Common Property Resource Management in Haryana State, India: Analysis of the impact of Participation in the Management of Common Property Resources and the Relative Effectiveness of Common Property Regimes*

Dr PV Subhash Chandra Babu
Deputy Conservator of Forests, Indian Forest Service
1 - 6 - 249/2/A
Friends' Colony Zamisthanpur
Hyderbad, A.P. 500 048 India
Fax: 914 0760 4321
Email: p.babu@mailcity.com

Stream: Global Themes

Abstract

Common lands in Haryana State, India have suffered severe degradation, continuous erosion and are becoming transformed to open access regimes due to increasing population pressure. This has resulted in environmental damage on a wide scale and reduced welfare of the inhabitants of the region. Realising the enormity of the problem and the critical need to initiate action for greening the common lands, the government and the people came together to establish a participatory planning and development process at the village level.

The purpose of this research is to examine the effectiveness of participation in managing common property resources. The results of the case study, show that clear benefits may be derived from common property regimes, are used to examine institutional development at the village level. A composite resource condition index is developed in order to measure the success of village institutions. The mechanisms and processes involved in assisting local people to establish common property regimes are also discussed. A mathematical programming model incorporating household dynamics and their interactions with both common property resources and private property resources is developed and scoping studies are conducted to analyse the impact of participation in the management of common property resources and the relative effectiveness of common property regimes.

Key words: Forestry, Management, Common Property, Modelling, Participation, Haryana.

1. Introduction

Many forests and natural resources have been managed for several centuries as common property regimes by communities all around the globe (McKean, 1995). The justification often provided for eliminating the communal ownership of common property resources is that individual or public ownership of common property resources would offer enhanced efficiency in resource use and greater long-term protection of the resource base. Although common property has proved a stable form of resource management in some traditional societies, the combination of population growth, technological change, climate and political forces has de-stabilised many existing common property institutions (McKean, 1995). In response to this, western economic consultants and planners have called for the imposition of private property rights (Johnson, 1972; Picardi, 1976).

* **Paper to be presented at the IASCP Conference, 1998 to be held in Vancouver, Canada 10-14 June 1998.**

As an institution, common property is to be distinguished from free and open access, where there are no rules regulating individual use rights (Ciriracy-Wantrup and Bishop, 1975). Problems of open access arise from unrestricted entry, whereas problems of common property result from tensions in the structure of joint use rights adopted by a particular village (McKean, 1995). The property rights in a common property regime can be clearly specified and they are by definition exclusive to the co-owners (Magrath, 1989). They are secure if they receive appropriate legal, financial and technical support from Governments (McKean, 1995).

In India, traditional village-based institutions have, in the past, regulated user access to the common property resources and enforced users' obligations relating to investment for the conservation and development of village common property resources. Villagers used to respect their village institutions and contribute to the upkeep of the common lands and other natural resources. Any violations of restrictions were met with stiff penalties. The advent of the modern legislative system has largely destroyed the authority that village organisations had in dealing with abusers of communally accepted distribution mechanisms. This is unfortunate as practice and theory alike suggest that real benefits may accrue from the allocation of common property rights in many situations.

Specific hypotheses addressed in this paper were:

- it is possible to define specific circumstances wherein the common property protects the natural resource base effectively;

- there exists a level of complimentarity between common property resources and private property resources in the case study area;

In order to test these hypotheses, a mathematical programming model was developed and when used in conjunction with an assessment of the strength of the CPR's they enable the hypotheses to be tested. The paper begins with a consideration of the background to the problem, and then the model construction and scoping studies results are presented.

2. Case Study Area and Problem Context

Haryana is one of the smaller states of Northern India. The population according to the 1991 census is 17.107 million, of which 78% live in the rural areas. The state's endowment with natural resources such as minerals and forests are meagre compared with other Indian states. Haryana has the lowest proportion of geographical area under forest cover at 3.86% (national average of 23%). The pressure of population combined with the favourable agro-economic factors have led to the expansion of agriculture into areas formerly under forest cover.

(a) Background to the Problem

Common property resources such as village common lands, which cover 10% of the total area of Haryana state, have a pivotal role in the subsistence economy of the state. They serve protection, production and conservation roles, which may conflict in the face of growing demographic pressures. Traditionally, common lands in Haryana have provided a range of products, but at present they are mainly used as a source of fuelwood and fodder.

Historically, these common lands were managed under traditional methods by the villagers coupled with state control. The growing population pressure and the growing industry demands have meant that most of the primary forest tracts of common lands have been degraded into secondary forests and subsequently, degraded village forests. Since the 1980's however there has been a marked shift in policy towards conservation with the enactment of the Forest Conservation Act - 1980 and the new National Forest Policy of 1988.

The current study area is an area of common lands belonging to 293 villages bordering the Aravalli Hills in the districts of Faridabad, Gurgaon, Mohindergarh, Rewari and Bhiwani. The common lands of the area belonging to these villages provide most of the fuel and fodder requirements for the cattle and livestock, which number 278,423 in an area of 40,335 ha. (HFD, 1988).

Despite making significant contributions to the rural community, common property resources have undergone severe degradation and are becoming transformed into open-access resources (Kaul, 1994). Common property resources play an important role in assuring the livelihood of the rural poor. The breakdown of traditional common property resource management systems not only causes environmental harm as resources are severely degraded under open-access regimes, but also social harm because the poor can no longer depend on them. Further conversion of common property resources into open-access regimes is likely to be profoundly detrimental to socio-economic development and the environment. One solution may lie in the creation of village level institutions that can take care of the rehabilitation of the common property resources.

(c) The Participatory Process: Institutional Development at the Village Level

Realising the enormity of the problem of destruction of the vegetative cover of the common lands in the Aravallis the Government of Haryana started a participatory afforestation project in 1990 for the rehabilitation of 33000 ha. under common lands. In order to re-establish community participation in the management of common lands by villagers, the Forest Department provided an institutional framework for the formation of village forest committees (VFC). In each village a 9-15 member VFC with the Sarpanch (Chairman of the Panchayath, an elected village council) as its head was constituted. The VFC includes the Sub-Divisional Forest Officer/Ranger and the concerned Forest Guard as its members from the Forest Department. The rest of the members come from the village community with at least 3 being women. Adequate participation of the members of the scheduled castes was also provided at the time of the constitution of the VFC. The VFC functions as an executive committee of the village Panchayath. All other villagers in the village are the general members of the VFC. VFC's meet as frequently as necessary for the purpose of taking decisions on the use of village common lands and distribution of the produce from the village common lands.

Through a participatory rural appraisal process taking due consideration of the villagers' expectations and choice of species, an agreement is signed between the Panchayath and the Forest Department for handing over a part of the village common land for the purposes of tree planting and seeding of grasses and legumes. The villagers agree not to graze afforested village common lands until the trees become mature. In the mean time, villagers are encouraged to cut and carry the grasses and legumes to stall feed their cattle from the areas under plantations. The Forest Department, after three years of maintenance, will handover the land to the VFC for further maintenance and management. The labour required for plantation activities is drawn from unemployed labourers of the village. In the meantime, all efforts are made by the Forest Department to train the VFC and the villagers in all aspects that require a smooth functioning of the VFC and taking over of the management of the village common lands.

3. Development and Construction of a Mathematical Model for CPR Management

In the following sections the need for a mathematical programming technique for modelling the use of common property resources is explored. A single objective linear programming model application is presented in the present context in order to analyse the effect of CPR management under different management options. Model development and construction is presented in order to conduct scoping studies, which would help in identifying the changes in the resource condition under different scenarios.

