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Determination of Soil Conservation Effects on Shadow Price of Soil Quality in Dry-Farmed Wheat in Iran (A Case Study)

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Abstract: This study attempts to measure the effects of soil conservation practices on soil quality in dry-farmed wheat in Iran(Zanjan province) using a bio-economic production function. Because of the nature of data(panel data) and information used in this study, error components approach (REM method) was used for estimating the production functions. The results indicate that the shadow price increases with soil depth and its magnitude is greater 72% in average - in conserved soils compared to non-conserved ones. In fact the results support the effectiveness of soil conservation in improving physical, chemical and biochemical properties of soil which contributes to sustainable agriculture. Finally, soil conservation benefits were estimated to be about 29.98 dollar pre hectare. That may be use for extension, payment of green subsidy, investment and adoption of new technologies for soil conservation. In this way, it will increase the real value of farm and farmer's welfare.

Key words: Soil conservation practices, biochemical properties, bio-economic production

INTRODUCTION

Soil is one of the most important factors in agricultural production. Its quality maintenance plays an important role in crop yield and sustainable development (Furtan and Hosseini, 1995; Hosseini *et al*., 2004). soil quality plays a role in six broad functions: food and fiber production, soil erosion, ground water quality, surface water quality, air quality and food quality (Karlen *et al*., 1997; Elwin *et al*., 2000; Ghorbani and Hosseini, 2006; Doran and Parkin, 1994; Parr *et al*., 1992; Warkentin, 1995; Elwin *et al*., 2000; Kennedy and Papendick, 1995).

Soil conservation is defined as the suitable measures taken to prevent the long-run soil productivity reduction. Soil conservation is a shift of extraction rates towards the future, while soil depletion or erosion is a shift of use rates towards the present (Hosseini *et al*., 2007; Van Kooten *et al*., 1990). Therefore, by decreasing erosion rate, soil conservation practices prevent the depletion of soil texture and contribute to its stability.

Population growth and increasing demand for food have exerted a high pressure on dry lands in Iran; even the dry lands with more than 20% slope have been allocated to the cultivation of cereals especially wheat. With an annual erosion of 33 tons per hectare (Refahi, 1999), the farmers incur a large amount of on-farm costs every year largely in the form of soil degradation and yield loss (Ghorbani, 2002). Using high yielding varieties, better management of weeds and fertilizer use, the farmers are able to compensate the adverse effects soil loss and to increase crop yield. Consequently, they ignore the on-farm effects of soil erosion or conservation and also the real value of soil quality, which affects the land value. However, advances in agricultural technology have been land complementary with topsoil depth rather than being a substitute for that (Walker and Young, 1986; Hosseini and Ghorbani, 2003). So, it is expected that if the real value of soil quality and the benefits from conservation practices get observable for the farmers, they would be greatly encouraged to invest in soil conservation technologies and soil erosion is not ignored any more.

Mechanical and non-mechanical methods are usually used to conserve the soil. The mechanical methods include practices such as bench terrace, diversion channel and constructing dams; non-mechanical methods include practices like appropriate use of land, suitable fertilizer application, improved tillage management (i.e., plowing abenefitst the slope and conservation tillage) and crop rotation (Refahi, 1999; Shiferaw *et al*., 2004; Ryan *et al*., 2003).

In Iranian rural area, the non-mechanical methods are often used for soil conservation, because these methods do not need plenty of investments and the only requirement is access to suitable equipment for contour plowing in steep lands (Ghorbani, 2002).

The study attempts to estimate the economic value of topsoil quality in dry land farms with and without conservation practices and then to determine the effect of

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non-mechanical conservation practices on the shadow price of soil quality in various depth of soil in dry land wheat farms.

MATERIALS AND METHODS

Determination of soil quality shadow value: An economic value for soil quality is obtained by integrating the Value of Marginal Product (VMP) curve for solum depth (obtained from production function) between zero and amount of solum depth in the field (Van Kooten *et al*., 1990). Set out this analytical methods let us assume that crop production function is:

$$Q_t = f(D_t, X_t) \quad (1)$$

Where:

Q_t = Output of wheat in period t
D_t = Soil depth
X_t = An index of variable inputs in period t

The value of the marginal product of solum depth is:

$$VMP_{D_t} = P.\frac{\partial Q_t}{\partial D_t} \quad (2)$$

Where, P is price of output.

Suppose s is a given solum depth. Then the value of s to the producer, say V_t, is found by integration:

$$V_t = \int_0^{s_t} VMP.ds_t \quad (3)$$

In Eq. 3, s_t measures the shadow value of soil quality in tth time.

