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Common Property Resources Agricultural Development Strategies and the Poor in West Bengal

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Common Property Resources, Agricultural Development Strategies And The Poor In West Bengal.

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EXECUTIVE SUMMARY

1.INTRODUCTION

This study examines the impact of agrarian development strategies on the use of rural common property resources (CPRs) by the poor in West Bengal.

Governments in developing countries usually aim at rapid agricultural development combined with uplift of the poor. However the relation between agricultural development efforts and the conservation of CPRs is often ignored. Agrarian Development adversely affects the supply of common property resources (CPRs) on which the poor largely depend for their livelihood. On the other hand, better income and employment opportunities that follow from development may also reduce the dependence of the poor on CPRs, thereby preventing the overexploitation of such resources. Thus while some of the poor may benefit from such development efforts like redistribution of land, public irrigation, input subsidies, creation of employment or income generating assets, others have to fall back on a reduced supply of CPRs

Ignoring the relations between the private property resource (PPR) and CPR based processes often lead to contradictory set of policies that are unsustainable in the long run. Subsidising irrigation in areas with a low water table or providing cattle through IRDP in areas where pastures are scarce are common examples. Thus a study on the impact of agricultual development strategies on the use of CPRs, is essential to promote a balanced development of CPR and PPR based activities for the improvement of the condition of the poor in the state.

2. OBJECTIVES OF THE STUDY

Our *overall goal* is to examine the impact of agrarian development strategies on the use of rural CPRs by the poor in West Bengal with a view to aid the formulation of an integrated policy for environmentally sustainable development of agriculture.In line with this goal, the *present objective* is to examine, in selected areas of West Bengal, the impact of *specific agrarian strategies* – like (I) *land reforms*, (ii) *irrigation* and promotion of *modern agrarian techniques*, and (iii) *rural development programmes* – on (a) the *interaction* between the CPR and PPR based processes, (b) the *supply of CPRs*, (c) the *demand and use of CPR* based items by the poor, and (d) *welfare and economic inequality,*

3. METHODOLOGY

3.1: Valuation Of CPR-Based Items

CPRs are usually freely accessible to all of the village so that markets or prices for them do not exist. We therefore have to adopt alternative methods for valuing them, such as:

1. Imputed Market Values: Value of Equivalent Alternative Market Based Items. This is applicable to food, fuel and fodder, though one must take the value of cheapest alternative as these are generally 'inferior' goods.

2. Time Spent In Collection: Value of Time that could have been spent in other gainful use (wage employment, leisure). This is similar to the 'Travel Cost Method' used in valuation of national parks (Dixon & Hufschmidt,1986)

3. Carrying Capacity: Maximum population size that a resource stock can sustain.

3.2 Supply Of CPRs

Some possible approaches are to adopt (a) Total Area under CPRs, (b) Area under CPRs relative to total village area or (c) Per Capita Area under CPRs as indicators of CPR Supply for the village. The problems with such measures are that (i) CPR area for a village is difficult to specify - the same CPR area may be shared by villages (ii) such measures do not take the quality of resources into account and (iii) they are more suitable when time series data is available.

Instead, we choose as our indicator of CPR supply:

$$\text{The } \frac{\text{value of collectn}}{} \times \frac{\text{CPR Area}}{} \times \text{vill area}$$

$$\text{Av value of CPRs collected pr hour} := \frac{\text{CPR Area} \quad \text{village area}}{\text{Number of adults}}$$

$$= \frac{\text{value of collection}}{\text{Hrs spent in Coll}} \times \frac{\text{Hrs spent in collection}}{\text{No of adults}}$$

$$= \text{Av value of collection per hr (V)} \times \text{Av Time Spent in collection per adult } (L^{O}_{CPR})$$

The last factor L^{O}_{CPR} varies across households and is related to CPR Demand, while the first factor V is approximately constant for a particular village and therefore may be appropriately used as an indicator of CPR supply. Note that (i)

such an indicator is appropriate for a comparison of CPR supply between different areas - those with high and low implementation levels of specific agricultural policies for example and (ii) it takes 'quality' into account. Thus average collection per hour in a village is lower if either relative forest area (quantity) or quality/state of the forest is poor.

3.3 Demand For CPRs

In this study, we take the ***time (hours) spent per adult in collecting CPR based items,*** L^{O}_{CPR} , as the main indicator of demand for CPRs. This is similar to the ***travel cost method*** of measuring the value of recreational sites such as national parks which cannot be adequately measured by the gate price and is approximated by their travel cost. Similarly, if rural households value the time spent in collecting CPR items we could use this as a proxy for their CPR demand. We ***do not value this time at the prevailing hourly/daily wage rate*** as people engage in CPR collection only when they do not find employment. CPR-based items are considered "inferior" and forms part of the household's residual consumption basket. The choice then is not between wage employment and collection, but between collection and leisure or household activities.

We first use ***OLS regressions*** with L^{O}_{CPR} as the dependent variable and $\overline{N}$ (household size), $\overline{Y}_{N}$ (per capita income) as independent variables:

$$L^{O}_{CPR} = \alpha + \beta_1 Y_N + \beta_2 N + \beta_3 \overline{L}_W \qquad (1)$$

Next since, household income and employment depend on family composition, area characteristics and policy benefits, we estimate the ***reduced form OLS equation***:

$$L^{O}_{CPR} = \alpha + \beta_1 Y_{NA} + \beta_2 N + \beta_3 Female\% + \beta_4 Child\% + \beta_5 Areadummy + \beta_6 Policybenefits \qquad (2)$$

Policies are frequently chosen based on household characteristics, income and area specifics. For example, the low income and low landowning households are beneficiaries of land reforms and rural development policies. Hence, in an OLS regression with CPR demand as the dependent variable, the coefficients of policy variables – particularly those that are more 'targeted' - may then be positive instead of negative, contrary to our expectation. This is because ***the recipients of***

antipoverty policy benefit smay have relatively higher CPR demand as almost all of them are poor. One way to get around this problem is to use ***the method of 2-Stage least squares*** where the family composition, income, land owned and area features are included as predetermined variables. We therefore estimate the following simultaneous equation system:

L_{CPR} = ϕ (**family size and composition**, , *policy benefits)* (3)

Policy benefits = ψ (**family size**, *other policies,* **land & other endowments**) (4)

by the method of 2-stage Least squares.

3.4 Common Property Resources, Inequality and The Gini Coefficient:

On the one hand Agricultural development policy may degrade the current supply of CPRs and on the other may increase the households non-CPR income leading to a reduction of CPR demand. In the short run, we may observe two kinds of effects on rural inequality if the CPR income is taken into account:

- ***higher rural inequality in the high policy implementation villages*** because only some of the poor receive benefits from these policies while those that do not fall back on a reduced supply of CPRs. This effect should be stark when only non-CPR income is considered, but still exists if CPR income is considered

- second, in general, the poor depend more on CPR income, so that ***if the CPR income is taken into account, the degree of inequality appears to be lower***.

