	.16	.23	.04	.98	.05	.08	.34	.15

a. Dependent Variable: Output

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	6.0656	8.6997	7.2620	.61121	39
Residual	-.92522	.39289	.00000	.26267	39
Std. Predicted Value	-1.958	2.352	.000	1.000	39
Std. Residual	-3.130	1.329	.000	.889	39

a. Dependent Variable: Output

Table 7.12. Summary results of Cobb-Douglas production function, cumin 2005-06

Variables Entered/Removed [b]

Model	Variables Entered	Variables Removed	Method
1	W1, W3, Energy, Labour, , Land W2, Input [a]	.	Enter

a All requested variables entered
b Dependent variable: Output

Model Summary [b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	0.883 [a]	0.780	0.561	0.50507	0.599

a Predictors: (Constant), W1, Energy, W3, Labour, Input, W2, Land
b Dependent Variable: Output

ANOVA [b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.341	7	0.906	3.551	0.058 [a]
	Residual	1.786	7	0.255		
	Total	8.127	14			

a Predictors: (Constant), W1, Energy, W3, Labour, Input, W2, Land
b Dependent Variable: Output

Coefficients [a]

Parameters	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	5.937	5.629		1.055	0.327		
Land	1.069	0.942	0.841	1.135	0.294	0.057	17.496
Labour	-0.146	0.572	-0.129	-0.255	0.806	0.123	8.149
Input	0.299	0.513	0.285	0.582	0.579	0.131	70616
Energy	-0.594	0.779	-0.485	-0.762	0.471	0.078	12.879
W1	-0.494	0.458	-0.498	-1.079	0.316	0.147	6.784
W2	0.976	0.913	0.830	1.070	0.320	0.052	19.194
W3	0.052	0.087	0.137	0.594	0.572	0.592	1.689

a Dependent Variable: Output

Collinearity Diagnostics [a]

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions							
				(Constant)	Land	Labour	Input	Energy	W1	W2	W3
1	1	6.124	1.000	.00	.00	.00	.00	.00	.00	.00	.00
	2	1.129	2.329	.00	.03	.00	.00	.00	.00	.00	.14
	3	.735	2.886	.00	.02	.00	.00	.00	.00	.00	.47
	4	.007	29.876	.00	.01	.07	.08	.00	.08	.01	.00
	5	.003	48.884	.01	.00	.28	.33	.00	.09	.01	.09
	6	.001	69.427	.05	.09	.48	.00	.16	.39	.01	.04
	7	.000	111.548	.51	.54	.13	.02	.68	.01	.02	.21
	8	.000	152.221	.43	.31	.04	.57	.16	.43	.95	.04

a. Dependent Variable: Output

Residuals Statistics [a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	5.3873	7.8542	6.4417	.67302	15
Residual	-.46211	.59746	.00000	.35714	15
Std. Predicted Value	-1.567	2.099	.000	1.000	15
Std. Residual	-.915	1.183	.000	.707	15

a. Dependent Variable: Output

Table 7.13. Summary results of Cobb-Douglas production function, summer pearl millet 2005-06

Variables Entered/Removed [b]

Model	Variables Entered	Variables Removed	Method
1	W1, W3, Energy, Labour, , Land W2, Input [a]	.	Enter

a All requested variables entered
b Dependent variable: Output

Model Summary [b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	0.969 [a]	0.938	0.899	0.12629	1.761

a Predictors: (Constant), W1, Energy, W3, Labour, Input, W2, Land
b Dependent Variable: Output

ANOVA [b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.674	7	0.382	23.953	0.000 [a]
	Residual	0.175	11	0.016		
	Total	2.850	18			

a Predictors: (Constant), W1, Energy, W3, Labour, Input, W2, Land
b Dependent Variable: Output

Coefficients [a]

Parameters	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	3.927	3.038		1.293	0.223		
Land	0.043	0.574	0.043	0.076	0.941	0.017	57.525
Labour	-0.189	0.270	-0.206	-0.701	0.498	0.065	15.494
Input	1.278	0.647	1.321	1.977	0.074	0.013	79.733
Energy	-0.212	0.360	-0.194	-0.588	0.568	0.051	19.505
W1	0.067	0.123	0.071	0.541	0.599	0.321	3.116
W2	0.260	0.143	0.274	1.820	0.096	0.246	4.064
W3	0.127	0.034	0.750	3.678	0.004	0.135	7.424

a Dependent Variable: Output

Collinearity Diagnostics [a]

