Management of Natural Resources in Sustainable Surface*

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1 Introduction

Since late nineteen, there has been ever increasing concern for adverse environmental impacts of intensive arable farming in varied land situations. Concerns like pollution of waters due to excess use of insecticides/pesticides, indiscriminate use of inorganic fertilizers and excessive irrigation under canal systems have attracted world wide attention in recent times. During the mid-sixties, the major goal of Indian agriculture was to increase food-grain production to cope up with the ever-increasing population. A composite strategy of introduction of high yielding varieties along with assured irrigation and fertilizers, and institutional support were provided to achieve quantum jump in agricultural production, which in turn provided additional employment in rural sector. A sizable investment has been made in creating assured irrigation facilities through major and medium irrigation projects with the target to increase food grain to a tune of 4 t/ha—5 t/ha in long term without causing any adverse effects on environment. Unfortunately, the introduction of canal irrigation resulted into development of soil salinity and shallow water-table in arid and semi-arid regions, which has serious negative impact on agricultural environment in the areas covered under canal irrigation systems. Despite massive invertment in creating canal irrigation systems, the present level of food grain production under canal command area is only around 1.7 t/ha (Satpate, 1988).

The basic principal of soil and water conservation is to use the land according to its capability and treat the land according to its Performance (Tideman, 1996). The production performance of a crop is directly guided by soil characteristics viz., soil depth, texture, slope, water-holding capacity, internal drainage, etc. Based on these criteria, land has been classified in eight categories called 'land capability classes'. The first four land capability classes are considered suitable for crop production. The remaining four land capabilities classes are considered fit for pasture, wood lots and wild-life use. The choice of crops and cropping patterns based on capabilities in order to produce higher returns per unit area with adequate provision of conserving the natural resource (Van wambeke and Rossiter, 1987). Under the irrigated conditions these land capabilities are called 'land irrigability classes'. Of late researchers and planners have laid much emphasis on 'Land Capability Classes' as such to achieve sustainability in agricultural production(Alagh, 1990). Therefore, what is urgently called for is an appropriate land use policy so that optimal use of land resources based on land capability or sustainability is taken care of (Khosoo and Deekshatulu, 1992). In the present analysis, an attempt has been made to document the crop production under different land irrigability classes and its impact on natural resources like soil and other causative factors in semi-arid region of Gujarat State, India.

2 Material and method

Gujarat State is having two major irrigation projects, viz., Ukai-Kakrapar and Mahi Right Bank Canal Command Irrigation Project. The Ukai-Kakrapar irrigation project is having four main canals called Ukai Left, Ukai Right, Kakrapar Left and Kakrapar Right. Ukai right and Kakrapar right bank canal command areas are located between Narmada and Tapi rivers. Mahi Canal Command area in *Gujarat* is located in port of Kaheda and Panchmahal districts. Three canal command areas represented by Ukai-Kakrapar Right Bank (UKRB), Kakrapar Left (KL) and Mahi Right Bank (MRB) have been selected for investigation. The study is based on the data collected from 400, 180 and 500 farmers distributed over 40,18 and 50 villages of UKRB, KL and MRB canal command areas, respectively during 1990—1991 and 1991—1992. A multistage stratified random sampling technique was used to select

* No Table 2—12.

ultimate respondents (farmers). The selected villages were classified according to Land Irrigability classes, as shown below:

Land irrigability class	No. of villages selected		
	UKR	KL	MRB
I	1	-	15
II	9	3	9
III	21	10	9
IV	7	5	5
V	2	-	12
Total	40	18	50

UKRB was covered predominately by four crops viz., rice, sugarcane, cotton and pigeonpea, while KL was dominated only by rice and sugarcane. In case of MRB, six crops viz., rice, wheat, bajra, (summer as well as kharif), groundnut (summer) and tobacco equally dominated the scene. All these crops occupied more than 90 per cent of the total cultivated tract in the respective canal command areas.