To examine these factors, we calculate the GINI coefficients of income with and without the CPR income included for all villages in the area studied. This is given by the formula:

$$G = |1 - \sum_{t=0}^{T-1} (Y_{t+1} + Y_t)(N_{t+1} - N_t)$$

where Y_t = Cumulative proportion of income upto t the income class and N_t = Cumulative proportion of income upto t the income class

Note that we calculate ***Gini coefficients for the entire village and not only for the poor***. This is because as a result of agricultural policy implementation a substantial proportion of the population that was initially poor may be presumed to have crossed the poverty line over a period of time. Thus restriction of attention to households who are presently poor would give an incomplete picture of the impact of agricultural policies..

3.5 Agricultural Policy Indicators

We adopt two types of indicators of agrarian development for the purposes of the study:

a) ***General indicators***: these are the items that indicate the overall level of agrarian development or progress in a region such as indicators of productivity like ***yield*** per unit area, ***cropping intensity***, ***wages*** per labour day.

b) ***Indicators of specific agrarian strategies***: These include:

1. ***Land Reforms*****:** percentage of landless who have received land and percentage of tenants who have recorded their tenancy, cropshare received by tenants,

2. ***Technological Reforms***: irrigation ratio, multiple cropping, fertiliser and HYV use per unit area, agricultural investment and institutional credit for production,

3. ***Rural Development Programmes***: proportion of the poor who have obtained jobs in rural employment (e.g. JRY) schemes or assets through self-employment (e.g IRDP) schemes like subsidies for cattle, poultry, making of saleable items from forest products such as 'sal' and 'kendu' leaves and promotion of fisheries.

3.6 The Survey

The data was obtained from the districts of Birbhum and Burdwan in West Bengal. **First,** we made a preliminary survey of 60 villages in Ausgram I and II and Raina C.D. blocks of Barddhaman and Bolpur, Ilambazar, Labpur and Rajnagar C.D. blocks of Birbhum based on the District Census Handbooks and maps from The Survey of India and National Atlas. We did a *Preliminary Village Level Report*

Information was obtained from discussion with block and district and *panchayat* officials, NGOs, and study of district and block reports and maps.

Based on this survey, 18 villages were selected in the **second stage** – 6 for each type of CPR, i.e., land, forest and water. Out of these 6, 2 are chosen to focus on each type of agrarian strategy, (i.e., land reforms, technology and rural development programmes). *Of these two*, one each has been chosen for 'high' and 'low' implementation. For example, the villages chosen to represent 'high' land reform implementation have high proportion of recorded leases, high cropshares and number of land redistribution beneficiaries. Similarly, those chosen 'low' technology policies have poor public irrigation facilities, unsatisfactory levels of insitutional credit disbursals etc. These are covered with a *Detailed Village Level Report* dealing mainly with (a) village natural resource and CPR flows (b) the access to these flows and (c) use and management of these flows.

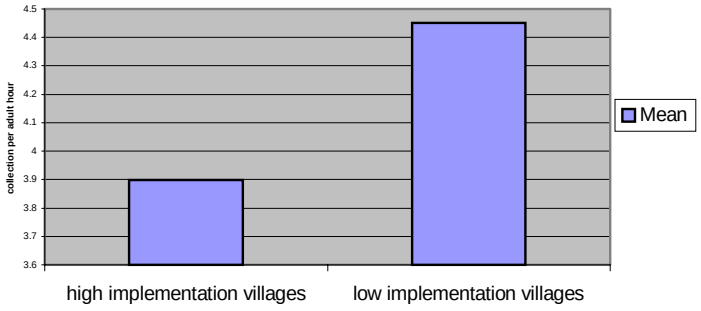
Along with the detailed village survey, a preliminary listing of all households in each of the 18 villages based on a *Preliminary Household Questionnaire* is carried out. This questionnaire focuses items including on (a) agricultural and nonagricultural income and assets (b) identification as poor or non-and leads to a classification of all households into : (I)non poor, (ii) poor, beneficiaries of agrarian development policies, (iii) poor non benefiaries. At the **final stage**, 30 households are selected from each villageaccording the proportion of the groups in the population. These are covered by a *Detailed Household Questionnaire*

4. DATA ANALYSIS AND RESULTS

4.1 The Supply Of CPRs

One important property of CPRs is that the supply of the resource is common to all households in a particular village or locality. Since we have detailed data for only 18 villages, we begin by studying the impact of policies on the average levels of supply.

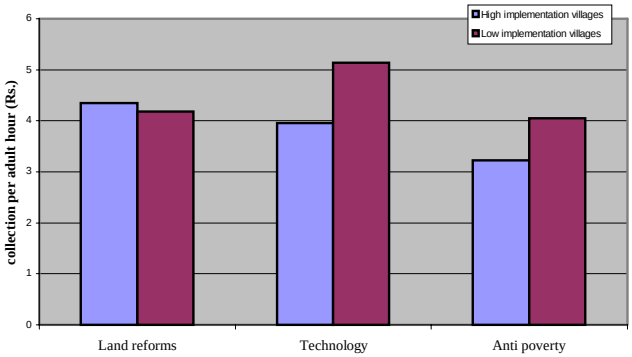
Chart 1: Effect of Policy Implementation on Average CPR supply



Result 1: *The av. collection per hr in the high implementation villages is lower than in the low implementation villages & this difference is statistically significant*.

However, it is important here to conduct the same test separately for the 3 policy areas

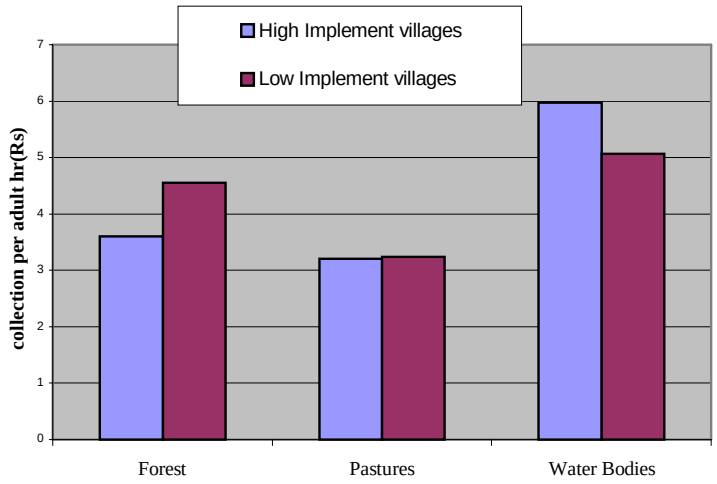
Chart 2: Effect of Specific Policies on Average CPR supply by policy



Result 2*:* *The av. collection hr is* (*significantly*) *higher in the 'low implementation' regions for Technology and Anti pov policy areas*; but *lower in the' land reform areas*

Thus, while implementation of technology and rural development policies deplete CPRs , land reforms do not. To probe this, we examine the average collection per hour in land reforms areas for the 3 types of CPR areas: forests, pastures and water bodies.

Chart 3: Impact of Land Reform on CPR Supply by area type



Result 2A: *Average collection pr hour in high land reform implementation villages is lower for forest and pasture areas but (significantly)higher in water-body areas*.

4.2 The Demand for CPRs

We estimate the OLS regression which sets household demand for CPRs - hours devoted to collection per adult (PRADHRCP) - as a function of FAMAD, PERCAPINC and LABDAYS and of household size (HOUSENO), percentage of children (PCTCHIL), of women among adults (PCTFEMAD) and area dummies (FOREST, PASTURE). The result is given in Table 1

Result 3. *Collection time per adult decreases with income, labour days and family size and increases with female and children. It is higher in forests and pastures compared to waterbodies*.