3.1 Linear Programming technique for CPR management

There are number of mathematical programming techniques available for incorporating complex information pertaining to resource management. Single objective linear programming (LP) is recognised as a powerful and versatile computer based aid to decision making at farm planning, since it provides valuable insights into the nature of resource allocation (Dent et al., 1986). LP has been applied to a wide range of allocation problems in resource management including forestry (Beneke and Winterboer, 1973; Barnard and Nix, 1979; Hazel and Norton, 1986; Bell, 1977; Mendoza, 1987; Dykstra, 1984; Rae, 1984; Nhantumbo, 1997). In an LP framework, the decision maker wishes to maximise or minimise an objective function, subject to a number of linear constraints. Usually the objective function represents profit maximisation or cost minimisation. LP formulation assumes that all the underlying relationships are linear, and parameters have single value expectations (Romero and Rehman, 1989).

However, single objective LP can accommodate multiple objectives in the form of constraints. The constraint method optimises one objective while all other objectives must be satisfied by linear inequalities and the procedure determines minimum or maximum values for those objectives. This reduces a multi-objective problem into a single objective formulation, which can then be solved by LP algorithms. The shadow prices of those objectives which are not optimised, will indicate the rate and limit of trade-off between the optimised and other objectives. This process can be repeated for all objective functions treating remaining objectives as constraints.

The mathematical basis of a single objective LP problem is stated in the form of the following equation:

$$\text{Maximise} \quad Z = \sum_{j=1}^{n} c_j x_j$$

$$\text{Subject to:} \quad \sum_{j=1}^{n} a_{ij} x_j \le b_i \qquad i = 1,2,3 \ldots\ldots\ldots\ldots m$$

$$\text{and} \quad x_j \ge 0 \qquad j = 1,2,3 \ldots\ldots\ldots\ldots n$$

Where;

'Z' denotes the objective function value
'c_j' is the forecasted net revenue of a unit of j th activity
'x_j' is the level of j th activity
'n' denotes the number of activities
'm' denotes the number of constraints
'a_{ij}' is the quantity of the i th resource required to produce one unit of the j th activity
'b_i' is the amount of the i th resource available

The main advantages of the LP formulation include the generation of many management alternatives that may aid conflict resolution in the VFC's with regard to efficient management of common property resources of the village, evaluation of management strategies and forecasting likely scenarios under open-access and common property regimes. The main disadvantages of LP include: (i) it may be difficult to decide which of the several objectives are fulfilled in different strategies when so many management alternatives are presented to the decision maker, (ii) the technique is not truly multi-objective but rather single objective with associated constraints, (iii) there are situations when some of the activities may take a zero or a very high level. This problem can be overcome by assigning lower and upper bounds to the objectives to be maximised or minimised. The main limitations of an LP model are divisibility of variables, linearity of constraints, additivity, and non-negativity of activities (Pannell, 1997). However, Dent, et al (1986) observed that, "the limitations imposed by the assumptions of linear programming are more perceived than real; given sufficient time and ingenuity it is possible to achieve a high degree of realism in representing a complex situation."

Despite these limitations and weaknesses, LP is a useful tool in representing a complex system in a single matrix. Unlike humans, an LP model is free to consider all strategies without preconceptions or prejudices. The LP model allows the modeller to put technical and biological information into an economic context and to quantify the economic, technical, and biological trade-offs in the system (Pannell, 1997). Often the amount of information available about a system may be so complex that managers may not be able to make coherent management decisions. The LP model fills this need well for large problems and is a valuable tool for developing an understanding of the subtleties and interactions of a complex management system (Pannell, 1997).

3.2 Objectives

In order to deal with the hypotheses the LP model was developed to achieve the following objectives:

(i) to optimise the use of private property resources as well as the common property resources of the village;
(ii) to integrate the private property resources and common property resources and the different households interactions with these resources into a simple and useful model;
(iii) to analyse the likely impact of different open-access and common property regime scenarios;
(iv) to study the impact of open-access and common property regimes on different households, such as, the large farmer, small farmer and landless households;
(v) to achieve overall economic efficiency in resource allocation of a village in a particular scenario; and
(vi) to forecast the likely patterns of agriculture and common land use under different scenarios.

3.3 Model construction procedure

The LP model was constructed at the village level and was applied to one of the surveyed villages. Rajgarh village of the Rewari district was chosen for this application.

A single objective LP model (incorporating multiple objectives as associated constraints) was developed and solved by using the software package LINDO (Linear Interactive Discrete Optimiser - version 5.3). This model was constructed with the objective of maximising the net income of the village. The entire society was considered in terms of three land holding classes: large farmers (those owning more than 3 hectares of land), small farmers (those owning less than 3 hectares of land) and landless households, for model construction.

The assumptions for model construction were:

(a). Production technology in agriculture is constant at the level of the year of survey (1995-96) (although some of the coefficients can be changed to reflect a change in the production process). The technology is assumed to be linear meaning that the production relationships in the model are constant irrespective of the scale of production;
(b). Input-output prices are assumed to be constant at 1995-96 prices (time of the survey);
(c). Different households were considered as homogeneous, even though the characteristics of different caste groups differ from each other. The composition in each household (males, females and children) was considered as fixed at certain level;
(d). All land was assumed to be of homogenous capability since the entire region has only one class of land, sandy loam;
(e). There is free flow of goods within the village and outside the village. Buying and selling of goods from within and outside the village is allowed. Each household can sell their surplus produce and buy according to their requirements;
(f). The basic needs of the people, such as, fuelwood, fodder and food items are satisfied in the model. Expensive items such as consumption of liquor, buying of fruits and spending on festivals and social functions were considered luxury items and not considered. The basic aim of the model is to satisfy the basic needs of individual households and then to maximise the net cash generated from the resources at their disposal in order to meet certain essential items of living, such as buying of clothes, tea, coffee, power, medicines, leisure and entertainment. The general structure of the model is given in Table: 1.

3.4 Activities Considered in the Model

3.4.1 Production Relationships involving agricultural land

From the land holding point of view three types of households were identified. Those households owning more than 3 ha of agricultural land have been categorised as large farmers, those households owning less than 3 ha of land have been categorised as small farmers and the rest of the households having no land have been categorised as landless households.

Cropping activities of the different farmers were decided on the basis of the field survey. Since little distinction was recorded across soil types, the entire area was treated as having same type of soil conditions with little or negligible variations. The soil type is uniformly sandy loam with minor variations in the organic matter content and phosphate content. Based on the field survey, land was treated as homogenous since the farmers did not express any appreciable differences in soil conditions. Almost any crop could be grown suitable for the sandy loam conditions on any farm without appreciably affecting the production levels. However, land of small and large farmers was treated differently since both of them have different access to resources such as inputs, farm machinery etc. Intensive crop production often allows more than one crop per year to be produced from the same piece of land. The land held by individual farmers is under intensive cropping. The year is divided into two seasons, the Rabi season (dry season) and the Kharif season (wet season). The Kharif season is from July to October, where as, the Rabi season is from November to March. No production activities are possible from April to June, owing to hot, dry and desiccate winds from the Thar desert. During Kharif, Jowar (Sorghum), Bajra (pearl millet), Onions and Gram are grown, where as, in Rabi season more varied crops such as Wheat, Mustard, Peas, Tomatoes and Barley are grown. Due to the need to have balanced production of crops some crops are bound by land constraints. Since subsistence farming dominates in this area, usage of fertiliser in crop production is not very common. Very rarely can one see fertiliser being applied by a farmer to his growing crops. Most people apply very little amount of fertiliser to small vegetable plots. Since there exists no pattern of fertiliser applications to agricultural crops, production of crops involving fertiliser is not considered in the model. However, dung usage in place of fertiliser is quite common. It provides a much needed nutrient replenishment for the soil and also provides dung cakes for fuel purposes. Hence, an option to produce crops using dung and without dung is provided in the model where, dung application to agricultural crops increases marginal crop production.