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions (Constant)	Land	Labour	Input	Energy	W1	W2	W3
1	1	6.925	1.000	.00	.00	.00	.00	.00	.00	.00	.00
	2	.982	2.656	.00	.02	.00	.00	.00	.00	.00	.00
	3	.090	8.758	.00	.00	.00	.00	.00	.00	.00	.14
	4	.001	70.676	.01	.00	.04	.00	.01	.22	.21	.00
	5	.001	76.269	.00	.00	.04	.00	.00	.43	.22	.03
	6	.000	136.025	.03	.09	.92	.01	.01	.17	.12	.02
	7	9.56E-005	269.156	.22	.06	.00	.04	.92	.08	.10	.45
	8	4.20E-005	405.851	.74	.83	.00	.94	.05	.10	.34	.36

a. Dependent Variable: Output

Residuals Statistics [a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	7.5196	9.1869	8.0549	.38545	19
Residual	-.16825	.19913	.00000	.09873	19
Std. Predicted Value	-1.389	2.937	.000	1.000	19
Std. Residual	-1.332	1.577	.000	.782	19

a. Dependent Variable: Output

Table 7.14. Summary results of translog production function, Cotton, 2003-04

Model Summary [b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.974 [a]	.950	.918	.25715	1.340

a Predictors: (Constant), I*W4, L^2, Labour, W3, A*W4, Energy, W1, Input, W2, E^2, W4^2, Land, H*W4, H^2, I^2, W3^2, W4, H*W3, W1^2
b Dependent Variable: Output

ANOVA [b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	37.328	19	1.965	29.710	0.000[a]
	Residual	1.984	30	.066		
	Total	39.312	49			

a Predictors: (Constant), I*W4, L^2, Labour, W3, A*W4, Energy, W1, Input, W2, E^2, W4^2, Land, H*W4, H^2, I^2, W3^2, W4, H*W3, W1^2
b Dependent Variable: Output

Coefficients [a]

Parameters	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	1.829	18.107		0.101	0.920
Land	1.214	0.608	1.103	1.996	0.055
Labour	-0.132	1.038	-0.173	-0.127	0.900
Input	0.104	0.386	0.194	0.269	0.790
Energy	0.126	0.146	0.272	0.862	0.395
W1	2.203	4.029	1.995	0.547	0.589
W2	0.046	0.352	0.042	0.131	0.896
W3	-0.528	0.766	-0.717	-0.680	0.502
W4	-0.058	0.331	-0.248	-0.174	0.863
$Land^2$	0.113	0.300	0.124	0.376	0.710
$Labour^2$	-0.076	0.079	-1.027	-0.965	0.342
$Input^2$	-0.005	0.030	-0.126	-0.161	0.874
$Energy^2$	-0.020	0.019	-0.500	-1.050	0.302
$W1^2$	-0.169	0.258	-2.449	-0.656	0.517
$W3^2$	-0.002	0.080	-0.038	-0.022	0.982
$W4^2$	-0.008	0.016	-0.285	-0.529	0.601
Area*W4	-0.016	0.088	-0.076	-0.180	0.859
Labour*W3	0.131	0.193	2.048	0.677	0.503
Labour*W4	0.004	0.048	0.105	0.088	0.931
Input*W4	0.017	0.026	0.569	0.640	0.527

a Dependent Variable: Output

Table 7.15. Summary results of translog production function, Cotton, 2005-06

Model Summary [b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.983[a]	.967	.951	.19876	1.888

a Predictors: (Constant), I*W4, W1, W3, L^2, W4, Labour, Land, Energy, W2^2, W4^4, W3^3, W1^2, Input, I^2, H^2, I*W3, E^2
b Dependent Variable: Output