Table 1: General determinants of hrs spent on collection per adult (PRADHRCP)

Model 2. OLS	1.OLS 3. OLS		
CONST	247.940 ** (8.470)	79.802* * (2.798)	23.091 (.753)
PRCPINC	-.774** (-2.171)	- 487 (-1.485)	-.576 (-1.788)
LABDAYS	.702** (7.196)	1.510** (4.081)	1.159** (4.202)
FAM ADL	-25.122** (-3.482)		
HOUSENO		-11.162** (-2.238)	-9.320** (-1.924)
PCTCHIL		2.798** (5.586)	2.484** (5.107)
PCTFEMAD		3.355 ** (8.306)	2.859** (7.208)
FOREST			151.900** (6.581)
PASTURE			58.901 * (2.575)
R^2	0. 188	0.305	0.358
AdjR2	0. 183	0.299	0.350
F	41.322	46.967	42.355
SigF	.000	.000	.000

* significant at 5% level; ** significant at 1% level

Next, we carry out OLS regression of the following policy variables on PRADHRCP: (1) VESTPERC – per capita vested land received– and REGDTEN – dummy variable indicating if tenancy is registered for land reforms, (2) IRDP – benefits under IRDP scheme and JRY as indicators of antipoverty programmes, and (3) CRINT – cropping intensity and COSTINT – expenditure on cultivation per unit gross cropped area as indicators of technology policy.

A possible problem is that ***the households who have received targeted policies like IRDP, JRY or vested land have been selected on the basis of their household characteristics, income, as well as area specific parameters***. We therefore estimate Equation (3) in Section 3.3 by the method of 2SLS where the above factors are include as Predetermined Variables and the policy variables as endogenous. The results of the OLS and 2SLS models presented below show :

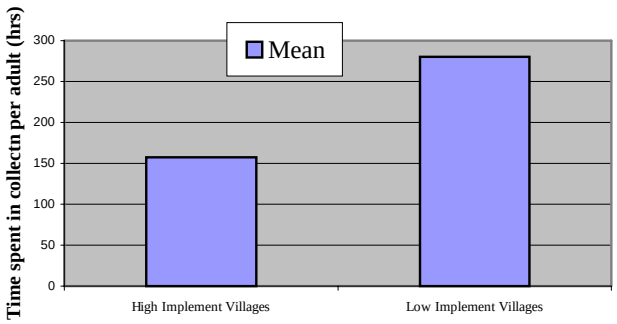
Result 4: *Time devoted to collection per adult member in the household is significantly*(*in the statistical sense*) *lower for households that have directly benefited from land reforms and technology policies. However, for policies targeted towards the poor - like IRDP, JRY and land redistribution - the validity of this relationship is difficult to discern from cross-section data.*

Table 2: Impact of Policy on hours spent on collection per adult (PRADHRCP)

Model	4. OLS	5.OLS	6. OLS	7.2SLS
CONST	226.856	117.064	23.464	373.88
	(7.179)	(2.450)	(.483)	(2.300)
REGDTEN	-49.390	-60.355*	-40.093	-7.556
	(-1.508)	(-2.028)	(-1.338)	(-.142)
VESTPERC	.547	398.613	325.493	303.540
	(1.449)	(1.497)	(1.915)	(.076)
COSTINT	-30.145**	-21.175*	-6.354	-136.428**
	(-3.383)	(-2.158)	(-.661)	(-3.144)
CRINT	-18.894	9.183	19.794	21.300
	(-.987)	(.609)	(1.365)	(.910)
IRDPBEN	23.221*	6.387	6.856	-15.369
	(1.753)	(.488)	(.554)	(-.820)
JRYPRCP	2.280**	1.557*	1.585*	-.490
	(3.377)	(2.240)	(2.385)	(-.077)
OWNPRCAP	-64.003**	-43.356	-41.807	
	(-2.655)	(-1.684)	(-1.687)	
NAGPCINC	-1.389	-.660	-1.216	
	(-1.260)	(-.553)	(-1.067)	
LEASEPERC		125.285**	143.036**	
		(3.682)	(6.197)	
HOUSENO		-11.682 **	-9.923**	
		(-2.626)	(-2.355)	
PCTCHIL		3.142**	2.541**	
		(5.928)	(5.140)	
PCTFEMAD		2.039**	1.818 **	
		(4.272)	(4.007)	
FOREST			92.863**	
			(3.668)	
PASTURE			66.401**	
			(2.5088)	
R^2	0.202	0.386	0.458	0.288
AdjR2	0.185	0.363	0.434	0.265
F	11.671	16.966	19.384	12.651
SigF	.000	.000	.000	0.000

Next, we compare the difference between the time devoted to collection in areas selected for high and low implementation of anti poverty programmes to check whether these have an impact on demand for CPRs in the area beyond the effect on targeted beneficiary households.

Chart 5: Impact of Policy Implementation on CPR demand in Anti Poverty Program Areas

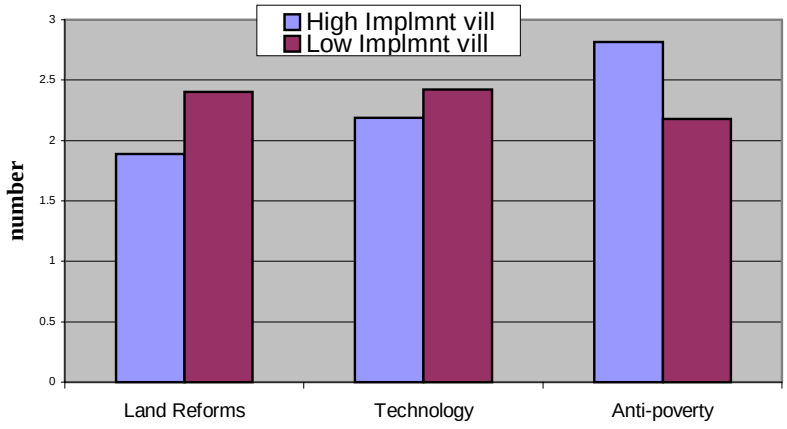


Result 4A: *The average time spent per adult is significantly* (*in the statistical sense) lower in villages selected for good implementation of anti poverty programmes compared to the areas where the implementation of such policies were poor.*

4.3 Interaction of PPRs and CPRS - Grazing

Hours spent on grazing is not an adequate indicator of the demand for grazing. While cattle ownership is an obvious measure of 'demand for grazing', the reduction in feed cost per cattle from grazing is an indicator of the grazing resources in the relevant area.

