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Determinants and incentives for soil conservation on farms in Central Gujarat: An empirical study

V. C. Pande[1], R. S. Kurothe[1], H. B. Singh[2] and S. P. Tiwari[2]

[1]Central Soil and Water Conservation Research and Training Institute, Research Centre, Vasad 388 306 (Anand), Gujarat, India.
[2]Central Soil and Water Conservation Research and Training Institute, Research Centre, Datia (M.P.), Madhya Pradesh 475 661, India.

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The present study examined the effect of incentives in crop production and identified the determinants of incentives on farmers in Central Gujarat. The real domestic prices of the pearl millet, the major crop, moved in tandem with incentive component over time. But this incentive failed to provide push to the crop productivity of pearl millet during the period. The real domestic price of pearl millet declined during the period under study. The factors such as prevailing interest rate and rural road infrastructure significantly affected the total factor productivity in the crop. While easy loan facility by banks with accessibility to smallholder farmers could go a long way, access to local market could also be ensured with good connectivity of road particularly the smallholders farmers located closer to ravines.

Key words: Soil conservation, incentive, determinants.

INTRODUCTION

The extent of area under water erosion in India is 23.62 M ha (Maji et al., 2010). The urgency of a nation-wide policy for dealing with various problems relating to water erosion has been emphasized through the First Five Year Plan. During the Second Plan, a small beginning was made for the reclamation of ravines, and pilot projects were set up in Madhya Pradesh and Gujarat. Programmes for successive Five Year Plans further provided for the reclamation of ravine lands. These programmes achieved partial success and it was argued that the problem of land degradation in general and adoption of conservation practice in particular in ravine lands of Gujarat cannot be tackled in isolation and must find a place in the approach of holistic development of small and marginal farms (Pande et al., 2011; Bamire and Amujoyegbe, 2005). The small and marginal farms along the course of ravines are characterized by small holding size with multidirectional slope. These vulnerable holdings have little scope of consolidation; as a result the farming is mainly practiced as subsistence agriculture. Productivity growth on such farms could address the problem of poor profitability and low farm investment leading to a vicious circle of poverty as total factor productivity gains are closely tied to increases in retained profits (McGuckin, 1992).

Scholars have examined the issue of productivity

*Corresponding author. E-mail: vcpande_2000@yahoo.com,vcpande64@gmail.com,pandevc.64@rediffmail.com

growth and documented various factors directly and indirectly affecting its determinants in the context specific to the studies. At macro level, Government tax policies and investments on R&D, in addition to the regional factors, have been highlighted (Hsu et al., 2003; Thiele, 2002). Yet the regional disparities also warrant further investigations on other socio-economic and geographic characteristics of provincial agricultural production (Hsu et al., 2003). Furthermore, McMillan et al. (1987), Wen (1993), and Lin and Wen (1995) provided comprehensive reviews on the total factor productivity (TFP) growth in China's farm sector during the reform era. They contended that the rapid TFP growth partly contributed to the rural China's miracle growth in the early 1980's. In the Indian context, Chaudhary (2012) observed efficiency decline in half of the Indian states implying, thereby, huge potential for increase increase in production even with existing technology.

Using Johansen's cointegration procedure, Thiele (2002) estimated the long-run relationship between agricultural production, direct and indirect price incentives, and non-price factors, for ten selected SSA countries over the period 1965 to 1999. These studies, by and large, have drawn attention to the association of factor productivity and agrarian economic growth. Examination of factor productivity and its determinants, therefore, could reveal the policy options to enhance farm profitability on small farmer holdings. The present study is an effort to examine the farm productivity in general and incentives for adoption of soil conservation measures in particular through total factor productivity analysis of the major cropping system on smallholder farms in Mahi ravines. The factors determining farm productivity are also examined for policy implications. The conservation measures, on marginal, small and medium farms, included land leveling and earthen bund along field boundaries in the slopy land parcels done through initial state help. These farms usually had positive effect on crop production with part of net returns invested to buy better parcels of field away from ravine lands (Pande et al., 2011).

MATERIALS AND METHODS

Study area, sample size and data collection

About four hundred thousand hectares of land is under gully erosion in Gujarat, majority falling in central Gujarat region. The maximum gullied land falls in Baroda district, followed by Kheda district (Figure 1). Large portion (71.3%) of the land is in 0 to 5 t /ha/yr soil loss category (Kurothe et al., 1997). Further moderate to slight (5 to 10 t/ha/yr) erosion occurs in parts of Surat, Valsad, Bharuch, Panchmahal, Sabarkantha, Banaskantha, Kheda, Bhavnagar, Junagarh, Rajkot and Surendranagar districts in an area of 21690 km^2. Parts of the State under 10 to 15, 15 to 20 and 20 to 40 t/ha/yr classes are in Banaskantha, Kheda, Junagarh, Surendranagar, Rajkot and hilly areas of Panchmahal, Vadodara, Bharuch, Surat Valsad and the Dangs districts. This comprises 6.4% of the total geographical area. Only 0.3% of the area is subjected to very severe erosion due to high rainfall intensity and/or topography in Surendranagar (dry grassland) and Bharuch districts. Based on maximum area under ravine problem and soil erosion problem, therefore, central Gujarat was a natural choice for study. Since the largest gullied area of 61,888 ha is along the River Mahisagar (Sharma et al., 1981), the ravines of Mahisagar were selected for the study. Two districts, Vadodara and Anand were selected along the left and right bank of the Mahi River, where most of the ravine lands are spread (Figure 2). Five villages, two in Anand district and three, in Vadodara district were selected based on ravine area in the districts. A list of farms, comprising marginal, small and medium farm category, with lands adjacent to ravine lands was finalized and data on land use and crops, collected. Thus, a sample of 120 farms was selected for the analysis.