ANOVA [b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	39.648	17	2.332	59.038	0.000[a]
	Residual	1.343	34	.040		
	Total	40.991	51			

a Predictors: (Constant), I*W4, W1, W3, L^2, W4, Labour, Land, Energy, W2^2, W4^4, W3^3, W1^2, Input, I^2, H^2, I*W3, E^2
b Dependent Variable: Output

Coefficients [a]

Parameters	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	4.492	8.351		0.538	0.594
Land	0.682	0.614	0.532	1.111	0.274
Labour	0.945	1.283	0.825	0.737	0.466
Input	-1.248	1.190	-1.092	-1.048	0.302
Energy	1.110	2.427	1.009	0.457	0.650
W1	-0.207	0.593	-0.235	-0.350	0.729
W3	-0.787	0.617	-0.833	-1.275	0.211
W4	0.413	1.094	0.418	0.377	0.708
Land^2	-0.098	0.256	-0.119	-0.385	0.703
Labour^2	-0.066	0.115	-0.676	-0.570	0.572
Input^2	-0.216	0.130	-2.465	-1.659	0.106
Energy^2	-0.069	0.167	-0.936	-0.412	0.683
W1^2	0.017	0.045	0.278	0.387	0.701
W2^2	0.012	0.032	0.168	0.381	0.705
W3^2	-0.061	0.072	-0.916	-0.850	0.401
W4^2	-0.120	0.075	-2.058	-1.604	0.118
Input*W3	0.273	0.184	3.353	1.485	0.147
Input*W4	0.250	0.163	3.266	1.537	0.134

a Dependent Variable: Output

Table 7.16. Diagnostics test for autocorrelation

Crop	Durbin-watson 'd' statistics	d_L		d_U		4 -d_L		4 –d_U		Criteria	Remarks
		5% level	1% level	5% level	1% level	5% level	1% level	5% level	1% level		
Castor 2005-06	3.058	0.407	0.282	2.667	2.467	3.593	3.718	1.333	1.533	$4\text{-}d_U \leq d \leq 4\text{-}d_L$	No decision about autocorrelation
Cotton 2004-05	1.575	1.336	1.186	1.882	1.72	2.664	2.814	2.118	2.28	$d_L \leq d \leq d_U$	No decision about autocorrelation
Fennel 2005-06	1.798	1.047	0.878	2.007	1.807	2.953	3.122	1.993	2.193	$d_L \leq d \leq d_U$	No dccision about autocorrelation
Summer pearl millet 2005-06	1.761	0.549	0.396	2.396	2.169	3.451	3.604	1.604	1.831	$d_L \leq d \leq d_U$	No decision about autocorrelation
Cumin 2005-06	0.599	0.343	0.226	2.727	2.53	3.657	3.774	1.273	1.47	$d_L \leq d \leq d_U$	No decision about autocorrelation
Fennel 2004-05	1.843	0.171	0.105	3.149	3.053	3.829	3.895	0.851	0.947	$d_L \leq d \leq d_U$	No decision about autocorrelation
Wheat 2004-05	1.472	0.171	0.105	3.149	3.053	3.829	3.895	0.851	0.947	$d_L \leq d \leq d_U$	No decision about autocorrelation
Cotton 203-04	1.252	1.201	1.039	1.93	1.748	2.799	2.961	2.07	2.252	$d_L \leq d \leq d_U$	No decision about autocorrelation

d_L, d_U = Lower and upper table values of Durbin-Watson 'd' statistics

Table 7.17. *Regression summary of water used at different stages of crop growth in the production function*