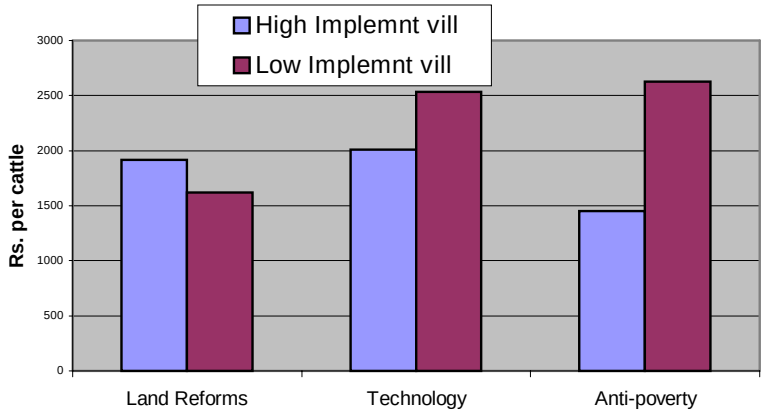
Chart 7: Impact of Specific Policies on average cattle ownership



Thus, average number of cattle cattle per household is higher in Low policy implementation villages than in high implementation ones except in case of areas for anti-poverty programmes which frequently subsidise purchase of cattle.

The 'supply' of CPR grazing resources is estimated by the value obtained from grazing per cattle. This indicates the degree to which grazing substitutes for purchased feed and depends on the quantity and quality of the uncultivated fallows that are utilized as CPR grazing lands.

Chart 8: Impact of Specific Policies on average income from grazing per cattle



Result 5: *The income from grazing per cattle is higher in the low implementation villages compared to the high implementation ones except in the case of land reforms, where the difference – although in the reverse direction – appears to be statistically insignificant.*

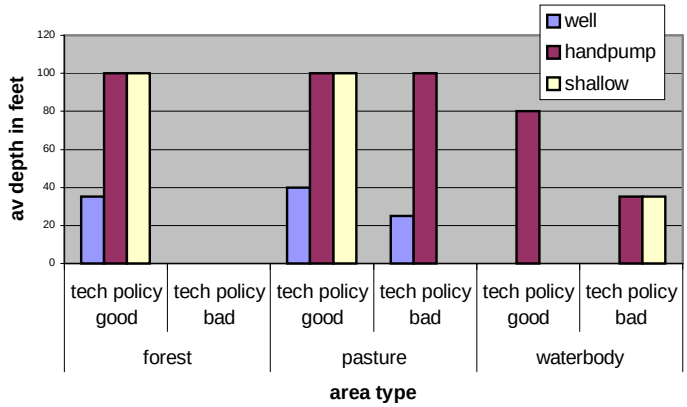
Since good implementation of anti poverty programs like IRDP lead to higher cattle per household, the greater pressure on grazing land is likely to reduce the income from grazing per cattle. For technology policy where 'high implementation' villages appear to have lower cattle ownership per household., the likely reason for lower average income from grazing per capital is the shrinking of grazing land as reflected in the higher number of cattle per unit grazing area.

Chart 9: Impact of technology policies on grazing intensity by Area Type

4.4 Use of Common Property Water

Domestic and farm use of water are difficult to link with agricultural policies. For example, overexploitation of groundwater raises tubewell depth both in the 'high' technology village and in its 'low' technology neighbour as both draw from the same underground aquifer. We may include the depth of wells and hand pumps but even then the depth to which these are sunk may not indicate the required depth. With these in mind, we present the water table data for the technology policy areas in Chart 10 to show that intensive cultivation indeed lowers the water table.

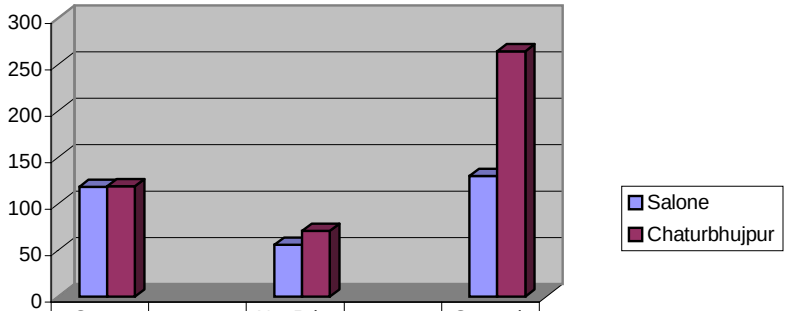
Chart 10: Impact of Specific Policies on the water table



4.5 Carrying Capacity Analysis:

Another way to analyse the impact of agricultural development is the method of carrying capacity analysis. We carried out this analysis for two ponds in waterbody areas selected for the study of technology policy - Salone and Chaturbhujpur.

Chart 11: Carrying Capacity Analysis of Impact of Technology Policy on Surface Water Resource Productivity



	Gross Prim		Net Prim Pdvt(mgC		Second. Fish
Salone	118.3		56.16		129.6
Chaturbhujpur	118.75		71.09		264.6

Briefly, the consultant finds that although the gross primary productivity values are equal in both the ponds, the net primary productivity and hence the estimated fish productivity is much greater in pond II (Chaturbhujpur) in the low technology policy implementation area.

4.6 Agricultural Policy, CPRs And Inequality

The poor depend more on CPR based resources than the comparatively better off. Thus, including CPR based income may decrease the estimate of rural inequalities. Agricultural policies, while improving the economic condition of a section of the population lead to a deterioration of most CPR products. Those not benefited directly by these policies may be forced to fall back on a reduced supply of CPRs. Thuis, while mean incomes in the area may inequality of income (as characterized by GINI coefficients in Table 3) including the CPR resources in the village is likely to increase over time.

Table 3. Impact of Policies on Mean Income and Income Inequality (Gini coefficients)

		land reforms				technology				Antipoverty			
	poly												
area	impln	PCpINC w/o cpr		PCpINC with cpr		PCpINC w/o cpr		PCpINC with cpr		PCpINC w/o cpr		PCpINC with cpr	
		mean	gini	mean	gini	mean	gini	mean	gini	mean	gini	Mean	gini
forest	low	6693.161	0.406	7867.28	0.353	3243.7	0.327	4718.69	0.273	1892.6	0.324	4037.89	0.235
	high	9303.133	0.596	10663.6	0.512	5428.38	0.538	7546.56	0.415	3042.36	0.298	4989.103	0.244
pasture	low	3769.303	0.347	4762.59	0.295	5389.88	0.526	9135.2	0.447	4940.45	0.439	6208.809	0.372
	high	2603.114	0.434	4060.57	0.339	7882.42	0.385	6938.93	0.314	7342.81	0.4	7711.421	0.383
watbd	low	6195.371	0.255	6718.21	0.268	3697.54	0.312	5608.12	0.238	2979.2	0.461	4729.776	0.405
	high	4261.002	0.315	5584.39	0.454	6709.95	0.422	7586.51	0.394	6514.85	0.36	7304.099	0.284

Result 6: *High implementation of Agricultural Development Policies*

1. *raises mean per capita income - with and without CPRs - except for land reforms*

2. *raises inequality except in the case of anti poverty programs*

5. A SUMMARY OF THE MAIN RESULTS

1. High implementation of Land Reforms reduces the demand for CPRs without significantly affecting supply and is unlikely to cause a major degradation of CPRs. Moreover, income from grazing does not decline in the 'high' implementation areas. However, land reform lowers per capita income - except in forests - and raises inequality except in waterbody areas.