Table: 1 General structure of the LP village model

ACTIVITIES	Production activities on agricultural land and common lands (68)*	Storage activities (8)	Selling activities (18)	Buying activities (20)	Consumption activity (60)	Labour activity (14)	Labour Selling activities (16)	Hous food dema activ (18)
Objective: (Maximise net income)								
CONSTRAINTS								
Total land under use (24)	+x							
Production, selling and consumption of food crops rec. (80)	-x	+x	+x	+x	+x			
Storage transfer of crops (2)		-x	+x		+x			
Labour[1] rec (39)	+x					-x	+x	
Fodder rec.[2] (14)	-x							
Household food[3] and fuel[4] rec. (58)	-x				+x			

TL = total land, rec. = reconciliation, * figures in parentheses refer to numbers of columns (activities) and number of rows (cons

1 = number of man days

2 = dry matter in kilo grams

3 = energy in kilo calories

4 = fuel in mega joules

Agricultural crops provide grain, straw and crop residues. Grain is used for meeting the household food energy requirements, whereas, straw is used as dry matter feed for livestock. Crop residues, such as mustard sticks are used as fuel for cooking food for household consumption. The produce from the farm can be sold, bought, or stored for later use, according to convenience and profitability. The input-output coefficients used in the model were derived from the field survey and various other sources including field observations (GOH, 1995, NRDMS, 1994 and DSO, 1994). It was therefore anticipated that crop yields would not vary significantly from year to year since the climatic factors remain stable from year to year. The average crop yields provided for various crops in the model adequately represent the actual situation. The grains, straw and crop residues can be bought, sold, stored and, or consumed by the large and small farmers, where as, landless households have to buy and consume in order to meet their requirements. Food grains are converted into kilocalories and fodder is converted into kilograms of dry matter to meet the fodder requirement of livestock.

3.4.2 Crop Storage

Storing crops is a necessity for the households in order to meet the food requirements for the next season. Storage of crops naturally leads to certain storage costs as well as certain storage losses. Therefore, grain losses from one season to another are incorporated in the model, as are storage costs.

3.4.3 Sale of agricultural produce

The cash generated from the sale of crops grown meets the input requirements for the next cropping season besides meeting several necessities of the household. The sale prices provided in the model are the prices prevailing at the time of data collection (1995-96)

3.4.4 Purchase of food grains

Purchase activities for buying the food grains is provided for in the model, so as to facilitate supply of food grains needed by the households. The average purchase prices of food grains were much higher compared to the sale price in 1995-96. The purchase prices prevailing at the time of field survey were incorporated in the model.

3.4.5 Household consumption of food energy

The model satisfies the requirements of food energy demands of various households, thus fulfilling one of the basic needs of the household. The annual kilocalorie requirements by adult male, adult female and children of southern region of Haryana were specified by the National Institution of Nutrition (1991). No distinction in terms of kilocalories for different types of households was considered, however. The average food energy requirements are constrained to atleast be met in the model by every household. In the model, energy is defined in terms of kilocalories and proteins in terms of kilograms.

Food energy requirements are normally met from cereals, pulses, milk, vegetables and fruits etc. Meat, being a costly source of energy (and also because it is consumed very rarely by a small section of the population) was excluded and not considered in the model.

3.4.6 Common land

The common land products are mainly fuelwood and fodder. The outputs that are extracted by different land holding classes was taken into consideration in the model. Raising of plantations was not considered in the base model but was a potential common land activity that could be brought in to increase the output of fuelwood and fodder. This step allows for the analysis of the effect of a joint management effort. Estimated production yields from raising the plantations are provided in the model. No costs of raising the plantations was provided since these are currently being provided by the Forest Department at no cost to the village. Outputs that accrue at regular intervals from these plantations was provided.

3.4.7 Livestock

Different types of livestock such as cows, buffaloes, goats, sheep and camels were treated as Tropical Bovine Units (TBU) for making the model structure simple and to keep it in manageable limits. The conversion factors used to calculate the number of TBU in each household type were adopted from the SETA report on rehabilitation of common lands in Aravalli Hills (1989).

Livestock feed demand was also ascertained during the field survey from different households and animal husbandry department officials. Fodder requirement in terms of kilograms of dry matter per livestock type was separately calculated and was provided as required by a TBU (20 kg Dry matter/TBU/day) in the model.

Fodder from farms and village common lands was converted into dry matter equivalent. Livestock provide milk and dung and both these products are utilised in meeting the agricultural crop requirement as manure, and for meeting the household energy needs and have been separately provided in the model.

3.4.8 Labour

Available labour resources were calculated in each of the households and were incorporated in the model. The resource units have been distinguished as adult males and adult females. Though children working as farm labourers can been seen quite often on the farms, their labour was not separately considered in the model as child labour is legally prohibited by the government.

There are two types of labour. One is domestic labour i.e., supply from one's own family/household and the second one is hired labour. In addition to its own supply, a household can hire labour as and when the demand for such labour becomes necessary in meeting the crop requirements. Different labour activities include farm requirement, domestic requirement and livestock requirement. Though there is no sex discrimination of labour in terms of wages paid to the hired labourer as every hired labourer has to be paid a minimum wage determined by the government from time to time on the basis of the prevailing inflation under the Minimum Wage Act. However, certain activities are performed by female labourers only. Hence, there is differential requirement of hired labour for different crops. Similarly, quarrying can be done by males only.

Labour availability is considered in terms of man days only. There exists no system of working in terms of labour hours. Normally a manday is considered to extend from morning 8 am to 5 pm with a two hour lunch break. In most of the households, domestic work such as cooking food, taking care of livestock, collection of fodder and fuelwood and other household tasks are done by women. Hence the number of mandays provided by women to the farming labour pool is less. All the available labour in various households has been pooled together for model purposes. Labour is drawn from the pool by the different households as and when it is required for their farm activities. In the model, provision has also been made to utilise the available labour from within the household and then hire the labour from outside the household since labour supply from within the household involves no cost but hiring of labour is certainly a costly proposition. Labour requirement per crop and other activities such as livestock rearing, working for forest and other public works department was provided in the model. Hiring of labour from outside the village is not provided since there is generally plenty of available labour from within the villages. Being an economically backward area, no such labour shortages could be anticipated. The average cost of hiring of labour is forty rupees per man day, at 1995 prices.

3.5 Constraints provided in the Model

3.5.1 Land

Land is a major constraint and is a fixed resource which can be utilised or remain slack. Land was considered to be of homogenous quality and to be distributed between the different types of household equally. Large farmers and Small farmers were provided at 4.2 hectares and 1.2 hectares respectively.

3.5.2 Production

Crop yields provided in the model are average yields mentioned in the survey by various households. Since no publication mentions crop yields with the application of dung and without the application of dung, the yields provided in the model are also based upon the survey of households. However, the figures provided with dung application were almost the same as the figures published in official documents, such as the Statistical Abstract of Haryana, 1995 with minor variations. The purpose of dividing the activities into with dung and without dung application was to see how the energy requirements of the family are met by different households. Dung has an important role in enhancing the crop productivity as well as meeting the household energy requirements for cooking food in the form of dung cakes. Under this constraint, the demand (for crops as manure and as dung cakes for cooking purposes) and supply (from the animal excretions) was specified as less than or equal to Zero, i.e., dung could not be imported into the household system.

3.5.3 Labour

Labour is in great demand especially during harvesting, weeding and land preparation periods. In addition to labour supply from within the family, hiring of labour is allowed in order to meet the short fall in labour requirements. Labour requirements of each crop was calculated and provided for in the model.

3.5.4 Household Food supply

The households have a choice of either producing food on their own farm or purchasing from the market, depending on the requirements. This constraint is concerned with the seasonal food consumption demand.

3.5.5 Household composition

The household composition is different for each land holding class. Based on the survey household composition of different land holding classes was incorporated in the model.