Pattanayak and Mercer (1998) suggest that the difference in the shadow value of soil quality in farms with and without conservation practices (in same conditions) is, in fact, the benefits obtained by the farmers using conservation practices. So, if V_{1t} and V_{2t} denote the shadow value of soil quality in farms with and without conservation practices, respectively, then the benefits from conservation practices (B_t) can be written as follows:

$$G_t = V_{1t} - V_{2t} \quad (4)$$

Land is an asset to the farmer and its quality and health is one of the important criteria for determining its value. Therefore, investment in soil conservation, as a means of preventing its quality and health loss, should leads to an increase in the real value of land.

The study is done for the crop year 1998-1999 (Ghahremanzadeh, 2002). The sampling method is stratified random sampling in which wheat farms under study were first divided into two groups: farms with conservation and without conservation. Then 15 farms were sampled randomly in any group. Since, the soil was of varying quality in different farms and these differences (in elements percent at soil) are a sign of the effects of conservation on soil quality, they were taken into account in sampling. To this end, three square plots of 0.5 m by 0.5 m dimensions were set in any farm and apart from taking samples some factors as slope, soil depth and slope and plowing direction were recorded in them. Also the crop yield of the plots were measured after harvesting.

The soil samples were analyzed at soil labs of the Department of Soil Science of Tehran University and some qualitative characteristics like nitrogen, phosphorous, absorbable potassium, organic matter, field capacity moisture, wilting point moisture and soil texture were measured. The crop yields of the 90 plots were measured after harvesting.

Since soil erosion and conservation processes are of a dynamic nature, the analytical method used should consider such a nature. Hence the data including the variables of yield and soil elements of nitrogen, phosphorous, potassium, organic matter, field capacity moisture and topsoil depth were simulated for 4 years using the SCUAF.4 package (Young *et al*., 1998). Land slope and soil management was assumed to be constant during the simulation period.

Empirical model of soil quality shadow value: The Cobb-Douglass form was used for yield function. Other functional forms were also examined, but this form produced the best results both statistically and economically. Dry land crop yield (Q_{it}) in terms of kilogram per hectare was estimated as a function of soil depth (D_{it}) in centimeter, land slope (S_{it}) in percent, soil moisture (Fc_{it}) in percent, nitrogen (N_{it}), phosphorus (P_{it}) and potassium (K_{it}) content all in gram per a kilogram of soil.

$$\begin{aligned} LnQ_{it} = {} & LnA + \beta_D LnD_{it} + \\ & \beta_{FC} LnFc_{it} + \beta_{OM} LnOM_{it} + \\ & \beta_N LnN_{it} + \beta_P LnP_{it} \qquad t = 1,2,...,5 \\ & + \beta_K LnK_{it} + \beta_{SL} LnSL_{it} + \varepsilon_{it} \quad i = 1,2,...,90 \end{aligned} \quad (5)$$

Where, β_D, β_{FC}, ..., β_{SL} are parameters or the partial production elasticities of the respective inputs, A is a constant, ε_{it} is the disturbance term with E (ε_{it}, ε_{jt}) = σ_{ij}, E (ε_{it}, ε_{is}) = σ and E (ε_{it}, ε_{is}) = 0 and Ln denotes natural logarithm. This function was estimated once for farms with conservation and another time for farms without conservation.

Because of the nature of data used in the study (pooling time-series of cross-section data) to estimate the production function, one of the common methods of pooling data - the error components approach- was used along with the Random Effects Model (REM) (Baltagi, 1999). In the REM, the effects of time cross-section unit are treated as random (Hisao, 1986). Baltagi (1999) suggest that the Feasible Generalized Least Squares (FGLS) estimator for linear regression model is more efficient than other estimators for estimating REM. Therefore, we applied this estimator (FGLS) by the Eviews 3.0 package. Then the shadow value of soil quality was calculated for both groups of farms using the Eq. 2 and 3. Next, the benefits from soil conservation at farms with conservation was estimated through Eq. 4. The results will be discussed in the following section.

RESULTS AND DISCUSSION

The statistical properties of the sample are examined first considering the distribution of observation in various classes of soil depth and land slope. The distribution is shown at Table 1.

According to the Table 1, most of the wheat farming is practiced on less steep lands; 50% of the cultivated lands have a slope of 0-5%, 22.2% are of a 5-10% slope and only 2.1% have a slope greater than 20%. This situation decreases the rate of soil erosion and hence soil quality and leads to wheat yield loss.

Topsoil is one of the most important factors in production. The greater the topsoil depth, the more the space for root growth and the most of the observable nutrients and moisture and the better the soil quality. The distribution of the observation in the six groups of soil depth is shown at Table 2. It is seen that 56.7 and 26.7% of the farms have a topsoil depth between 10-15 and 15-10 cm, respectively. Only in 1.1% of the farms, the soil depth is greater than 25 cm.