2. Implementation of Technology Policies reduces both the demand for and the supply of CPRs and also perennial and seasonal fallows so that the income from grazing is reduced. The long run impact therefore depends on which of the two effects are stronger. Per capita income and income inequality within the village is higher as a result of policy implementation

3. Implementation of anti poverty programmes raises the demand for CPRs while degrading supply and are most likely to cause degradation of CPRs. For example, IRDP programmes lead to higher cattle ownership causing greater pressure on land and lowers the income from grazing. However, these programmes raise per capita income and reduces rural inequality

6. POLICY RECOMMENDATIONS

If we look at specific agricultural policies, the recommendations are as follows:

1. **Land Reforms:** Policies in these regard were formulated and implemented before 1980s - and their little scope for further reform in our study area.

2. **Technology and Irrigation Policies:** Sustainable agricultural policies should aim at preserving agricultural income and employment - particularly of the poor - without degrading CPRs. These include: (a) study of the natural resources in each area (b) Choice of appropriate crops through incentive or support prices, (c) ncrease in the use of organic manure and pesticides to replace chemical fertilizers and pesticides to through appropriate taxes and/or subsidies (d) Optimizing the use of surface and groundwater to preserve the water table, possibly by participatory management methods

3. **Anti Poverty Programmes:** It is important that the administrators of these programmes take into account the consequences of these policies on CPR demand and supply. Thus, promoting purchase of cattle by the poor in an area with low pastures should be discouraged. The need is: (a)setting up Joint Rural Resource Management Committees that take an integrated approach towards the private and common property resources in an area. (b) Selection of appropriate self employment and rural works schemes (c) Coordinate the functioning of CPR management schemes (such as JFM committees) with Rural Development Programmes and judicious use of rural works programmes - like JRY - for developing and maintaining watersheds and in promoting social forestry.

Chapter I. INTRODUCTION AND BACKGROUND

1. 1 INTRODUCTION

This study examines the impact of agrarian development strategies on the use of rural common property resources (CPRs) by the poor in West Bengal. Agrarian Development adversely affects the supply of common property resources (CPRs) on which the poor largely depend for their livelihood[1]. On the other hand, better income and employment opportunities that follow from development may also reduce the dependence of the poor on CPRs, thereby preventing the overexploitation of such resources. In the state of West Bengal, which is considered as having satisfactorily implemented most of the agrarian development strategies but is limited in CPRs, we propose to study the impact of these strategies on the use of CPRs by the poor and identify strategies for a balanced development of CPR and PPR (private property resource) based processes to promote a more equitable allocation of resources.

1.2 BACKGROUND

Agricultural development efforts — like more irrigation, intensive cultivation, use of chemical fertilizers and pesticides — are commonly associated with degradation of CPRs[2]. So is land reform, particularly when it involves redistribution of reclaimed land or cultivable fallows of large landowners. It is now recognized that 24% of all irrigated land world wide suffers from salinisation due to bad irrigation practices, while deforestation of tropical forests due to agricultural, construction and other uses is currently proceeding at the rate of 0.9% a year. In India, deforestation prceeded at a rate of 0.15 million hectares annually, although this declined to the present rate of 16000 hectares per year since the Forest (Conservation) act was enacted [GOI 1999]. Permanent pastures have also declined at the rate of 0.8% between 1965-89. There is also a significant loss of biodiversity from this loss of natural habitat (World Bank 1992).

[1] Gradwold and Greenberg (1988) and Fisher and Hanemann (1997), for example, note the threat posed to forest resources by increased use of modern agrarian techniques while Vyas and Reddy (1993) examine the environmental problems of intensive agriculture in India. The adverse institutional impact of agricultural development on CPRs is also discussed by Somenathan (1991), Dasgupta and Maler (1997), Noronha (1997) and othes.

[2] see for example Commoner (1971), Ehrlich, Ehrlich and Holden (1977) for the general dangers posed to to the environment by increased irrigation and use of fertilizers and pesticides. See also footnote 1.

This *reduction in the supply of CPRs* severely affect the poor who in India as elsewhere, depend more on CPRs than the better off, the dependence being markedly greater in agriculturally backward areas. Thus, agricultural development efforts may worsen the relative position of the poor, leading to an *increase in economic inequality*.

On the other hand, *free access* to CPRs such as grazing grounds or forests may lead to their *overexploitation*. This is particularly true in agriculturally backward areas where the *opportunity cost* of labour is very low due to low wages and high unemployment. Increased irrigation or adoption of new agrarian techniques in these areas is likely to increase the demand for labour and wages, thereby mitigating the problem of overexploitation of CPRs to a certain extent. Thus Rao (1994) finds that "area under forests as well as their denudation is higher wherever the percentage of net sown area is lower"(pp 187-88). The same may be true of land redistribution and rural development programmes which endow the poor with income generating assets. Such *reduction in demand* for CPRs by the poor is particularly likely when the associated goods are *inferior* in the sense that their consumption decreases with rising incomes.

In sum, while agricultural development efforts *reduce the supply* of CPR based items, they may also *reduce the demand* for such items by the poor. In the latter case, their lower use of CPR based resources may imply that they are actually *better off*.

Governments in developing countries usually aim at rapid agricultural development combined with uplift of the poor. However the relation between agricultural development efforts and the conservation of CPRs is often ignored. As a result, while some of the poor may benefit from such development efforts like redistribution of land, public irrigation, input subsidies, creation of additional employment or income generating assets, those that do not, have to fall back on a reduced supply of CPRs (Dasgupta, 1997).

In fact, ignoring the relations between the private property resource (PPR) and CPR based processes often lead to inconsistent and contradictory set of policies that are unsustainable in the long run. Subsidising irrigation in areas with a low water table

or providing cattle through IRDP in areas where pastures are already scarce are common examples of such fallacies.

West Bengal is one of the few states in India where all the three major strategies of agricultural development — i.e. land reform, the so called "Green Revolution Strategy" and the rural development programmes, were implemented with a reasonable degree of effectiveness. It has been argued [See Kohli (1987)] that this is largely due to the *pro-poor policies* of the government that ruled the state since 1977. There have been studies in support of the official claim that the *effective implementation of agrarian development strategies has improved the well-being of the poor* [Sengupta and Gazdar (1996)]. At the same time, there was a *remarkable growth in agricultural productivity* in the state throughout the 1980's and beyond.

Regarding CPRs, on the other hand, it is well known [See for example Ghosh (1998)] that both the area of degraded land and forests is much lower in West Bengal, compared to the national average [degraded land and fallows — WB : 4.4 %, India 17.5 %, forests – WB 13.7%, India 23.3% {GOWB(1998), GOI(1998)}]. The depletion in these resources have also been much faster in West Bengal. The state is, however, quite rich in water resources, principally through tanks, rivers and canals.

It is clear, then, that a study on the impact of agricultual development strategies on the use of CPRs, is essential to promote a balanced development of CPR and PPR based activities for the improvement of the condition of the poor in the state.

1.3 SURVEY OF LITERATURE

Our research is linked with the literature on sustainibility of agricultural development [see for example Conway (1987), Nadkarni (1993), Parikh (1991), Reddy(1995), Singh (1995)]. The Food and Agriculture Organisation (FAO) defines sustainable agricultural development as "environmentally non degrading, technically appropriate, economically viable and socially acceptable" [FAO(1991)].