Simple tabular and production function approach were used for the present study. The Cobb-Douglas production function was estimated by using Ordinary Least Square (OLS) technique. The variables included in the production function were:

$$Y = f\,(X_{1,} X_{2,} X_{3,} X_{4,} X_{5,}\ X_6)$$

Where Y = Crop yield (q/ha).
X_1 = Land quality representing different irrigation classes (I to V)
X_2 = Soil quality representing extent of soil degradation level (1 = normal, 2 = marginal, 3= Moderate, 4 = Severe degradation).
X_3 = Expenditure of fertilizer and manure (Rs/ha).
X_4 = Hired labour (mandays/ha).
X_5 = Family labour (mandays/ha).
X_6 = Other expenses including seeds, irrigation charges, chemical, ploughing charges, etc. (Rs/ ha).

3 Results and discussion

3.1 Existing and suggested cropping pattern

The suggested cropping pattern in a canal command area is based on the classification of land in different categories. The existing cropping pattern reflected the choice of crops by the farmer. The recommended and existing cropping pattern in both command areas is shown in Table 1, which indicated high degree of divergence. More than 10 percent area has been under high water requiring crops, which is much higher than the recommended cropping pattern. The sugarcane and rice dominated due to their ability to fetch high economic returns (Nilkantha and Mitra, 1986).

The different land classes had different cropping patterns based primarily on soil-water-crop relationship. As the land irrigability classes differ, the choice of crops also differs. The suggested and actual cropping patterns under different land irrigability classes are given in Table 2. Under the suggested cropping based on soil-water relationship, the choice of crops becomes limited as the land irrigability class sequence increased Infect, the choice of crop and cropping intensity have become limited. The land irrigability class V is at all not suitable for irrigation. The high water requirement crops like sugarcane and rice were grown in all the classes of land, which was basically violation of scientific norms i.e., choice of crop and cro intensity based on soil-water-crop relationship. The land irrigability classes III and IV are suitable only for seasonal crops, whose water requirement is relatively lesser. The internal drainage of land irrigability class III and IV is poor to very poor. The introduction of high water requirement crops under such land, will result in accumulation of water in sub-soil strata causing rise of water table. The artificial drainages is required where internal drainage is poor (Benoit Lesafre, 1992). By adopting recommended cropping pattern, land has to be kept fallow for one to two seasons. Such remedies measures are not being taken at al at any place in canal command area under study. The land, which is not suitable for irrigation, has also been brought under irrigation. This has caused very adverse effect on plant-soil-water relationship.

3.2 Crops productivity under different land irrigability classes and soil degradation levels

The productivity in terms of output per ha of various crops under different canal commands showed decline in yields with increase in land irrigability class sequence (Table 3) simultaneously, land degradation also exhibited sharp increase with the increase in land irrigability class sequence. The maximum yield is obtained under normal soil condition of land irrigability class I and II which is very close to targeted yield of 4 t/ha—5 t/ha Under National Demonstrations as fixed by National Commission on Agriculture (Rolsert 1992). The National Demonstration is predominately held on ideal soil condition (i.e. land irrigability class II and I). The minimum yield is obtained in severely degraded soils of land irrigability class V. The required yields under land irrigability class II is obtained only by better and efficient management practices. The occurrence of moderate and severe degradation under land irrigability class II is due to natural land heterogeneity. The land irrigability classes III and IV indicated reduction in yield level as well as increase in soil degradation level. The average yield of crops under land irrigability classes III and IV is half of the average crop yield obtained under land irrigability class I and II. This indicates that the inclusion of land irrigability classes III, IV and V reduce the crop yield drastically. It is due to adaptation of high water requirement crops along with high cropping intensity (300%). The land irrigability classes III, IV and V are not suitable for high water requiring crops because high cropping intensity results into accumulation of water in sub-soil profile causing rise in water table and if the ground water is saline, it leads to secondary salinisation. If the existing canal irrigation is used only for land irrigability class I and II, the present level of crop production would have been much higher (nearer to double) without degradation of environment and sustainability of production could have also been maintained.