Structured questionnaire was used to collect specific information related to study from the field. Surveys were conducted during 2003 to 2004 through 2004 to 2005 to elicit primary information on soil conservation history, crop and cropping system adopted on the farms. The marginal farmers owned an average landholding of 0.6 ha, small and medium farms, an average holding size of 1.5 and 2.9 ha, respectively, among the farms with conservation history. The medium and large farms had 50% or more land under ravines; marginal and small holdings had only a small share of land under ravines. On the other hand, among the farms without conservation history, the marginal farmers owned an average landholding of 0.5 ha, while small and medium farmers had an average holding size of 1.3 and 2.8 ha, respectively. Bajra (*Pearl millet*) and Bajra-based cropping system was most prevalent across all the categories of farms. The secondary data on input and output of Pearl millet in respect of Vadodara district was collected from Government records since maximum gullied lands falls in this district. This data represented the Pearl millet production system of Mahi ravines (Appendix I).

Model used

The model used in this study captures the component of incentives in soil conservation through policy induced changes in total factor productivity and then decomposes the total factor productivity into productivity changes brought about by incentive and other residual factors.

The model formulation was done following Che et al. (2004) and McMillan et al. (1989) as under.

Let N represent total farmers and L represents total sown area. Further, let ε_n represent the level of effort of a typical farmer so that for N workers $\varepsilon_n N$ represent the effective contribution of labour to output measures in 'efficiency units'. The value of ε_n can be broadly interpreted to include everything that determines the quality of the farmer's labour as well as the willingness to internally exert more effort due to the enhanced incentives that accompany initial state assistance including market, credit, extension service if any. A typical farmer is expected to manage his land use in a way which increases the productivity of a given area. Let L represent total sown area and let ε_l capture the effort associated with land improvement. This may involve effort directed towards increasing the number of different crops or increasing the yield on a given land holding. Let $\varepsilon_l L$ represent the total input of land measures in efficiency units.

The technical constant return to scale production function[@] can be given as,

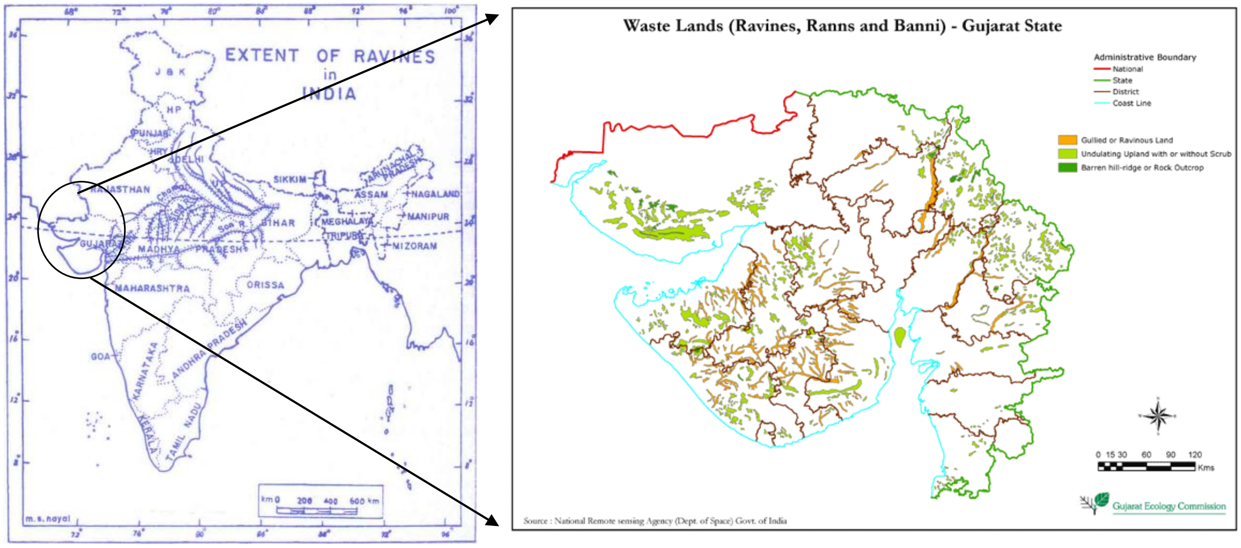

Figure 1. Gullied lands in Gujarat. Source: Dhruvanarayana (1993); Gujarat Ecology Commission.