3.5.6 Fuelwood

Fuelwood can be purchased from the market or collected from the common land or from the farm land by individual households owning farms. Landless households have to either purchase from the market or collect fuelwood from the common lands. The other alternative to meeting the fuel supply is from the burning of dung cakes or mustard sticks. These three sources of fuel energy provide most of the cooking needs of the households. The annual requirements of the households are forced to be met in the model. Household fuel requirements provided in the model are based on the survey of the different households. There are no published surveys of the energy requirements of the households. The amounts of fuelwood, mustard sticks and dung cakes utilised by different households were converted into Mega joules and are provided in the model. Conversion ratios were, 12.368 mega joules/kg fuelwood, 11.255 mega joules/kg. crop residues and 8.753 mega joules/kg dung cakes respectively. The annual demand of the households was the same for small farmer and landless households at 36588 mega joules of energy, where as for large farmer households it was slightly higher at 48784 mega joules. No supply of alternative sources of fuel was considered in the base model, but in the scoping studies these alternatives were considered.

3.6 Model Validation / Verification

Validation is a process of checking whether the matrix is consistent with the real world (Pannell, 1997). In other words, it is a process by which a model is determined to be a valid portrayal of the system modelled. Model validation refers to activities to establish how closely the model mirrors the perceived reality of the model user/developer team (Gass, 1983). However, a model cannot represent all of the perceived reality, so attention should be narrowed down to that part of the reality which the model is intended to represent (McCarl, 1984). The validation procedure involves comparing the performance of the model either against recorded data for the system or against a subjective judgement of what the output should be, given a broad understanding of the system or type of system which the model represents (Dent and Blackie, 1979). Many of the difficulties in validating a model arise from the data it is being validated against (Hazell and Norton, 1986). A model can also be validated by assumption, with or without comparing the results with the recorded data (McCarl, 1984). In order to judge if a model is valid, the optimal values of the decision variables, the dual prices and the objective function should be systematically validated. This validation of the model can be by construct or by results (McCarl and Apland, 1986). Validation by construct relies on the procedure believed to be appropriate by the model builder. These are based upon experiences, precedence, and or theory, using scientific estimation or real world data. Validation by construct means the validity of the model is assumed. Validation by results usually follows validation by construct and consists of a comparison of model solutions with corresponding real world outcomes. Virtually all models go through a validation by assumption stage, which involves a judgement of validation through expert opinion, antecedent, theory, data or logical structure. In this study, model validation relies on the logical framework with which the model was built. Most of the data was either collected during field survey or taken from published sources. Efforts were made to make the model realistic and logical. The experience of the researcher of having worked and lived in the area for over ten years also strengthens the presumption that the model is valid / verified.

4. Analysis of the Scoping studies Results and Discussion

In the following sections the single objective linear programming model developed is used for conducting the scoping[1] studies in order to determine the solutions under open-access and common property situations. The solution runs that were undertaken under different scenarios are presented and the results are discussed.

4.1 Scoping studies

The main purpose of this research is to understand the likely scenarios if the current open-access situation continues and to forecast the likely benefits that would accrue to the different households under a common property situation. This study should help the village communities and their advisers to decide as to which one of these is beneficial for them to pursue.

The studies are conducted with the sole objective of maximising the net income of the village under both open-access and common property, while fulfilling the basic household needs. The different scenarios under which the scoping studies are conducted include:

(i) The likely scenario if open-access is pursued from the current level of extraction of fodder and fuelwood from the common lands;
(ii) The likely scenario if common property is pursued rigorously with stricter controls in access, distribution of produce from the common lands accompanied by proper enforcement;
(iii) The likely scenario under both common property and open-access if the present level of increase in both human as well as livestock populations takes place over a period of time (dynamic situation);
(iv) The likely scenario if alternative energy sources are provided by restricting different households access to the common lands for both fuelwood as well as fodder;
(v) The likely scenario if agricultural production levels increase or decrease from the current level of production. These scoping studies results are presented and discussed in the following sections.

4.1.1 The likely scenario if open-access is pursued from the current level

For conducting the scoping studies under this scenario the observed resource degradation patterns in various case study villages formed the basis for determining the output that would be

[1] Means a range of view or the extent to which it is possible to range (Oxford Dictionary of Current English, 1992).

extracted successively by different households. The fuelwood and fodder resources were assumed to be degraded and are likely to result in a short fall of 20 percent successively from year to year since it is a free for all situation resulting in the absence of any proper management structure. In this scenario, no improvements in the situation are possible and a stage would eventually result whereby it would not be possible to extract anything, implying that the ultimate resource availability would be zero. The current level of extraction was the level which was prevailing at the time of the survey (1995-96). The solution runs were undertaken with the current annual extraction level of fodder and fuelwood from the common lands at 219,450 kilo grams and 184,000 kilo grams respectively. These figures were calculated by extrapolating and aggregating the extraction levels for whole of the village from the sample surveyed. The results from different runs with the successively declining extraction levels show that the village income declines under open-access for all the households. The net income of the entire village declines from Rs.5,973,569 to Rs.5,487,790 in a span of 60 years at the current prices (1995-96). While the decline is initially faster compared to the later years. As the following sub sections show, almost every household gets affected under open-access, irrespective of land holding status.

4.1.1a Large farmer households under open-access

A marginal decline in the net income of the large farmer household takes place after the first three years. Thereafter it remains constant, since large farmers are not very dependent on fuel and fodder resources from the common lands.

Apart from the slight decline in the net income of the large farmers a slight change in landuse pattern takes place in order to compensate for the loss of fodder and fuelwood supply from the common lands. The area under mustard crop grows slightly from 1.6 ha. to 1.7 ha. The model uses the alternative source of fuel (mustard sticks) in order to compensate for the loss of fuelwood supply from the common land. A similar pattern emerges from the fodder point of view. While the production of wheat declines an increase in Jowar (Sorghum) production takes place in order to compensate for the loss of supply of fodder from the common lands.

As far as fuel sources are concerned the model predicts the non-usage of dung cakes as a source of fuel. Instead, it increases the usage of mustard sticks produced through increased area under mustard crop. In reality, most large farmer households do use some dung cakes for cooking some of the traditional items but the model allocates dung to more productive purposes for increasing the usage of dung as a manure for agricultural crops for increasing yields and hence, the net income.

The fodder consumption pattern for large farms does not indicate any major changes to overall consumption patterns. The compensation of lessened fodder supply from the common lands is met by an increased supply of fodder through the increase in Jowar production.

4.1.1b Small farmer households under open-access

The net income of the small farmer household also declines over a period of time under open-access. The level of decline in the initial years is not appreciable. From year 3 onwards it declines gradually from Rs.11420 to Rs.10230 at current prices (1995-96) with the falling extraction levels of fuelwood and fodder from the common lands.

As the open-access situation continues changes in landuse pattern become substantive indicating the increase in area under production of agricultural crops that provide fuel for cooking. For example, mustard production goes up from 0 ha in year 1 to 0.3 ha in year 25 in order to compensate for the loss of fuelwood supply from the common lands. At the same time, the area under wheat declines from 1.08 ha to 0.77 ha in 25 years.

The fuel consumption scenario also undergoes a change. Surprisingly the diversion of dung as manure to agricultural crops increases with the falling usage of dung cakes. Since the area under mustard crop increases, the amount of available mustard sticks for cooking purposes goes up. This increased mustard stick availability not only makes up the loss of fuelwood from the common lands but also reduces the conversion of dung to dung cakes thereby making more dung available to agricultural production.

Since the area under mustard crop increases a shortfall in fodder production from farm lands occurs. Since fodder from the common lands also declines under the open-access situation the amount of TBU's that can be fed decreases from 1.81 to 1.59. The model uses only 1.81 TBU's as against the 2.6 TBU's available in the model. This indicates that the present livestock is underfed and will continue to be underfed. This decreases the livestock productivity and reduces the income level of the small farmer households.