It is well understood that there are tradeoffs between these various objectives [see for example Redclift (1992)] and a number of economists and environmentalists believe that optimal policy involves securing the livelihood for the critical groups of the very poor which would create conditions for a long term sustainable use of the

environment [Chambers (1987)].More generally, the relationship of sustainability to poverty has been widely noted [see for example Vyas (1991), Reddy (1995)].

Regarding the issue of common property resources, David Hume (1740) was among the earliest to mention the problem of *overexploitation of the commons* in the context of grazing cattle on village pastures. The term 'tragedy of commons' was coined by Garett Hardin (1968) who applied it to the issue of overpopulation. Many economists have noticed the resemblance of the problem to a Prisoners' Dilemma [Dasgupta (1982), Wade (1988), Basu (1993)]. Basu (1993), in particular, shows that the simple Prisoners' Dilemma model of 'the commons problem' can used to develop more rigorous analyses of sustainability.

The *adverse impact of modern agrarian techniques* – often called the 'Green Revolution Technology' - on common property resources (CPRs) and more generally on the environment has been widely noted in the literature. Commoner (1971), for example, analyses the dangers posed to the environment by increased use of fertilizers and pesticides. The link between irrigation and increased soil salinity is mentioned by Ehrlich, Ehrlich and Holdren (1977). Gradwohl and Greenberg (1988) and Fisher and Hanemann (1997) note the threat posed to forest resources from both commercial and subsistence agriculture. In India, Vyas and Reddy (1993) find that major environmental problems of intensive agriculture include – degradation of groundwater quality, increase in use of pesticides leading to health hazards, deforestation and neglect of CPRs, problems of pests and plant diseases, water logging and salinity.

It is well known also that *institutional factors* – of both the market and non-market varieties – associated with agricultural development also endanger the local commons [see for example Chambers (1987), Jodha (1980, 1986), Dasgupta and Maler (1997)]. Noronha (1997), for example, suggests that common property is rarely totally 'open-access' and usually belongs to a particular community [see also the definition of 'common pool resources' in Singh (1994, 1995)]. These communities often possess traditional institutional arrangements backed by social disapproval of violations to sustainably exploit their common pastures and forests [see for example Cordell and Mckean (1992), Acheson (1993)]. With agricultural development,

communities turn away from custom and move towards the market resulting in the abolition of traditional rules and informal management practices [Somnathan (1991)]. Along with this, the dependence on such resources (for at least the better off sections) decline. Consequently, such resources have become virtually open access and subject to overexploitation, indifference and unregulated utilisation [Rao (1991)]. Thus, taking institutional aspects into account, Jodha (1987) finds – in contrast to the observations of Rao (1994) referred to earlier - that decline of CPR areas are lower in smaller, isolated, and backward villages due to easier ability to maintain social discipline, less market influence and greater dependence on such need.

The *substantial decline in CPR areas in India* has been recorded by a number of authors [Iyenger (1988), Brara (1987), Chopra et al (1990), Jodha (1990)]. Thus, official records [GOI (1987, 1997)] show that between 1950-51 and 1993-94, while net area sown increased from 118.74 million hectares to 142.1 million hectares, fallow lands declined from 28.1 million hectares to 25 million hectares and other uncultivated lands declined from 49.4 million hectares to 29.3 million hectares. In a survey of 84 villages in 21 districts spread over seven Indian states, Jodha (1986) reports that CPR area declined by 31-55% between 1950-52 to 1982-84.

This *reduction in the supply of CPRs have been found to severely affect the poor*, who in India as elsewhere, depend more on CPRs than the better off, the dependence being markedly greater in agriculturally backward areas. Jodha (1986, 1990), for example, finds that the rural poor obtain the bulk of their fuel supplies and fodder from CPR related sources. Proportion of poor households depending for food, fodder and fuel on CPRs varies between 84-100% with CPR income accounting for 14-23% of income from all sources. In the field of production, 31-42% of own farm inputs used during the pre-sowing to pre-harvest stages of cropping are from cash or kind inflows from CPRs for small and marginal farmers. Others, however, find that while a larger proportion of the poor depend on CPRs, and may obtain a larger proportion of their income from CPR related sources, absolute income derived from CPRs is, on the average, higher for non-poor households than the poor [Nadkarni et al (1989), Pasha (1992)].

Some studies have analysed the ways in which different economic groups alter their behavior towards CPRs as a result of agricultural development. They find that development prompts the better off to *reduce their demand from CPRs* and withdraw

from CPR related activities and concentrate more on private property resource based pursuits [Jodha (1986), Iyengar (1988)]. According to Jodha (1986), this is because the opportunity cost of labor spent in collection of CPR based resources becomes greater than the value of collected items. It has been noted that *the demand for CPRs is lower in agriculturally developed areas* compared to backward and arid regions, mountain regions and unirrigated areas [Agarwal and Narain (1989), Chopra, Kadekodi and Murthy (1989)].

Modern *agricultural development does not benefit all economic groups equally*. Parthasarathy (1991) observes that the agriculturally developed states are marked by growing inequalities among social groups, between cultivators and labourers and between subsistence and capitalist farmers. Thus, unlike the rich, the poorer sections who are bypassed by agricultural development react to the reduced supply of CPRs with increasing desperation. Brara (1987) finds that the poor turn to inferior CPR products with negative side effects on health and overcrowding and overexploitation of CPRs. According to Rao (1994) the area under forests as well as their denudation is higher wherever the percentage of net sown area is lower. Thus, Dasgupta (1997) is concerned that agricultural development efforts may worsen the relative position of the poor, leading to an *increase in economic inequality.*

A number of studies, therefore, emphasize the link between poverty and environmentally sustainable agriculture. Chambers (1987) argues that sustainable development can be attained through positive impact on the livelihood of the poor. Vyas (1991), thinks that properly conceived poverty alleviation programmes could be a step in the direction of an environmentally safe world. According to Nadkarni (1994) poverty alleviation programs that ignores the dependence of the poor on CPRs are likely to be abortive, and an integrated view of development must be taken for both poverty alleviation and environmental protection..

Thus the formulation of the *appropriate CPR management regime* for a particular context assumes importance [see for example Singh (1994), Noronha (1997)]. Prescriptions range between *state ownership* or intervention [Hardin (1968)] and *privatization* [Hardin (1978), Demsetz (1967)], both of which are controversial. In particular, Chambers et al (1989) note that state monopoly often ends up depriving the poorer sections of the benefits of CPRs and ultimately alienating them. Nadkarni, Ninan and Pasha (1994) found that the villagers stopped cooperating with the Forest

Department when they started taking up village grazing land for social forestry. Similarly, the problems of privatizing CPRs, by way of land reforms or by providing incentives to higher income groups have been widely discussed in the literature. Binswagner (1989) has shown how acquisition of forest lands by the rich in Brazil led to deforestation. Jodha (1986) finds that the failure to obtain lands through land ceiling laws or other means, curtailment of CPR lands were often the easiest route for land distribution.

When consideration is taken regarding the livelihood of the poor, there is greater success. Singh and Bhattacharjee (1992a) find, in a study of Nepura village in the Midnapore district of West Bengal, that State-led privatization of CPRs through land reforms, can lead to equity, efficiency and sustainability in CPR management. Here Singh (1994) emphasizes the importance of *participatory management* of CPRs This could take the form of fishing [Singh and Bhattacharya (1991b), Chatterjee and Bandopadhyay (1990)] or tree growing *cooperatives*[Singh and Ballabh (1989)]. Village *panchayets* may also be effective [Brara(1987)], though politicisation and opportunism often prevent them from enforcing user regulations, turning CPRs into 'open access resources'[Gupta(1987),Bromley and Cernea(1989)].