3.3 Unit cost of production

The sustainability and economic viability of agriculture in long-term depends upon the efficient utilization of natural resources like soil and water. The unit cost of production reflects how efficiently natural resources (soil and water) have been used. The unit cost of production at cost C level increased with increase in land irrigability class sequence coupled with increase in the degree of soil degradation level (Table 4). The cost of production under land irrigability class I to marginal level of land irrigability class II is far below as compared to unit cost under other land irrigability class IV to V. Therefore, crop production under land irrigability class I and II, where the unit cost of production is likely to be much lower, is the indicator of sustainability. The land irrigability classes IV and V are often subjected to economic and technical constraints for crop production (Donald, 1980). The land irrigability class III that is marginally economical had either soil-depth or internal drainage or both constraints, which adversely affected the production performance. Therefore, the inclusion of land irrigability classes III, IV and V have led to increase in the unit cost of production, which is much higher than average cost of production. As mentioned earlier, if the canal irrigation potential could be limited to land irrigability classes I and II, the average unit cost of production is would have been much lower than the present level. The lower cost of production of these crops would definitely boost exports of sugar and rice in the world market. More over higher crop production coupled with low per unit production cost and eco-friendly environment, canal irrigation under land irrigability classes I and II will also prevent secondary salinization.

3.4 Measure of profitability

The effects of soil degradation and land irrigability classes can further visualized from measurement of profitability. The net incomes were worked out and are presented in Table 5. Maximum net income generated by land irrigability class I and minimum by severely degraded soils of land irrigability class IV and V. The net incomes under moderately and severely degraded soils under land irrigability classes III, IV and V registered net losses in all most all crops. The reason for cultivation of such soils is that it generated some amount of farm business income (not shown in tables). In some cases, although even farm business with huge energy input in form of family lanour, crops proteccting chemical and also crops production increasinf chemical. In some cases even small farm income also could not be generated, yet the farmers are found to cultivating crops. The main reason for cultivation of some crops may be due to retention of the title of the lands on their names otherwise the farmers may loose the land as per the state rule for retention.

3.5 Employment

The labour use under different land irrigability classes and soil degradation levels is set in Table 6. The labour use decreased with increase in land irrigability classes and soil degradation levels. The use of hired labour in moderate and severely degraded soils of land irrigability class III and IV is due to fact that certain operation has to be performed in time. For example, the transplanting of rice seedlings and removal of weeds are to be performed within a time frame. In case of sugarcane, sugar factory performs the transplanting of seed and harvesting of sugarcane. The labour charges for other cropping operation are to be met by the farmers. The agricultural sector is already facing a serious threat of unemployment and under employment. Therefore, it should be of serious concern for planner to devise strategies so that favorable production environment can be maintained and the rural sector continues to explore more avenues for employment instead of contributing to the already existing challenge of unemployment.

Raj Krishna (1975), Billings and Singh, (1971) ; Singh, (1976) have opined that the labour demand is either stagnant or decreasing whenever the production technology is same. Vaidynathan (1978) explained that inter-regional variation in human labour demand depends on the crop yields and relative prices of different inputs. This confirms that the reduction in the yield level also reduced the requirement of human labour. The reduction in labour used is therefore, directly related to crop yield. The yield of crops can be maintained by adopting the suggested cropping pattern which is based scientofically efficient on soil-water crop relationship.

3.6 Impact of resource allocation on crop productivity

Before establishing a relationship between various factors of production and output, a zero order coefficient of correlation matrix was generated among the varibles under study to find out the presence of multicolinearity. The zero- order correlation coefficient of all the crops grown in the respectative command area were presented in Tables 7, 8, and 9. It can be seen that the yield of the crops under study had a negative and significant correlation with land quality and soil degradation level, implying that as the land quality and soil degradation level changed, the crop yield response showed reverse direction. A positive and significant coefficient of correlation was observed between yields of all the crops and fertilisers, hired and family labours.

The land quality and soil degradation level have a positive and significant correlation, indicating that soil quality detoriorates with the deterioration in land quality. Therefore, the practice of irrigated agriculture in lands belonging to class IV and V, which are prone to salinity and waterlogging creates the adverse environment. The land quality has a negative but significant effects on use of fertilisers and hired labour. Similar observations were made with soil degradation levels. The positive and significant correlation between yields depends on land quality as well as soil quality. The positive and significant correlation between yields of all crops and fertilisers and hired labour indicating that the use of and hired labours depends on the yields of the crops which in turns depends upon the land quality and soil degradation levels. The other expenses have a positive and significant correlation with yield in most of the crops. The negative and significant correlation coefficient between hired and family labour was also noticed. This shows that as the use of hired labour increases, the use of family labour decreases. However, the use of hired labourand crop yield have positive relationship. This furthure showed that the use of family labour decreases as the yield of crops increases. The coefficient of correlation ® for all the variables under study was less than the value of multiple correlation ® indicating the absence of multicollinearity.