4.1.1c Landless households under open-access

The net income levels of the landless households also decline under open-access considerably over a period of time. The net income decreases from Rs.5173 to Rs.4372 in 15 years at current prices (1995-96).

Increasing open-access, resulting in a reduced availability of fuel and fodder resources, makes it difficult for the landless households to meet their fuel and fodder requirements.

Most of their fodder and fuel requirements have to be met from the market by paying cash. The landless households earnings are totally dependent upon their income from the sale of labour to either large farmers or small farmers or government agencies. Labour requirement from these areas of employment is almost stagnant. With no other industries coming up in this area the level of unemployment is likely to be higher as at present. This will force them to migrate to nearby towns and seek employment elsewhere. Given the mindset of people of this area it is unlikely that this might happen. With the increasing rate of growth of population it becomes a question of survival for the landless households. This proposition is examined later under a dynamic situation.

4.1.2 The likely scenario if common property is pursued by the village

In this section the model results are presented assuming that there exists a common property situation. This means that the regulated access system is in force in place of an open-access situation. A strict common property regime includes regulation of access, equitable distribution of produce, monitoring all the behaviour and sanctioning the violators of the commonly agreed restrictions.

For conducting the scoping studies under this scenario the growth parameters concerning the increase in bio-mass of this forest type are taken into consideration. Since there would be stricter controls and the common lands are free from grazing it can safely be expected that there would be an increase in the availability of fodder and fuelwood. The solution runs were conducted using a much lower level of extraction of fuelwood and fodder levels from the common lands initially as against the current level of extraction. An amount of 46,200 kg fuelwood and 69,300 kg fodder extraction in the first year is considered for safe removal as against the current level of extraction of 184,000 kg and 219,450 kg of fuelwood and fodder respectively. With reduced removal of fuelwood and fodder from the common lands, with proper monitoring and enforcement in place, was assumed to make that the resource supply levels will continue to increase at the rate of 7.5 percent per annum over the next 25 years until production levels peaked at 262,086 kg fuelwood and 393,130 kg fodder. These increases are in line with the projections predicted in the unpublished reports of the Aravalli project (GOH, 1989) assuming the scenario without the tree plantations on vacant spaces in common lands. Removal of 1134 kg fuelwood per ha of common land and 1701 kg fodder per ha in the 25 th year is a reasonable estimate if the access controls are strictly enforced by the village community. This exercise may be termed suspect but it provides reasonable answers to the likely scenarios under common property regime. In the absence of any published volume tables for this type of mixed forest, dominated by the presence of *Anogeissus pendula* the output levels prescribed are considered reasonable for forecasting the likely scenario.

The changes in net income and the resulting changes in landuse patterns, fuel consumption scenarios and fodder consumption scenarios for each of the different type of households are presented in detail in the following subsections under a common property regime.

4.1.2a Large farmer households under common property

The net income level of the large farmer households increases over a period of twenty five years from Rs.64,483 to Rs.65,885 at current price levels (1995-96) representing an increase of 2.17%.

Since fuelwood and fodder from the common lands is allowed to be distributed equitably amongst all households from the common lands the availability of these resources increases year after year. Due to the increased availability of fodder and fuelwood from the common lands under the common property the land use pattern changes.

The area under mustard production decreases from 1.65 ha to 1.4 ha. The area under wheat crop also increases from 1.49 ha to 1.74 ha. There is a slight shift in the pattern of wheat crop. Wheat using dung as manure declines from 0.55 ha to 0.33 ha, where as wheat crop with no dung application increases from 0.94 ha to 1.41 ha. The area under Gram production increases from 0.98 ha to 1.19 ha indicating a shift in production towards cash crops.

The fuel consumption scenario for large farmer household changes with the increased availability of fuelwood from the common lands. The usage of mustard sticks comes down from 3639 kg to 3099 kg over a period of twenty five years. Though the model does not show any usage of dung cakes for cooking, this is unlikely to happen since some of the traditional dishes are made using dung cakes.

The fodder consumption scenario also changes with the availability of increased fodder from the common lands.

The major change in the fodder consumption scenario is the increase in fodder availability from the common lands. The model predicts that the amount of fodder allocated to the large farmer households is cut and carried from the common lands. However, this scenario seems unlikely as the costs of labour may force them to abandon the difficult task of cutting and carrying the grass from the hills. It was observed from the survey that most of the large farmer households prefer to under feed the livestock rather than cutting and carrying the grass from the common lands. Some of them even consider it as below their status to cut and carry the grass from common lands although they may have no reservation in bringing headloads of fuelwood from the common lands.

4.1.2b Small farmer households under common property

The net income of the small farmer households increases substantially under common property from Rs.10775 to Rs.13034 over a period of twenty five years at current prices (1995-96).

The land use pattern of the small farms also undergoes some change. As the fuelwood from the common lands keeps increasing, the area under mustard production declines from 0.18 ha to 0 ha in 15 years. The area under barley also declines marginally over the same period whilst the area under wheat increases from 0.91 ha to 1.1 ha.

The fodder consumption scenario also changes under common property as the fodder from common lands increases over the period. The model predicts increased activity levels in the utilisation of Tropical Bovine Units (TBU) from 1.69 to 1.95 over the same period. This means that the present level of livestock numbers kept by the small farmers is underfed and the optimal levels that can be sustained are far below the existing level of 2.4 TBU.

The fuel consumption scenario also changes with the increased availability of fuelwood from the common lands. From year 1 to 15 the use of dung cakes as fuel increases from 3304 kg to 3539 kg with the decline in the availability of mustard sticks. Thereafter, with the increase in fuelwood supply from the common lands the use of dung cakes declines to 3104 kg in twenty-fifth year, thereby increasing the availability of dung as manure for agricultural crops.

4.1.2c Landless households under common property

Landless households also benefit from the common property situation. Their net income levels increase from Rs.4456 to Rs.4848 over a period of twenty five years, showing an increase of 8.79% at current levels (1995-96).

In this scenario fodder consumption undergoes minor changes. Since the landless households have to meet their fodder requirements only from two sources, namely, common lands and bought fodder. The increased availability of fodder over the period of time reduces the amount of fodder needed to be bought by the landless households.

The fuel consumption scenario also undergoes similar changes as the common property situation continues. The use of dung cakes remains the same for the entire period since they have no need to apply it for any agricultural crops.

4.1.2d Comparison of open-access and common property scenarios

The results obtained from different runs of open-access and common property situations clearly show that pursuing the common property option is the best solution for the village over a period of time. Figure. 1 explains the changes in net income of different households under both common property as well as open-access. The changes in net income levels are less profound in large farmer households under both the scenarios in comparison to small farmer and landless households. The landless households suffer the most under open-access. They are predicted to experience a loss of 15.48% in their net income level over a period of 25 years from the current level (1995-96). The small farmer households gain considerably under common property due to the increased availability of fuelwood and fodder from the common lands, which results in an increase of 20.95% in their net incomes. Since 73.8 percent (324 out of 439) of the households belong to the small farmer type, this increase in the net income level will bring substantial benefits to a majority of the households in the village, and thus, to the welfare of the village as a whole.