There are several distinct types of agrarian development strategies that governments in developing countries undertake to promote agricultural development. These include (a) institutional changes like land reform, (b) promotion of irrigation and agrarian techniques through incentives and subsidies and (c) rural development programmes (see Chakrabarty, 1996). However, the specific impacts of these different types of policies on rural CPRs has not so far been thoroughly investigated. The present study proposes to fill this gap.

Chapter II : OBJECTIVES OF THE STUDY

The ***overall goal*** of our study is to examine the impact of agrarian development strategies on the use of rural CPRs by the poor in West Bengal with a view to help improve the design of an integrated policy for environmentally sustainable development of agriculture

In line with this goal, the ***present objective*** is to examine, in selected areas of West Bengal, the impact of *specific agrarian strategies* – like (I) *land reforms*, (ii) *irrigation* and promotion of *modern agrarian techniques*, and (iii) *rural development programmes* – on

a) the *interaction* between the CPR and PPR based processes,

b) the *supply of CPRs*,

c) the *demand and use of CPR* based items by the poor,

d) *welfare and economic inequality,* particularly among the poor.

Chapter III : METHODOLOGY

The major methodological issues that we encounter in the context of this work relate to:

1. Measurement and Valuation of CPRs
2. The analytical framework
3. The method of survey

3.1 MEASUREMENT and VALUATION OF CPRs

It is well known that the valuation of CPR based resources presents a number of difficult methodological problems (see for example Parikh and Parikh 1997).

- First, there are a variety of CPR resources ranging from forest products like timber, leaves and herbs to water based items such as foods and plants. Further, use of water for bathing and washing and use of pastures for grazing cattle must also be accounted for.
- Second, since these CPR based resources are accessible to all members of a village or community they do not have a sale or rental price in the common sense of the term
- Third, even if the area of the forest, pasture or water body within the village or their distance from the village may be obtained, it is very difficult **to measure their quality.**

3.1.1 Imputed Market Valuation

We attempt to tackle this problem principally by imputing **monetary values** to the CPR based resources, supplementing it with alternative methods of valuation. The advantage of monetary valuation is twofold: first, it can be compared across types of CPR based resources. Second, it implicitly takes account of the differences in 'quality' of the heterogeneous CPR based products better by putting a monetary value on the resources collected. Thus, the resources obtained per hour from a natural 'sal' forest would be higher than from a 'eucalyptus' or 'sonajhuri' forest created through the government's social forestry schemes.

Of course, the important issue here is how to attach monetary values to these products. It is here that we bring in the approach of ***imputed market valuation***. For CPR based items that are bought and sold in the market like 'sal' leaves and other items of food and fuel one can use direct market prices. For items which are not, we use the prices of the cheapest market based alternatives. For example, we often value CPR (e.g. forest or cowdung) based fuel at the ***value of equivalent amounts of market based alternative fuel*** (eg kerosene). In the light of the fact that these resources are not usually marketed or even marketable this might seem somewhat puzzling. Remember, however, that our purpose is to obtain a comparative measure of the quantity and quality of CPRs across different types of regions chosen. In other words, our objective is to find ***a relative measure rather than an absolute one***.

It is important to keep two things in mind. The first is that market prices for the same quality and quantity of a resource may vary widely between different regions due to factors such as taste, scarcity, technology etc (for example, the same fish that obtains a high price in West Bengal may find no market in Tamil Nadu). Our study is restricted to two contiguous districts in the state of West Bengal. Hence the market prices attributed to most commodities in our study villages are quite close to each other.

Second, our method probably leads to a slight overvaluation of the CPRs in absolute terms because the CPR based resources are usually 'inferior' in the sense that consumption of such resources decline with higher income level. However, ***unless it is established that the different CPR based resources strongly differ between themselves in terms of their relative inferiority, this method appears valid for the type of comparative valuation we propose to do***.

3.1.2 Specific types of CPRs and Supplemental Measures

Most CPR based products can be evaluated reasonably well using the method of imputed market valuation. This is true for items like fuel and food related items collected from forests, pastures and water bodies. Collection for sale can be evaluated at direct market values. We therefore separately estimate the average (imputed) market value of CPR based foods collected per adult hour (FDPRHR), fuel per hour (FUPRHR) and saleable items collected per hour (SLPRHR).

However, not all types of CPR based resource products can be measured using this procedure. A prime example is grazing land. It is relatively easy to put a monetary value on the benefit obtained from grazing cattle. The method we have used is as follows. We have calculated that the standard expenditure on feeding cattle if it exclusively depends on purchased feed is Rs. 9.00 per day. We then asked each household the actual expenditure on feed per day in each of the 3 agricultural seasons. Finally the total money spent on cattle feed during the entire year was worked out and subtracted from the money that would have been spent if the cattle were not grazed at all. The net result is the value obtained from grazing.

3.1.3 Carrying Capacity

Another method that we use to evaluate the state of CPRs is the analysis of "carrying capacity" - the ***maximum population size that an ecosystem can sustain*** without degrading the environment. In this method, the actual productivity of a particular resource stock is compared to its maximum potential. Since this analysis can only be done by technical experts, we did this with the aid of consultants [see Appendix B]

3.2 THE ANALYTICAL FRAMEWORK

3.2.1 Supply of CPRs

One of the major objectives of our study is the analysis of the impact of agricultural development policies on the supply of CPRs. For this, we need to introduce a method of measurement of supply appropriate for this analysis. Here we discuss some possible ***alternative methods of measurement of supply*** before introducing the one we propose to adopt.

Alternative 1: The ***total area under CPRs*** in a particular village before and after the implementation of agricultural development policies.

Limitations:

a) many CPR areas accessible to villagers may not be within the boundary of the village as per the land records.

b) the same general forest area may be accessible to many villages.

c) policies take long periods to implement and are often implemented simultaneously so that it is difficult to isolate the impact of specific policies.

d) reliable time series data on the CPR areas are difficult to obtain.

e) this method takes account of only absolute area and is useless in comparing between villages of different sizes.

f) no account of the 'quality' or 'productivity' of CPRs is taken, and a 'natural' sal forest obtains the same value as an 'eucalyptus plantation' under social forestry schemes.

g) no account is also taken of the population density of the village

Alternative 2: Comparison of ***relative area under CPRS*** – as a proportion of total village area – between villages with high and low implementation of specific agricultural policies.

Advantages: This method overcomes the problems of (d) inter-temporal comparison, (c) isolating the impact of different policies. It also allows for (e) comparison between villages with different levels of policy implementation.

Limitations: However, the problems (a) and (b) of identifying the area under CPRs remain. So do the problems of ignoring (f) the quality of CPRs and (g) the population density of the village.

(h) given two villages with roughly equal total and CPR area, one with a substantially larger forest would automatically show a smaller area under other categories.

Alternative 3: Comparison of ***per capita area under CPRs*** between villages with different levels of policy implementation.