In summary, the soil depth of most farms lies between 10 and 20 cm and this indicates the importance of soil conservation in the area.

The results of the estimation of dry land wheat yield function for the two groups are shown at Table 3. The calculated shadow value of soil quality and the benefits from soil quality and conservation practices in different depths are shown at Table 4.

As shown in Table 3, the variables of soil depth, moisture, phosphorous, organic matter content of soil all have a statistically significant positive effect on dry land wheat yield. The effect of slope and potassium content is not statistically significant. However, as expected, the land slope has a negative effect on the yield. Since the topsoil provides a suitable environment for plant root growth, its depth is key variable in crop yield and its effect is more than other factors, so that one percent increase in solum depth results 1.306 and 0.786% increase on yield of wheat in farms with and without conservation, respectively.

From Table 4, it is seen that the shadow value of soil quality is dry land wheat farms increases with solum depth. The figure for 5-10 cm depth in farms applying conservation practices is 22.7$ (181301 Rials) ha and increases with solum depth; it is 124.3$ in 25-30 deep which is about 5.5 as large as the previous figure. Likewise, the shadow value of soil quality in solum of 25-30 cm depth in farms without conservation is 59.6$,

Table 1: Statistical results of the distribution of wheat farms in various classes of land slope

Slope (%)	Wheat distribution (%)
5-0	50.0
10-5	22.2
15-10	16.7
20-15	8.9
20<	2.1

Table 2: Statistical results of the distribution of wheat farms in various classes of soil depth

Soil depth (cm)	Wheat distribution (%)
5-0	50.0
10-5	22.2
15-10	16.7
20-15	8.9
20<	2.1

Table 3: Estimated regression coefficient of the wheat production functions

	Farms with soil conservation		Farms without soil conservation	
Parameters	Coefficient	t-statistic	Coefficient	t-statistic
β_D	1.30600	15.0720*	0.7860	9.1610*
β_{SL}	-0.03400	-1.2450	-0.0071	-0.1760
β_{FC}	0.84610	6.1596*	0.3540	1.9670*
β_{OM}	0.06990	1.7947**	0.2670	4.7730*
β_P	0.35590	7.2790*	0.3210	3.5220*
β_K	-0.00149	-0.0246	-0.0659	-0.0887
Constant	-0.65000	-1.2620	2.3750	3.8660*
$\bar{R}^2$		0.5044		0.6240
DW		1.6600		1.8200

*: Significantly different from zero at 0.01 level, **: Significantly different from zero at 0.1 level

Table 4: Estimated shadow value of soil quality and soil conservation benefits

Soil depth (cm)	Shadow value of soil quality in wheat farms*: With soil conservation	Without soil conservation	Soil conservation benefits ($)
10-5	22.7	21.5	1.20
5-10	44.3	32.1	12.20
20-15	68.8	41.8	27.00
25-20	95.5	50.9	44.60
30-25	124.3	59.6	64.70
Average	71.1	41.1	29.94

*: Difference between shadow price of soil quality in two groups is significant at 0.05 level

about 2.8 times higher than solums of 5-10 cm depth. This indicates that first, in farms with conservation, the shadow value of soil quality increases more rapidly with soil depth compared to farms without conservation. Second, the average shadow value in farms with conservation in 72% higher than farms without conservation. In fact, this indicates the efficiency of soil conservation methods, which finally contribute to sustainability of agriculture by affecting soil quality in physical, chemical and biochemical dimensions. The benefits from soil conservation practices are shown in Table 4. It can be seen that the benefits increase with solum depth; the benefits from soil conservation in solum 25-30 cm deep is 54% higher that those in solum of 5-10 cm depth. This indicates the importance of solum depth soil conservation benefits. Finally, the average gain from conservation is 29.9$ ha. this is enough to encourage the extension, payment of green subsidy and investment in new conservation technologies. It can be concluded that implementing soil conservation practices would increase the real value of land and farmer's welfare.

Soil conservation is a phenomenon which occurs in any kind of soil management and completely preventing its occurrence is impossible. On the other hand, any soil conservation practices would results in the decrease of erosion rate and soil health, thereby decreasing erosion costs.

The effect of non-mechanical soil conservation practices is 72% higher than its alternative-without soil conservation practices. In other words, the conservation practices can play a very important role in reducing soil quality loss which is reflected in higher real value of agricultural land. So, the awareness of farmers of the importance of soil conservation and the associated benefits make a better environment for the adoption of and investment in conservation technologies. The results provide a good explanation for policy making, deriving and implementing new and advanced practices of soil conservation as at least extension of traditional practices and their adoption by farmers.

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