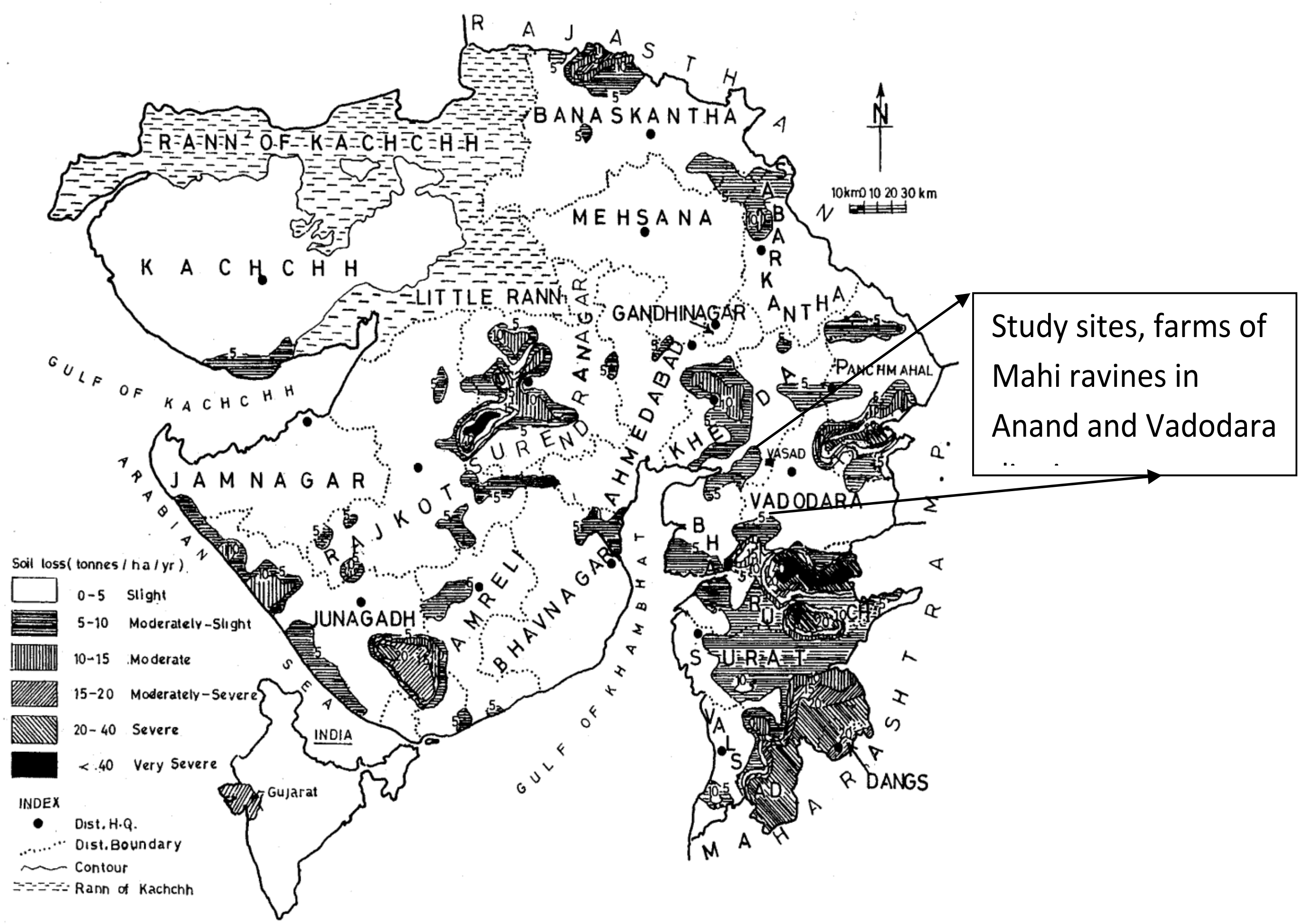

Figure 2. Soil erosion map of Gujarat. Adopted from Kurothe et al. (1997).

$$Q = \alpha_0 (\varepsilon_l L)^{\alpha_1} (\varepsilon_n N)^{\alpha_2} M^{\alpha_3} K^{\alpha_4} \quad (1)$$

Where
Q = total output
L, N, M, K = land, labour, material inputs and capital inputs, respectively
αi = Share parameters on factor inputs, i = 1,2, 3, 4

The production of a representative farmer can be given (in per capita terms) as,

$$q = \alpha_0 \varepsilon_n^{\alpha_1} (\varepsilon_l l)^{\alpha_2} m^{\alpha_3} k^{\alpha_4} = Q/N \quad (2)$$

where, q and l, m, k = output and land, material input and capital input per farmer.

Farmer's profit function

Farmer's income from agricultural production is given as,

$$y = p(q-d) \quad (3)$$

where,
p = price of agricultural output
q = output produced
d = fixed rent or lump-sum tax, the farmers pays to state.