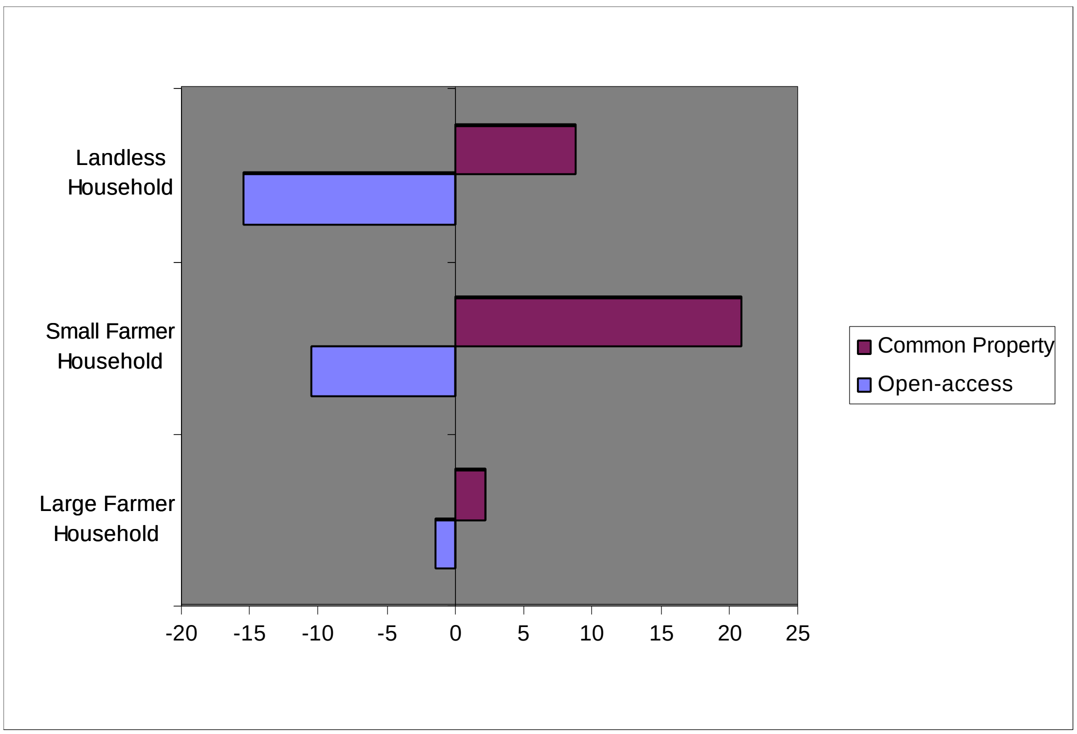

Figure 1: Changes in net income over twenty five years from the current level (1995-96) under different regimes (in percentage)

This comparison clearly indicates the importance of pursuing the common property regime by different types of land holding classes. If they co-operate, they stand to gain or else they stand to lose substantially if the open-access situation allowed to continue. It is in their mutual interest that they all pursue a regulated access management system towards their common property resources.

4.1.3 The likely scenario under common property if tree plantations are undertaken on village common lands

As part of the participatory development the Forest Department is raising tree plantations on village common lands as one-off investment for the welfare of the village community. This process is aimed at arresting the degradation of village common lands. This increases yields of fuelwood and fodder supply from the village common lands under the common property regime.

The model is run assuming that the common property situation would continue from the current year (1995-96), and that 5 ha of village common land is planted every year for 21 years on a 21 year rotation. That means, a total of 105 ha are afforested by planting trees out of a total of 232 ha of village common lands. These plantations continue to provide increased supplies from the common lands. These increases, resulting from thinnings and final harvest, are included in the model and the produce is assumed to be equally distributed amongst the households. The results from these model runs indicate a substantial increase in the net income of the village.

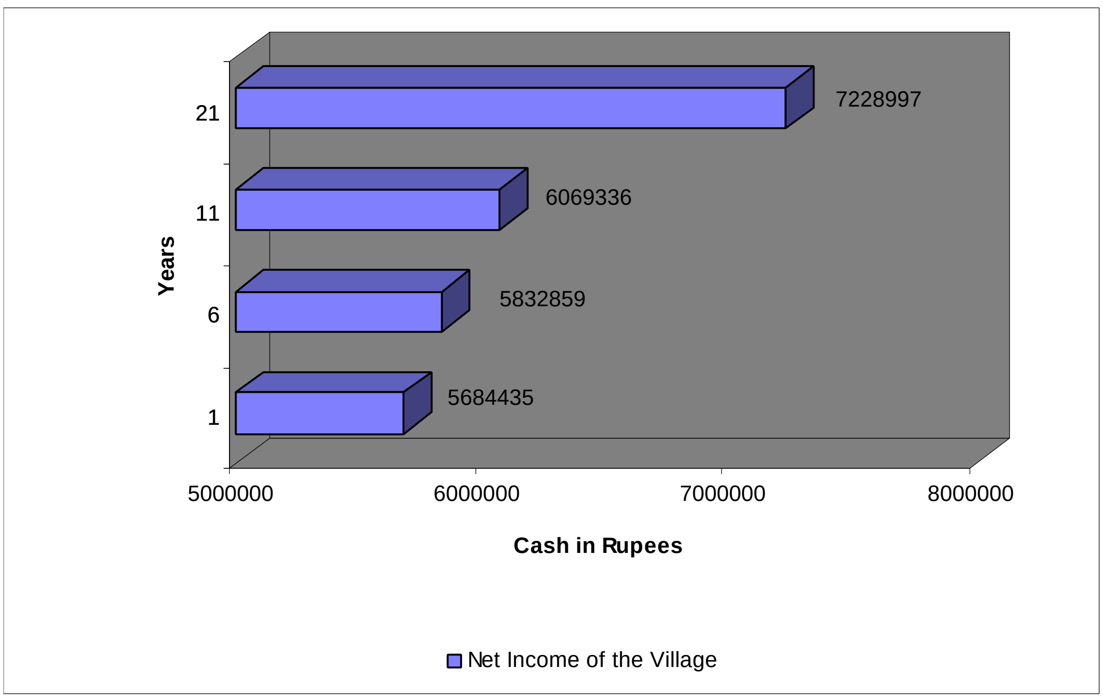

Figure 2: Net income of the village under common property if plantations are undertaken

Net income of the different households also goes up considerably over the period of time if plantations are raised and well protected (Figure. 3).

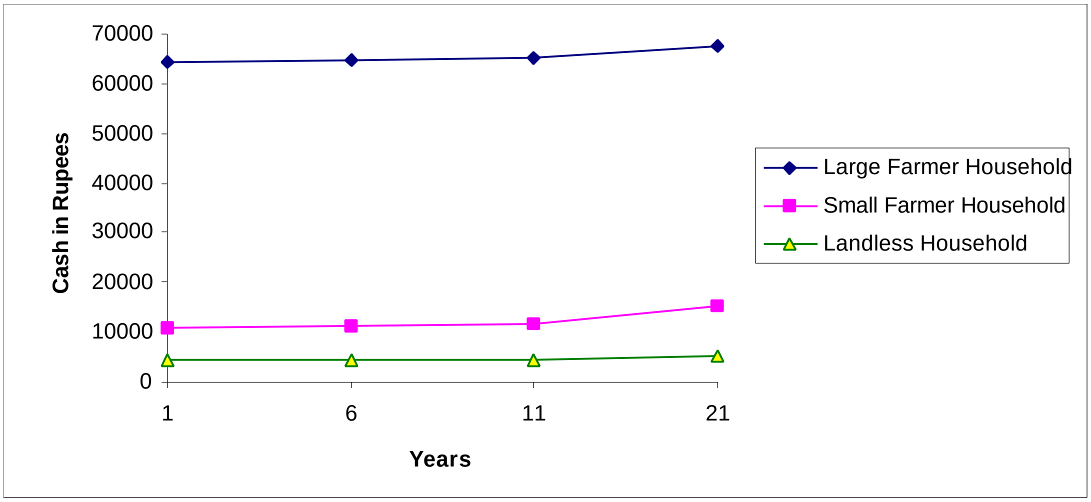

Figure 3: Net income of different Households under Common Property if Plantations are undertaken on Common lands

Though the model predicts the increases in income of different households due to increased supplies from the plantations, it remains to be seen as to how the villagers decide to use final harvest proceeds. Since the Forest Department is providing the initial investment, in plantations which do not share any of the revenue accruing from the final harvest, the VFC has a responsibility to raise plantations in the second and subsequent rotations. For this purpose they need to set aside a portion of the revenue from the final harvests. That means, part of the produce from the final harvest has to be sold in the market in order to have sufficient money required for planting in the harvested area. This ensures that the village can continue to benefit from the village common lands on a sustainable basis. It is therefore hoped that the VFC will be responsible enough to take care of the tasks of management of the village common lands for the common good.