The Cobb- Douglas production function was fitted to various crops grown in the command area under study. The estimated parameters with standard errors and coefficient of determination (R^2) are set in Table10, 11and 12 for UKRB , KL and MRB, respectively. The input variables included in the present study explained adequate variation in productivity of all the crops. The observed 'F' ratio indicated that production functions were significant at 1 percent level.

The land quality and soil degradation levels had a negative relationship with the crops indicating that the crop output was guided by land irrigability classes and soil degradation levels. The other input variables like fertilizers and manure, hired labour and family labour had a positive relationship indicating with increase/decrease in crop productivity, the use of these inputs also varied in the same way. This further indicated that the use of fertilizers and manure, hired labour and family labour were well guided by land irrigability classes and soil degradation levels. The high crop productivity clearly associated with good quality of land (land irrigability class I and II), higher amount of fertilizer and manure application, and intensive use of hired labour and family labour. The inclusion of land irrigability class III, IV and V under high water requiring crops created soil degradation problem which in turn adversely affected the crop productivity.

3.7 Issues related with reclamation technology

3.7.1 Reclamation technology

The saline reclamation technology of waterlogged soils is depends upon the quality of ground water. The waterlogging with good quality of ground water can easily be controlled by vertical drainage (construction of tube wells). However, the reclamation technologies of waterlogged saline soil having saline ground water and waterlogged saline soils having natural soil salinity involve sub-surface drainage and leaching of salts, respectively.

3.7.2 Sub-surface drainage

The reclamation technology for waterlogged saline soils, having saline groundwater requires sub-surface drainage systems. Drainage removes excess salts and water from the root zone through leaching to create favourable conditions for crop production. Several studies (Joshi *et al*., 1987 and Datta and Joshi, 1993) indicated that the sub-surface drainage system is feasible. The crops grown under sub-surface drainage, as reported by Joshi *et al*. (1987) indicated that the cotton-wheat; cotton-barley; bajra-mustard; and bajra-wheat were the suitable rotations. The potential and existing saline and waterlogged areas need appropriate choice of crops as a strategy for prevention of further spread of the problems as well as for their reclamation (Datta and Joshi, 1991). The crops which require low to moderate amount of water with some degree of salt tolerance are suggested for these soils. In the absence of the right choice of crops and their appropriate area allocation, the efficiency of the drainage systems in controlling the salinity and waterlogging will be far below the expectation. If the recommended cropping pattern is followed strictly in the land irrigability class III and IV i.e., if only seasonal crop(s), the twin problems of salinity and waterlogging could be minimised to greater extent. Dhawan (1994) raised the question as to where the problem will appear and at what time ? He further opined that it depends upon the pre-canal depth to water table, drainability of soils, conjunctive irrigation practices, proximity of fields to main canals, etc.

From the above discussion, it is clear that the salinity and waterlogging will appear in lands belonged to with progress of time - land irrigability class III, IV and V. The land irrigability class V soils often has severe drainage problem while the land irrigability class IV comprises poorly drained soils. The association of land irrigability class III, IV and V with land irrigability class I and II occurs in small area/pockets. Hence the problem of salinity and waterlogging will appear only in pockets in land irrigability class II.

Leaching of salts: The leaching of salts from waterlogged natural saline soils can be accomplished through sub-surface drainage. The leaching of salts from saline soils is possible by bunding the fields of small size . These bunded fields have to be filled by fresh water and then only salt tolerant rice has to be grown for first two years. The salt leaches out within two years time and farmers presume that the land has been reclaimed fully. Subsequently, farmers adopt rice - wheat rotation. This leads to rise in water table. These saline soils belong to land irrigability classes III, IV and V which are not suitable at all for rice cultivation. The lands which are initially saline turn into waterlogged saline soils. Hence the methods of salt leaching in such situation are not workable to desired extent.