Assuming the farmer chooses inputs in order to minimize costs, the total cost (TC) function is given by

$$TC = c_0 \sum_i x_i^{\alpha_i} Q \quad (4)$$

Where, α_i are the share parameters in the technical production, c_0 is a constant and x_i are input prices indexed across labour, land, material, inputs and capital.

Defining $X(x) = \sum_i x_i^{\alpha_i}$ as the average (real) factor price, cost of production is given as,

$$C = c_0 X(x) Q \quad (5)$$

Further, considering factor and product prices generally change at different rates, this can be captured as, $\beta = X(x)/p$ which is weighted cost share parameter or ratio of observed average factor to product prices.

Using Equations (3) and (5) and the definition of β, farmer's profit function (π), thus, becomes

$$\pi = p(q-d) - c_0 \beta(x) q$$

In other words,

$$\pi = p[q(1-c_0\beta) - d] \quad (6)$$

Further, in order to examine the relationship of incentive with farmer's behavior, utility function approach could be used.

Farmer's optimal behaviour and regional production function

Assuming the farmer receives utility from income but dislikes the effort of hard work and planning for more efficient use of land, including investment on farm. Following McMillan et al. (1989), his utility is given by the function,

$$U(\pi, \varepsilon_1, \varepsilon_2) = \pi - \frac{\varepsilon_n^z}{z\delta} - \frac{\varepsilon_l^z}{z\delta} \quad (7)$$

Where,
δ > 0 and z > 0 are constants, so that marginal dis-utility of effort increases with effort.
z = effort- disutility coefficient (Measures curvature of utility function) (assumed to be same across effort variable for land and labour).
z is analogous to coefficient of risk aversion and δ is taken such that the utility function is concave.

Substituting Equations (2) and (6) gives,

$$U(\pi, \varepsilon_1, \varepsilon_2) = p[\alpha_0 \varepsilon_n^{\alpha_1} \varepsilon_l^{\alpha_2} l^{\alpha_2} m^{\alpha_3} k^{\alpha_4} (1-c_0\beta) - d] - \frac{\varepsilon_n^z}{z\delta} - \frac{\varepsilon_l^z}{z\delta} \quad (8)$$

Farmer's optimal choice of effort levels can be obtained from this. The production function, as given in Equation (8) is maximized with respect to ε_n and ε_l. This implies that the optimal values for labour and land effort must satisfy

$$\varepsilon_n^* = (\delta p(1-c_0\beta)\alpha_0 l^{\alpha_2} m^{\alpha_3} k^{\alpha_4} \alpha_1^{(z-\alpha_2)/z} \alpha_2^{\alpha_2/z})^{1/\nu} \quad (9)$$

and

$$\varepsilon_l^* = (\delta p(1-c_0\beta)\alpha_0 l^{\alpha_2} m^{\alpha_3} k^{\alpha_4} \alpha_1^{(z-\alpha_1)/z} \alpha_2^{\alpha_1/z})^{1/\nu} \quad (10)$$

for $\nu = (z - \alpha_1 - \alpha_2)$.

Substituting Equations (9) and (10) into the per capita technical production function as given in Equation (2) and multiplying both sides by N, gives the following 'regional' production function,

$$Q = AN^{\gamma_1} L^{\gamma_2} M^{\gamma_3} K^{\gamma_4} \quad (11)$$

where the total factor productivity (TFP) coefficient A is given by

$$A = \alpha_0^{z/\nu} \delta p(1-c_0\beta)^{(\alpha_1+\alpha_2)/\nu} \alpha_1^{\alpha_1/\nu} \alpha_2^{\alpha_2/\nu} \quad (12)$$

and share parameters for labour land, material inputs and capital are,

$$\gamma_1 = (z\alpha_1 - \alpha_1 - \alpha_2)/\nu \quad (13)$$

$$\gamma_2 = z\alpha_2/\nu \quad (14)$$

$$\gamma_3 = z\alpha_3 / \nu \quad (15)$$

$$\gamma_4 = z\alpha_4 / \nu \quad (16)$$

Equation (11) may be called ‘regional’ production function to distinguish it from the ‘technical’ production function. While technical production function reflects technical relationship between inputs and outputs, Equation (11), in addition, also incorporates farmers’ response to institutional/ policy arrangements. The regional production function captures the farmer’s response to non-price factors and government policies, through changes in effective prices (p), average ratio of input to product prices (γ) and (z) which reflects farmer’s risk taking ability and is taken to be governed factors like credit availability and its cost to farmers, extension support etc.

Equation (12) was estimated using observable input and output data for Vadodara district in particular. Double-log regression model was used to regress total factor productivity on policy variables.