4.1.5 The likely scenario if LPG (Liquefied Petroleum Gas) is supplied as an additional source of fuel

In this scenario an attempt has been made to visualise the net income changes at the current level if all the households in the village are allowed to buy an alternative source of fuel in the form of LPG. At present, LPG is supplied by the government at subsidised prices only in cities and big towns. If this supply is also made available to the villages then there would be substantial savings for the small farmer households. The model predicts that their net income level increases since the LPG is cheap and provides three times more energy per kg than the other sources currently being used by the households (Table 2). This increase in income levels would result from the utilisation of more dung as manure for agricultural crops rather than burning it as dung cakes. Large farmer households net income levels almost remain the same since the model does not utilise any dung cakes even without the supply of LPG for cooking purposes. Also, landless households net income levels remain the same even if LPG is provided.

Table 2: Net income changes of different households if LPG is supplied

Household Type	Current level (in Rupees)	Net income if unlimited LPG supply is allowed (in Rupees)
Large Farmer	65115	65550
Small Farmer	11420	13454
Landless	5173	5173

4.1.5a The likely scenario if no fuelwood is extracted from common lands and LPG is supplied as alternative source of fuel

Under this scenario the net income level of the village goes up from Rs.5973569 to Rs.6297321. The net income level of different households undergoes significant changes if no fuelwood extraction is allowed from the village common lands. When LPG is provided as an alternative source of fuel, the results indicate that the landless households, who are critically dependent on fuelwood from the common lands have to spend more money for buying LPG/fuelwood, and as a result, suffer a reduction in their net income levels. On the other hand, the small farmers gain since they need not divert dung for dung cakes and can meet their energy requirements from LPG. The increase in dung availability as manure also again increases their agricultural production, which in turn increases their income levels (Table 3).

Table 3: Net income changes if no fuelwood extraction is permitted

Household Type	Current level (in Rupees)	Net income if LPG supply is allowed and no fuelwood extraction is permitted from the common lands (in Rupees)
Large Farmer	65115	65174
Small Farmer	11420	12935
Landless	5173	3232

4.1.5b The likely scenario if no fuelwood is extracted from common lands, LPG is supplied as alternative source of fuel and fodder extraction by only landless households is permitted.

The model was run under this scenario to see how the net income levels change for different households. LPG availability was ensured for all the households as an alternative source of fuel. No extraction of fuelwood from the common lands was allowed but fodder was allowed to be collected only by the landless households. The model predicted that if there was no fodder available to buy from the market then the income levels significantly changed for the landless households (Table 4). The optimum levels of the TBU's that can be kept by the landless comes down to 0.34 TBU. In this scenario, both large and small farmers tend to produce more crops that would provide sufficient fodder for their livestock, such as sorghum and Bajra. At the same time since the labour requirements are less for these crops the overall employment available for landless households comes down. This resulting unemployment and the lessened income from the sale of livestock products on account of use of only 0.34 TBU as against 2.6 TBU by the landless households considerably reduces their net income to only Rs.540.

However, due to the increased availability of dung for application as manure on account of availability of LPG, the large and small farmer households are able to maintain their net income levels even though there is shift in the crop production pattern. The small farmer households net income level goes up slightly.

Table 4: Net income changes if no fuelwood extraction is permitted and fodder extraction is restricted to only landless households.

Household Type	Current level (in Rupees)	Net income if LPG supply is allowed and no fuelwood extraction is permitted from the common lands and fodder extraction is permitted by landless only (in Rupees)
Large Farmer	65115	64699
Small Farmer	11420	12736
Landless	5173	540

4.1.5c The likely scenario if no fuelwood and fodder is extracted from common lands and LPG is supplied as alternative source of fuel.

The model was run under this scenario to see how this sort of situation can be overcome by different households with no fuelwood and fodder extraction from the common lands and with non availability of fodder to buy from the market. However, in this case, no feasible solution could be found by the model since landless households are critically dependent upon the supplies from the common lands. Paying for their cooking fuel as well as being unable to feed the livestock and the reduced employment levels, drive them to a situation of starvation. The model is built to satisfy particular energy requirements of the households and since these energy requirements were not fulfilled (in the absence of money to pay for food and LPG by the landless households) the model cannot solve and provided an infeasible solution.

Although such a situation is unlikely to happen, it provides enough indications as to what would be the likely result under such a scenario.

4.1.6 The likely scenario under a dynamic situation under both open-access and common property

To examine the likely effect of increasing population numbers of both human and livestock, the model was run over a period of twenty five years. Increases in population numbers of humans was provided progressively at the current annual growth rate of 1.8% per annum (source: Census of India, 1991). Livestock numbers were also increased progressively at 3.4%, based upon the annual growth in livestock population for southern Haryana (Source: Livestock census, 1987).

Instead of splitting and increasing the number of households it was assumed that the number of households would remain the same with only number of members increasing in each household. This assumption is in line with the current joint family system prevalent in the case study area. A condition was imposed that the entire household needs (such as food energy and fuel energy requirements) are fully satisfied by all the households. This model was run under both open-access and common property situations. The changes in the net income of the village are profound under both these scenarios (Figure 4). After the tenth year with the continuing increase in the population numbers of both human and livestock, the situation gets in to a difficult position. From year 10 onwards there will be a continuous decline in the net income levels under the common property situation. The model does not run beyond ten years under open-access as it creates infeasible solutions since the entry of one or more persons into the landless households does not satisfy the minimum prescribed food energy requirements. The same is the case with common property situation after 15 years. Hence, results are presented only until 15 years for common property and 10 years for open-access situations.

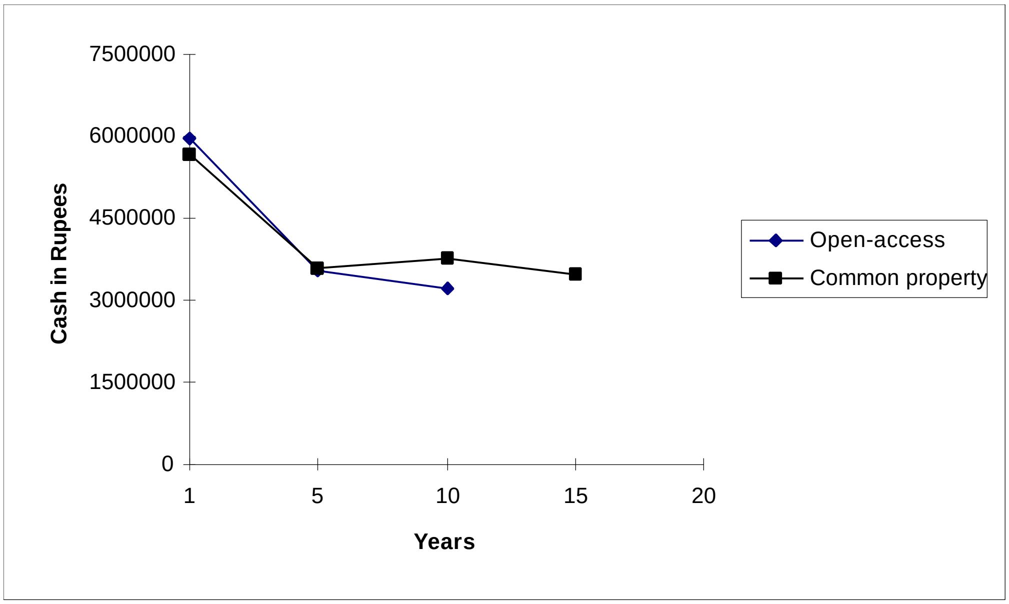

Figure 4: Village net income changes under dynamic situation

This situation clearly explains that if population growth is not controlled urgently it would lead to chaos and ultimately results in a general increase in poverty and environmental collapse irrespective of whether open-access or common property is pursued. The results of both these scenarios are presented and discussed for different types of households.