3.8 Water management practices

Several water management practices have been advocated for controlling the salinity and waterlogging. These practices included use of sprinkler irrigation, drip irrigation system etc. Rice requires stagnant water and sugarcane also needed nearly 200 mm^3 water. The question arises as to how the sprinkler and drip irrigation systems are feasible to meet the water requirement for production of these crops. The application of low quantity of water to any crop will cause reduction in yields. It is reported (Satyasai and Viswanathan, 1997) that under sprinkler irrigation system, which is more useful under water scarce areas, more area can be brought under irrigation. Narayanmoorthy (1997) reported that under drip irrigation system, expenditure is increased on weeding, fertilizer and irrigation. It is a well known fact that reduction in intensity of weed results in increase of the crop yield. However, it still not clear whether it is due to improvement of crop-water relationship or due to control of weeds. Drip and sprinkler irrigation systems cannot be used for rice crop. Under these systems of irrigation yield of sugarcane is also reduced (Satyasai and Viswanathan, 1997). Hence these methods of water management cannot be generalized for all the crops.

References

Alagh, Y.K. 1990. Agro-climatic planning and regional development. Indian J. Agril. Econ. **45**(3): 244-268.

Benoit Lesatfre 1992. ‘Diagnosis and identification of problematic soils as related to drainage : overviews of diagnosis and identification of problematic soils’. Proceedings 6th International Drainage (ICID-CIID IWSORT) Workshop held at Lahore, Pakisthan from 8-15 Feb. Vol. **I**, 17-57.

Billings, Martin, H.,A and Singh, A. 1969. Labour and green revolution. Economic and Political Weekly Vol. **4**, No.52: 221-224.

Datta, K.K. and Joshi, P.K. 1993. Problems and prospects of co-operatives in managing degraded lands - A case of saline and waterlogged soils. Economic and Political Weekly, March 20-27.

Dhawan, B.D. 1994. Land Degradation, Groundwater Depletion and Irrigated Agriculture in India. Institute of Economic Growth, University of Delhi, p. 124.

Joshi, P.K., Singh, O.P., Rao, K.V.G.K. and Singh, K.N. 1987. Sub-surface drainage for salinity control: An economic analysis. Indian J. Agril. Econ. **42**: 198-205.

Khoshoo, T.N. and B.L. Deekshatulu. 1992. Land and Soils. Indian Science Academy, Har-Anand Publications, New Delhi.

Narayanmoorthy, A.L 997. Economic viability of drip irrigation : An empirical analysis from Maharashtra. Indian J. Agril. Econ. Vol **52**: 728-739.

National Commission on Agriculture 1976. ‘Report of the National Commission on Agriculture, Part V: Resources Development”, Ministry of Agriculture and Irrigation, Govt. of India, New Delhi.

Nilkantha and Mitra 1986. Economics of utilisation of canal water in dry agricultural region. Ind. J. Agril Econ. **4**(2): 121-140.

Raj Krishna 1986. “Measure of the direct and indirect employment effects and agricultural growth with Technical change in E.O. Heady and L.R. Whiting (Eds), Extranolities in Transformation of Agriculture. Iowa State University Press, Amas Iowa pp:305-332.

Robert, C. 1992. Managing Canal Irrigation. Oxford and IBH, New Delhi.

Satpute, T.G.1 988. Irrigation Management in Command Area, Mittal Publishers, New Delhi.

Satyasai, K.J.S. and Viswanathan, K.U. 1997. Evaluation of alternative water management strategies for water scares area. Indian J. Agril. Econ. **52**: 499-507.

Singh, S.N. 1976. Modernization of Agriculture. Heritage Publishers, New Delhi.

Vaidyanathan A. 1978. Labour use in Indiana Agriculture: An analysis based on Farm Management Survey. ILOARTEP, Bangkok.

Van Wambeke, A. and Rossiter, D. 1987. Automated land evaluation systems as a focus for soils research, IBSRAM, New letter Vol. 6.

Tideman, E.M. (1996)"Watershed Management, Guidelines for Indian Conditions" OMEGA SCIENTIFIC Publishers, New Delhi.