Factor productivity and incentives

Here, attempts were made to capture the component attributing to change in factor productivity and examine its effect on total factor productivity. The regional production function (Equation 12) is used to decompose TFP coefficient (A) into two components; the first component, attributable to incentive effects as captured in effort variables or

$$A_1 = \left[\beta p(1 - c_0\beta)\right]^{(\alpha_1+\alpha_2)/\nu} \quad (17)$$

and the unexplained residual

$$A_0 = \left(\delta^{\alpha_1+\alpha_2}\alpha_0^{z}\alpha_1^{\alpha_1}\alpha_2^{\alpha_2}\right)^{1/\nu} \quad (18)$$

Where $A_1 . A_0 = A$ and $\nu = (z - \alpha_1 - \alpha_2)$.

The unexplained residual reflects a host of other factors. While z, δ, α_1 and α_2 are known and assumed to be time invariant, α_0 will vary over time. Further, since the time path of A can be estimated as Solow residual and we have time series data for p and β, a time path for the incentive component of TFP or A1 can be estimated. Using this framework, Total Factor Productivity (12) and incentive components (17) and (18) were computed.

RESULTS AND DISCUSSION

Gujarat occupies third place in the country in terms of area and production of pearl millet. This is the major crop in the subsistence farming of this region. Incidentally, this is also the major cropping system of smallholder farmers in Mahi ravine area. So, examination of total factor productivity of this crop would not only reveal the productivity scenario but also the reasons of subsistence on these farms. For this, regional production function of this crop was fitted using statistics of Vadodara district and this was used to compute total factor productivity indices.

Adoption behaviour of soil conservation practices

Farms in general perceived occurrence of run-off and its effect on crop production; however, the individual efforts to adopt conservation measures were meagure. In fact, the majority of marginal, small and medium farmers (more than 60%) got it done initially through the state agency. Some of the farmers, however, later made some investment on maintenance. Further, the farms with conservation history invested on the maintenance of conservation measures, though a small amount; on earthen bunds (earthen field bund and levelling were reported to be the only conservation measures).

Regional production function, total factor productivity and incentive

The Regional production function was fitted with data on pearl millet input and output for Vadodara district. The production function fitted is as under,

$Y = 1.31\ N^{0.71} L^{0.80}\ M^{0.25}\ K^{-0.30}$ $\quad n = 17, R^2 = 0.60$
(1.62)(0.40)(0.71)(0.37)(0.36)

The fitted function was reasonably good and explained sizeable proportion of variation on crop production by the variables. This was used for further computation of incentive component using Equations (17) and (18).

The total factor productivity (TFP) calculated as Solow residual is presented in Tables 1 and 2. The total factor productivity indicated sharp fluctuations during the period with a cyclical pattern (Figure 3) peaking at a time lag of four years, the highest during the year 1997 to 1998. Weather partly explained the variation (Figure 4). The crop mainly grown as rainfed responded to the rainfall; the rise in factor productivity coincided with better rainfall with time lag of one year. The total factor productivity, however, did not change during the period of study. This is line with other observations of efficiency decline in majority of the Indian states (Chaudhary, 2012). This has serious implications for the farms of the region, in general and smallholder farmers in particular. In absence of factor productivity growth, these farms have failed to generate surplus from the agriculture as farm profitability has been quite low. Most of these smallholder farms are still practicing subsistence farming. Therefore, it was pertinent to examine the price and non-price incentives giving push to factor productivity on these farms. This was examined by computing the incentive component in the total factor productivity.

The index of incentive component (Index of A1) varied from 26% in 1988-1989 to 92% in 1994-1995 during the period of study (Table 3). Further, as a proportion of total

Table 1. Index of total factor productivity (1986-1987 = 100) for Pearl millet production in Mahi ravines.

Year	Total factor productivity
1986-1987	100.00
1987-1988	68.84
1988-1989	124.97
1989-1990	133.19
1990-1991	105.38
1991-1992	93.49
1992-1993	122.26
1993-1994	134.47
1994-1995	93.41
1995-1996	121.56
1996-1997	133.69
1997-1998	161.28
1998-1999	88.80
1999-2000	98.85
2000-2001	68.43
2001-2002	68.38

Table 2. Indices of output, input and TFP growth in pearl millet, Vadodara.

Year	Total output	Land	Labour	Material input	Capital	TFP growth
1986-1987	94.6	104.5	109.1	100.2	90.1	
1987-1988	75.3	111.2	120.5	100.5	121.4	-0.31
1988-1989	123.1	115.2	131.1	101.6	96.1	0.82
1989-1990	129.6	110.7	130.7	112.1	91.0	0.07
1990-1991	105.9	108.4	131.3	123.2	101.1	-0.21
1991-1992	95.2	101.7	130.2	122.1	106.1	-0.11
1992-1993	118.3	92.7	121.3	100.9	84.5	0.31
1993-1994	128.5	92.1	120.5	112.7	71.9	0.10
1994-1995	93.0	84.8	114.4	117.5	75.8	-0.31
1995-1996	118.8	100.6	139.7	140.7	101.2	0.30
1996-1997	127.4	87.6	125.5	123.6	98.2	0.10
1997-1998	152.7	102.2	155.7	185.5	101.4	0.21
1998-1999	87.6	71.9	112.8	135.4	62.0	-0.45
1999-2000	97.3	80.3	129.3	151.2	58.9	0.11
2000-2001	69.4	63.5	104.0	93.6	53.9	-0.31
2001-2002	69.4	63.5	106.7	93.6	61.3	-0.001