4.1.6a Large farmer households under dynamic situation

Large farmer households can accommodate the increase of more members in to their households. Since they own large farms they can even accommodate an increase in livestock numbers. Under both open-access as well as common property the net income levels decrease from year 1 to year 5 on account of increases in population numbers and the need to feed both human as well as increased livestock populations. From year 5 onwards the net income level increases under both the scenarios. Even though there is an increase in human population putting a drain on the net income level of the households this is more than offset by the increased livestock numbers to which there is sufficient fodder. As the milk production level increases on account of this increase in livestock from 2.6 TBU to 3.6 TBU revenue increases. The increased number of TBU's also raises dung production and application of more dung to agricultural crops increases the production levels. This in turn increases the revenue of the household. The scenario is the same for the open-access and common property situations, with a slight increase in income in the common property scenario on account of an increasing availability of fodder and fuelwood from the common lands. Beyond year 10, as number of persons increases in the household the net income level starts decreasing, even under common property situation, as the marginal productivity of livestock no longer sustains food demands.

4.1.6b Small farmer households under dynamic situation

The net income level of the small farmer household also undergoes similar changes as in the case of large farmer household. Under the open-access situation the net income level declines gradually from Rs.11420 to Rs.3466 in 10 years with the increasing human and livestock numbers. Increase in livestock numbers does not create any increase in the net income levels as in the case of large farmers since their livestock is already under fed and there is no more scope to increase the availability of fodder from the farm land. The net income level under common property also decreases in the first five years on account of restrictions in removal of fodder and fuelwood from the common lands, but registers an increase in the net income level marginally up from Rs.4678 to Rs.5036. This increase is attributable to the increased supplies from common lands. The income level declines marginally under common property from Rs.5036 in the tenth year to Rs.4936.

4.1.6c Landless households under dynamic situation

Landless households are the worst affected if any increase in the number of members in the household takes place. With access regulations in force they cannot collect fuelwood and fodder under common property situation in an unlimited quantity. They can only collect in a limited quantity as specified by the VFC. With employment levels remaining constant, there is no scope for them to increase their income levels even though working members number in the household rises. Under open-access, resources will soon be exhausted due to excessive exploitation of fodder and fuelwood from the common lands. Under both scenarios they become the worst affected. The model creates infeasible solutions under open-access after 10 years time and under the common property situation, after 15 years. These infeasible solutions are the direct result of increase in the landless household size as they cannot fulfil their food energy and fuel energy requirements.

It can be safely concluded that under such a dynamic situation, people will be better of if they control the population and adopt a common property regime in place of an open-access regime. This situation might change with the falling population growth level with the spread of better education and awareness about limiting the family size and the increasing adoption of family planning methods. In the coming years population growth will definitely come down as it has been the case in the last two decades. The key to the success of the common property regime and people’s participation in participatory development will depend upon the extent to which population growth can be reduced.

5.2 Sensitivity analysis of the model

An attempt has been made to understand as to how stable the model will be if either the yield levels of agricultural crops increase or decrease over the current level by 20% and the prices of agricultural products and labour increase by 20%. Decreases in prices could not be anticipated since normally such a thing never takes place and the prices in the past fifty years have always shown an upward trend (Dantwala, 1996).

5.2a Sensitivity analysis due to fluctuations in agricultural crops yield levels

The model predicts that the changes in level of agricultural production can have a significant impact on the level of net income the households can generate. While it is more profound in large and small farmer households it does not have any change as far as the landless households are concerned. Their cash levels by and large remain constant irrespective of the decline or increase in the level of agricultural production. This situation can be understood easily by the fact that the land use almost remains the same, hence the level of employment for the landless remains the same as the labour requirement for different crops remains the same. These runs are undertaken at the current level of extraction of fodder and fuelwood from the village common lands. Increase in agricultural production is anticipated at 20% on account of better monsoon and other favourable conditions. Similarly a decline of 20% in agricultural production level is anticipated if there is a drought or flood. The model remains fairly stable under these changing scenarios.

The landuse pattern does not undergo any significant variation whether the production levels of agricultural crops change by 20% either way. The model is therefore fairly stable in its' projections in both the scenarios and does not predict any significant changes in the landuse pattern as far as Large Farms are concerned.

The model does, however, predict some change in to landuse as far as Small Farms are concerned.

Onions are grown to the extent of 0.057 ha. if the production level increases by 20% where as no onions are grown if the production levels fall by 20%, since the drop in food grains production has to be compensated by allotting more area under cereals in order to meet the food grains requirement of the family. Despite these minor variations the model is fairly stable under both the scenarios.

5.2b Sensitivity analysis due to increase in prices of agricultural products and labour wages.

The model was run to examine how net income levels would change under a scenario of an increase in prices of agricultural products and labour at 20%.

The model is fairly stable to price changes and corresponding increases in the incomes can be seen if the products they produce can fetch them more money. At the same time landless households also substantially benefit from the increase in labour prices. It can be safely anticipated that the prices of agricultural products keep increasing every year as a result of increase in support prices by the government from time to time. Similarly the labour wages also go up periodically and are dictated by the minimum support price announced by the government from time to time under the provisions of the Minimum Wage Act. These increases in labour wages are due to the increase in inflation level.

5.3 Conclusion

The scoping studies undertaken to forecast the likely scenarios under various options were presented. A single objective linear programming model incorporating multiple objectives as associated constraints was used in conducting scoping studies. This model incorporated the household dynamics of different land holding classes, their interactions with the private property resources as well as common property resources. Thus, reflecting entire village community into a single model served a very useful purpose in analysing the situation. The socio-economic survey undertaken in 1995-96 formed the main basis for deriving the coefficients used in the model.

In the absence of recorded data the validation could not be possible. Ideally speaking each of the coefficient values in the matrix should be validated individually. But in reality, this was not entirely possible in the absence of recorded data on many of the coefficients. Most of the data were judged to be reasonably reliable as they were based on either records or observation or estimates and experience of the households participated in the area. Village wise landuse patterns and crop production parameters were not available. Specific data was not available in respect of demand for various products. The survey results provided the much needed information in specifying the coefficients. Due to the limitations in the availability of the recorded data the model is assumed to be valid by the experience and knowledge of the researcher concerning the area.

Despite these limitations the model is a useful tool for analysing the different scenarios of CPR management. This is also a novel application of mathematical modelling which has not previously been applied to study the effect of participation in CPR management and to the outcomes of open-access and common property. These outcomes are extremely useful in understanding the institutional success in management of common property resources. No single optimal solution to the problem exists. Under different scenarios the model generates a different set of outcomes and each scenario has to be judged from its usefulness from the management point of view. The model developed can be used to judge the institutional success or failure in managing the common property resources.

There is a need to further explore all the possible management options based on different level of inputs on the common land and the farm lands. More data collected on the basis of field experimentation and work studies would have made the model more useful. For example, plantation species in different combinations and different agroforestry techniques to augment the fuel and fodder resource supplies from the farm lads would have given a wide range of potential options to choose from. Only through the multidisciplinarity can problems of resource management be solved. However, any such follow up work should involve a multi-disciplinary team comprising experts from various fields of rural development. This team should be as broad based as possible, but it should, at least include a forester, a sociologist, a political scientist, a soil scientist, an agronomist, an economist, a farmer and a modeller in order to make this model a more meaningful tool for testing the efficacy of different options available to them. It is also the first time that the concept of modelling has been applied to test the effectiveness of the institutions under open-access and common property. Despite the limitations the modelling can be made more elaborate to accommodate further activities in order to make the model reflect every activity of the households.

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