S. No.	*Crop*	*Constant*	*Variables*								*Adj. R^2*	*N*
			Ln (Land)	*Ln (Human Labour)*	*Ln (Input)*	*Ln (Energy)*	*Ln (W1)*	*Ln (W2)*	*Ln (W3)*	*Ln (W4)*		
1	**Agricultural year 2003-04**											
a)	Cotton	3009.59	1.342*	0.074	0.089	-0.025	-0.398	-0.083	-0.043	0.016	0.93	50
b)	Fennel	2.405	++	2.113	-467	-0.808	-0.038	-0.104	1.505	-0.570	0.81	9
2	**Agricultural year 2004-05**											
a)	Cotton	18.289*	2.692*	0.324	0.097	0.002	0.028	3.388*	0.047	0.007	0.88	66
b)	Castor	379.31**	0.747***	-0.100	-0.115	0.067	0.138*	0.284	0.022	-0.019	0.84	23
c)	Fennel	81.880	0.205	0.919	0.139	0.053	-0.005	-0.008	-0.062	-0.024	0.98	12
e)	Wheat	106.530	0.371	-0.386	0.945	-0.187	0.053	0.019	0.083	0.020	0.93	12
3	**Agricultural year 2005-06**											
a)	Cotton	2.891	0.213	0.280***	0.158***	0.212	-0.013	0.306	0.037	0.002*	0.95	52
b)	Castor	33.296	1.353*	0.243	0.022	-0.519	0.209*	0.371*	0.435*	0.104*	0.94	18
c)	Fennel	34.712**	0.414	0.588*	0.137	-0.339	-0.007	0.240	0.125	0.006	0.80	39
d)	Cumin	854.84	1.069	-0.146	0.299	-0.594	-0.494	0.976	0.052	#	0.59	15
e)	Summer pearl millet	88.708	0.043	-0.189	1.278**	-0.212	0.067	0.260**	0.127*	#	0.90	19

* *Significant at 5% level,* ** *Significant at 10% level,* *** *Significant at 15% level*, # No groundwater applied
++ *Variables excluded from fitted function due to poor tolerance (2.33E-005),* N= Number of data sets.

Table 7.18. *Marginal productivity[a] of water at different stages of crop growth in the production function*

S. No.	Crop	Variables			
		W1	*W2*	*W3*	*W4*
1	**Agricultural year 2004-05**				
a)	Cotton	0.03	1.00	0.11	0.006
b)	Castor	0.33	0.52	0.03	++
c)	Wheat	0.57	0.14	0.17	0.09
2	**Agricultural year 2005-06**				
a)	Cotton	++	0.20	0.11	0.001
b)	Castor	0.92	1.00	0.56	0.16
c)	Fennel	++	0.25	0.13	0.01
d)	Cumin	++	0.67	1.00	**
e)	Summer pearl millet	0.17	0.56	0.32	**

a. At mean level of all other input use in the respective crops in the watershed

++ Not considered in final analysis due to inconsistent (negative) sign. These coefficient of the parameters were also non-significant.

** No groundwater applied

Table 7.19. *Crop and growth stage -wise output elasticity and marginal value product of water in agricultural production*

Crop	*Summer pearl millet*		*Cotton*		*Castor*		*Fennel*		*Cumin*		*Wheat*	
	Output elasticity (-)	*Marginal Value Product (Rs/m3)*	*Output elasticity (-)*	*Marginal Value Product (Rs/m3)*	*Output elasticity (-)*	*Marginal Value Product (Rs/m3)*	*Output elasticity (-)*	*Marginal Value Product (Rs/m3)*	*Output elasticity (-)*	*Marginal Value Product (Rs/m3)*	*Output elasticity (-)*	*Marginal Value Product (Rs/m3)*
Agricultural Year 2004-05												
Initial stage			0.03	0.50	0.14	4.95					0.05	4.56
Development stage			3.38	16.00	0.28	7.80					0.02	1.12
Mid stage			0.05	1.76	0.02	0.45					0.08	1.36
Late season			0.007	0.10	++	-					0.02	0.72
Agricultural Year 2005-06												
Initial stage	0.06	1.02	++	-	0.21	13.80	++	-	++	-		
Development stage	0.26	3.36	0.31	3.20	0.37	15.00	0.24	7.50	0.97	26.8		
Mid stage	0.13	1.92	0.03	1.76	0.43	8.40	0.13	3.90	0.05	40.00		
Late season	#	-	0.002	0.01	0.10	2.40	0.006	0.30	#	-		

Output prices (Rs./kg) for cumin, fennel, cotton, castor, wheat and summer pearl millet were considered as 40, 30, 16, 15, 8 and 6, respectively.

++ Not considered in final analysis due to inconsistent (negative) sign. These coefficient of the parameters were also non-significant.

No groundwater applied