factor productivity (TFP), the incentive component varied from 21% during 1988-1989 to 98% during 1994-1995 reflecting remarkable contribution towards the growth in TFP. It is interesting, however, to observe the trend of real domestic price of pearl millet during the period. This was defined as the ratio of farm harvest price for pearl millet in Vadodara district and the consumer price index for agricultural labour. The role of this price indicator as incentives to farmers is positive as the real domestic price, which indicates purchasing power of a unit of farm produce, have moved in a similar trend as that of incentive component over time (Figure 1). This implies that the price indicator provided positive signal to farmers to continue with existing production system. However, as seen from the data (Figure 1), the real domestic prices of pearl millet, in fact, declined during this period. It can be argued that the observed fluctuations of TFP in Mahi ravines are partly explained by change in real domestic price of Pearl millet realized by the smallholder farmers. However, this incentive failed to provide push to the crop productivity of pearl millet during the period. Further, since change in total factor productivity (TFP) results

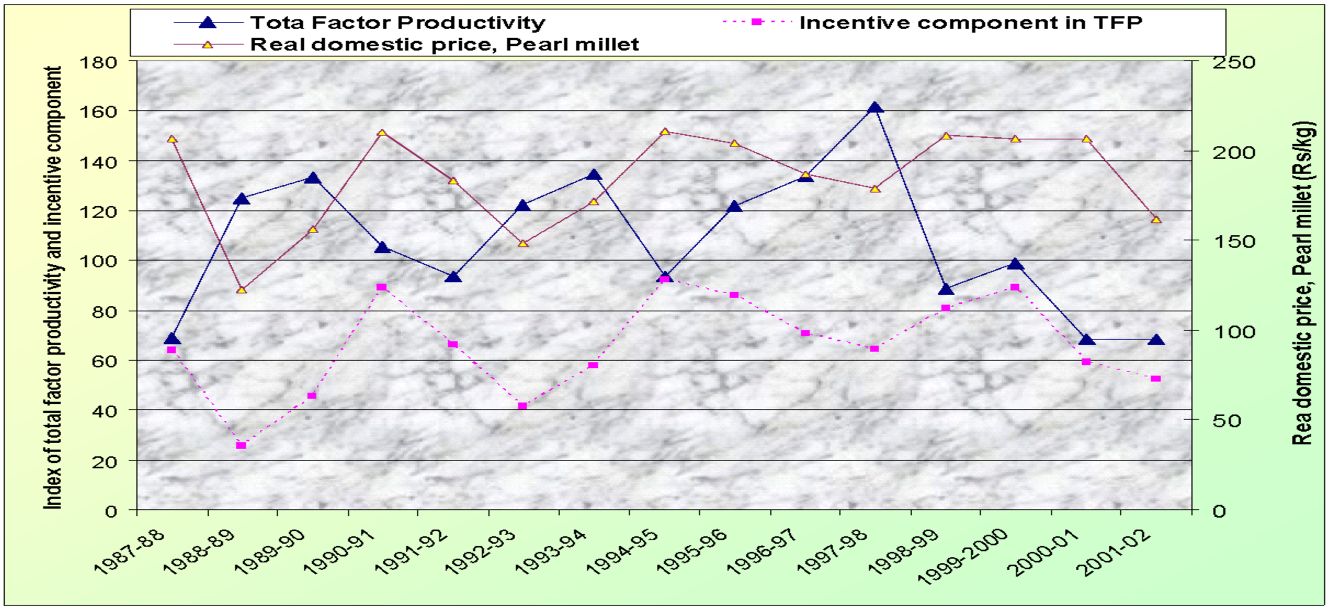

Figure 3. Indices of total factor productivity and real domestic price in Pearl millet production, Mahi ravines.

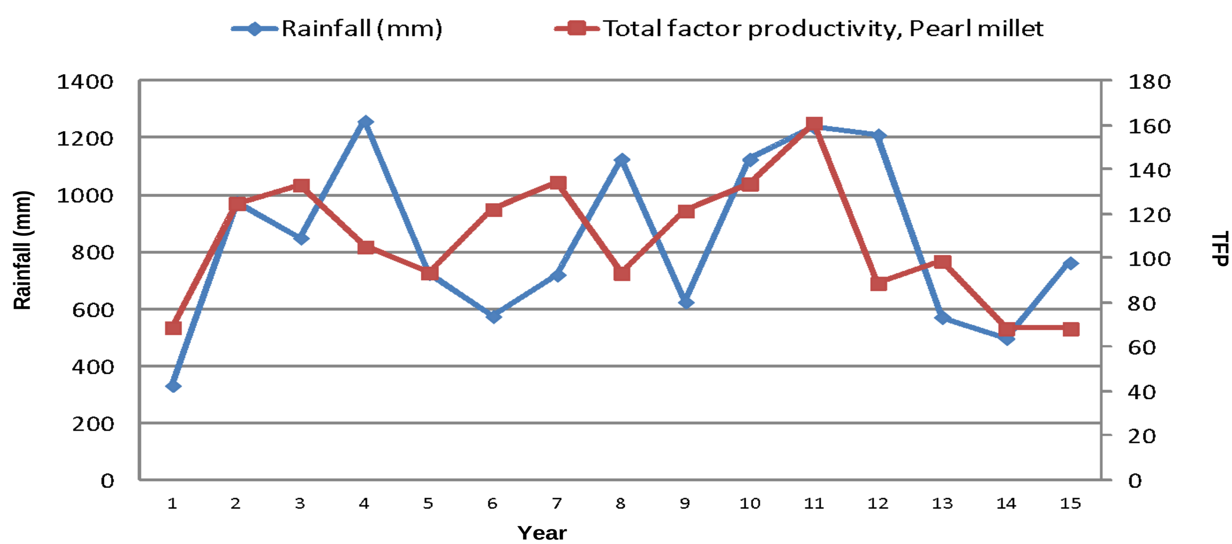

Figure 4. Total factor productivity indices (Pearl millet) and rainfall trend, Mahi ravines.

predominantly from public investment (or lack of it) in infrastructures (irrigation, electricity, roads) and in agricultural research and extension, and from efficient use of water and plant nutrients (Singh, 2002), it is imperative, therefore, to examine the determinants affecting the change in factor productivity.

Determinants of total factor productivity (Pearl millet)

Determinants of total factor productivity (TFP) were examined by regressing the TFP indices of different years with price and non-price factors. These included real price of pearl millet (Rs/ha), rate of interest (%) prevailing, rural road infrastructure in the district (km), rate of inflation (%). Other factors such as, tractors, gross irrigated area etc were omitted from regression as these were observed to be insignificant or absent on these subsistence farms. Extension service was reported by farmers surveyed to be absent in the villages, hence, this was also not considered. A brief description of the policy variable follows,

Table 3. Components of total factor productivity (TFP) in Pearl millet production in Mahi ravines, pooled analysis.

Year	1- c_0w	Average price (Rs/kg)	Index of A	Index of A1	Proportion of TFP explained by incentive effort (%)
1986-1987	0.96	223.80	100.00	100.00	
1987-1988	0.96	206.43	68.84	63.91	92.84
1988-1989	0.94	122.66	124.97	25.72	20.58
1989-1990	0.95	156.54	133.19	45.40	34.09
1990-1991	0.97	210.14	105.38	89.13	84.58
1991-1992	0.97	183.00	93.49	66.10	70.70
1992-1993	0.97	148.32	122.26	41.50	33.95
1993-1994	0.97	171.75	134.47	57.89	43.05
1994-1995	0.98	210.94	93.41	92.04	98.53
1995-1996	0.98	204.27	121.56	86.10	70.84
1996-1997	0.98	186.72	133.69	70.78	52.94
1997-1998	0.98	179.03	161.28	64.57	40.03
1998-1999	0.98	208.11	88.80	80.55	89.94
1999-2000	0.98	206.38	98.85	88.91	89.94
2000-2001	0.99	206.56	68.43	59.15	86.43
2001-2002	0.99	161.69	68.38	52.30	76.48

Real price of pearl millet: This reflects the real purchasing power of a rupee earned from this crop and is indirectly correlated with technical push that it provides to productivity growth. This is hypothesized to have positive correlation with TFP growth.

Rate of interest: This was hypothesized to affect farmers risk taking ability in agricultural production. A lower interest rate would prompt farmer to invest on land including soil and water conservation.

Rural road infrastructure: This is hypothesized to provide connectivity to market and thus would have a positive correlation with TFP growth.

Rate of inflation: This has been observed to have mixed relationship. If rise in prices is contemplated to be permanent, farmers tend to withhold decision to exploit land. On the other hand, if the output price rise is considered to be temporary, farmers exploit land to reap benefit. So, accordingly this has positive and/or negative correlation with TFP growth depending upon time horizon.

As expected, the results of the analysis revealed the coefficients of the independent variables to have the desired sign. Rate of interest (-0.691) and rural road infrastructure (0.721) turned out to be statistically significant; while the former was negatively correlated the latter variable was positively correlated with total factor productivity growth (Table 4). A high interest rate would adversely affect the risk taking behavior of the farmers, thereby adversely affecting the total factor productivity growth. Similarly, higher rural road infrastructure would enhance the productivity growth by connecting to the local market. The village surveyed in Mahi ravine area though had motorable roads but the connectivity of road and their maintenance was poor in remote villages closer to River Mahi Sagar. It can be inferred, therefore, that improving banking facilities with cheap loan to the farmers of this region would improve the productivity of the crop through investment on land and thereby, the profit on farm. The financial inclusion as policy support in this region (Pande et al., 2011) should be supported with easy and cheap loan availability. The road infrastructure in the remote villages could be further strengthened with regular maintenance to improve market connectivity. The villages situated close to ravine and away from the local markets were observed to be in poor shape during survey, warranting immediate attention of the policy makers. The share of incentive effort in TFP in the major crop (Pearl millet) of this region worked out to be substantial (21 to 98%) but this incentive failed to push the factor productivity as farmers could not generate sufficient surplus for investment on farm in general and expenditure on soil conservation in particular on the fields. In fact, the real domestic price of this crop declined during the period under study. The non-price determinants of TFP such as rate of interest and rural road infrastructure turned out to be statistically significant. While easy loan facility by banks with accessibility to smallholder farmers could go a long way, access to local market in the region could also be ensured with good connectivity of road. In fact, the poor road maintenance also turned out to be responsible for poor accessibility to nearest bank. It was revealed during the survey that visit

Table 4. Determinants of total factor productivity (TFP), Pearl millet.

Parameter	Coefficient	t- value
Real price of Pearl millet (Rs./ha)	0.391	1.87
Rate of interest (%)	-0.691*	-2.61
Rural road infrastructure (km)	0.721*	2.30
Rate of inflation (%)	-0.034	-0.37
N =	8	
Adjusted R^2 =	0.99	
F (4,4) =	183.35	
Durbin-Watson D Statistic	3.10	

***Significant at 10% level of significance.

of bank representative and extension personnel was a far cry as some of the interior villages had not seen them for a long time. An earlier study (Pande et al., 2011) also highlighted farmers' poor credit worthiness in the region which adversely affected their ability to take credit for farm investment. This fact in conjunction with adverse interest rate faced by these smallholder farmers makes strong case of easy loan terms along with financial inclusion of the government.

DISCUSSION

The problem of poor land productivity and adoption of conservation practice on smallholder farms have eluded the attention of policy makers, particularly in the marginal lands of ravines. The total factor productivity growth which encompasses the policy variable required to push the farm productivity further, therefore, need to be addressed. Studies have identified several factors addressing which would help adopt new technologies for enhancing crop productivity such as capital and labour constraint, social network, extension contacts (Abdulai and Huffman, 2014). While the factors affecting factor productivity have been examined at macro scale, the factors providing push to factor productivity at micro scale have drawn little attention of scholars. Identification of region specific factors responsible for pushing productivity growth could greatly eliminate the regional disparities in agricultural growth. This warrants assessing the incentive components in total factor productivity. The small farm holdings, particularly along the Mahi ravines, which hold little scope for land tenure security, are irregular in slope and size and, hence, need immediate investment for enhancing productivity. This evidence contrasts the findings elsewhere (Mugonola et al., 2013). Land ownership and security assures reward to cultivator for efforts in enhancing productivity. However, such scope on marginal lands in Mahi ravines does not exist for the reasons identified. While a favourable credit and infrastructure improvement would give a definite push, an initial government intervention to help improve land through soil and water conservation measure shall go a long way in improving the economic conditions of these farms. This is supported by evidence elsewhere also (Jara-Rojas et al., 2013; de Graaff et al., 2013). At country level, factors like government expenditure on infrastructure (Desai and Namboodir, 1997) have been identified to affect productivity. Similarly, improved rural markets have provided impetus to enhance productivity (Rosegrant and Evenson, 1995); such developments at micro level have not been identified by this study. In fact, rural roads- a proxy to rural market was observed to have affected the total factor productivity in this region. It is therefore strongly contended that these policy options should be strengthened to enhance the factor productivity growth. Hence, the central Gujarat region in general and Mahi ravine area in particular would be benefitted immensely.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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Notes

The literature on agricultural production functions is abound to support this (Hayami and Ruttan, 1985; Tang, 1980). The specification is also confirmed on cross-sectional data collected in the study.

APPENDIX I

Outputs and inputs for Pearl millet production, Vadodara district.

Year	Total output (Tonnes)	Land (ha)	Labour (person-days)	Material input (tonnes)	Capital (hp)
1986-1987	17600	18600	5309.70	197.38	3943.01
1987-1988	14000	19800	5861.37	197.98	5314.82
1988-1989	22900	20500	6378.29	200.09	4205.09
1989-1990	24100	19700	6362.00	220.79	3980.68
1990-1991	19700	19300	6388.25	242.67	4423.87
1991-1992	17700	18100	6333.84	240.59	4643.71
1992-1993	22000	16500	5903.67	198.67	3697.17
1993-1994	23900	16400	5861.52	222.09	3144.53
1994-1995	17300	15100	5566.73	231.36	3315.22
1995-1996	22100	17900	6798.27	277.07	4430.10
1996-1997	23700	15600	6107.85	243.43	4298.59
1997-1998	28400	18200	7578.47	365.45	4435.68
1998-1999	16300	12800	5489.45	266.63	2713.42
1999-2000	18100	14300	6293.45	297.88	2578.93
2000-2001	12900	11300	5060.96	184.326	2359.31
2001-2002	12900	11300	5191.48	184.32	2681.61