Advantages: Unlike alternative 2, it takes account of population density and is not subject to problems of relative measures (h). The problems (c), (d) and (e) are also taken care of.

Limitations: The problems of specifying area (a) and (b), and ignoring quality or productivity (vi), however, remains.

Our Approach: Comparison of ***average (mean) value of CPRs collected per unit of time*** spent by households between villages with different levels of policy implementation.

Formulation:

Average (household) supply of CPR resources per adult:

$$: \quad = \frac{\frac{\text{value of collection}}{\text{area under CPRs}} \times \frac{\text{area under CPRs}}{\text{village area}} \times \text{village area}}{\text{Number of adults}}.$$

$$= \frac{\text{value of collection}}{\text{Number of adults}}$$

$$= \frac{\text{value of collection}}{\text{Time devoted to collection}} \times \frac{\text{Time devoted to collection}}{\text{Number of adults}}$$

= Average value of collection per hour x Average Time Spent per adult

Average (household) supply of CPR resources per unit of time

$$= \frac{\text{Average (household) supply of CPR resources per adult}}{\text{Average Time Spent per adult}}$$

= ***Average value of collection per hour***

Justification:

i) It would seem more natural to adopt Value of Collection per adult rather than per hour as the measure of supply. Clearly, the former measure equals the latter times the time devoted to collection per adult. The collection time per adult, however, varies across households and areas in proportion to their dependence/need for CPR based resources and is thus more closely linked to the demand rather than the supply of CPRs.

ii) The value of collection per hour on the other hand, is ***more or less invariant between different households in the same village***, while varying from village to village. It is therefore a better indicator of the "supply of CPR" for a village.

iii) it also ***gives an appropriate measure of the 'quantity' as well as the 'quality'*** of CPR resources. Thus, if the residents of one village collect less fuel per hour (valued in terms of the least cost

market alternatives) than the residents of another it must be (i) either because they have to travel longer on average to access the forest based fuel which means that the village forest area is relatively small, or (ii) the quality of forests in this village has been degraded.

iv) The problems (a) and (b) of precisely identifying 'accessible' CPR areas, (c) of inter-temporal comparisons, (d) isolating the effects of specific policies and (h) problems of relative measures are also eliminated.

Method of Analysis: We estimates of the average (mean) value of collection per hour on the basis of household questionnaires. We then ***compare this mean value across high and low implementation villages*** with respect to specific policies/policy groups.

It is important to note here that studying the determinants of CPR supply through ***OLS regression is inappropriate*** due to two reasons:

a) first, while CPR demand may vary between households due to a variety of factors, CPR supply accessible to residents is ***approximately constant within a village*** . Thus there are only 18 data points, one for each village.

b) Second, each of the 18 ***villages have been chosen by stage wise design*** rather than randomly. Since the explanatory factors (i) CPR type, (ii) policy type and (iii) level of policy implementation have been included in the selection of villages, a comparison of means is adequate to demonstrate the influence of the explanatory factors on Supply. Hence we have gone for a "Compare Means" Test.

3.2.2 Carrying Capacity Analysis

As already indicated, we have conducted a carrying capacity analysis of CPR stocks with the help of consultants [see Appendix B]. For this, we have compared the state of CPR resource stocks in the high and low "technology policy" implementation villages. This is because it is mainly the excessive use inputs associated with modern intensive farming techniques that directly degrade the potential of common property resource ecosystems. The present productivity of these stocks is compared to their potential is these two kinds of villages.

3.2.3 Demand for CPRs :

In standard economic theory, the individual's demand for commodities is the outcome of the individual's utility maximization subject to his/her budget constraint which is parameterized by commodity prices and income:

Maximise $U(X,Y)$ subject to $Px.X + Py.Y = M$

In this framework, the demand for a commodity is (say) X and the total value of consumption of this item is PxX, a product of its "price" and "demand".

By contrast, there are usually ***no markets for CPR based items*** and the rural household does not buy it from the market. Consequently, an alternative way has to be found to evaluate the demand for CPR based products.

Our Approach: In this study, we take the ***time (hours) spent per adult in collecting CPR based items*** as the main indicator of demand for CPRs.

Justification: Note that this approach is similar to the ***travel cost method*** of measuring the value of recreational sites such as national parks (Dixon and Hufschmidt, 1986). The benefits obtained by consumers from national parks cannot be adequately measured by the gate price, which is usually very low. Instead this method attempts to measure the approximate benefits derived by consumers from their travel cost.

Similarly, if we assume that the rural households value the time spent in collecting CPR based items – which could have been spent in household activities and leisure – we could use this as a proxy for their demand for CPRs. Note that we ***do not value this time at the prevailing hourly/daily wage rate***. In our context, there exists a substantial amount of unemployment and the members of the households engage in CPR collection only when they do not find wage employment. CPR-based items, as already noted, are considered "inferior" and forms part of the household's residual consumption basket. The choice then is not between wage employment and collection, but between collection and leisure or household activities.

Formulation:

$\overline{Y}_N = \overline{Y}_{NA} + \overline{Y}_A + \overline{Y}_P$ (non-labor income percapita including income from nonagricultural sources, from cultivation and from self employment schemes)

= f (percapita own land, nonagricultural income, benefits received from land reforms, technology policy and rural development programmes)

$\bar{L}_W = \bar{L}_{NA} + \bar{L}_A + \bar{L}_P$ (hours of employment per adult in agriculture, nonagricultural occupations and government rural employment schemes)

= g (Y_N, household size, proportion of females and children, area characteristics)

R = Leisure hours per adult

$\bar{L}$ = Total hours per adult

$L_{CPR} = \bar{L} - \bar{L}_W - R$ = Time Spent on CPR collection per adult

$\bar{N}$ = number of adults in the family (a given for the family)

$\bar{v}$ = CPR collected per adult hour (fixed at the village level by 'supply' factors)

$\bar{V}$ = Value of CPR collected by household = $\bar{N} * L_{CPR} * \bar{v}$

$\bar{W}$ = Wages per hour

$\bar{P}$ = Price of other commodities

C = Value of CPR consumed

Q = Quantity of other goods consumed

Maximize $U = U(C, Q, R)$ (1)

Subject to $C + PQ \leq \bar{N} * L_{CPR} * \bar{v} + \bar{N} * \bar{L}_W * \bar{W} + \bar{Y}_N$ (2)

and $L_{CPR} = \bar{L} - \bar{L}_W - R$ (3)

Substituting for R in the objective function (1) from constraint (3) and taking CPR-based consumption to be "inferior" in the sense that it forms part of the household's residual consumption basket, so that from (2)

$$C \leq \bar{N} * L_{CPR} * \bar{v} + \bar{N} * \bar{L}_W * \bar{W} + \bar{Y}_N - PQ \quad (4)$$

The consumer's problem is to maximize

$$U = U(\bar{N} * L_{CPR} * \bar{v} + \bar{N} * \bar{L}_W * \bar{W} + \bar{Y}_N - PQ,\ Q,\ \bar{L} - \bar{L}_W - L_{CPR}) \quad (5)$$

with respect to L_{CPR} and Q. The solution to the problem – which exists if U is continuous and concave - would be of the form

$Q^O = \psi(\overline{N}, \overline{Y}_N, \overline{L}_W, \overline{v}, \overline{W}, \overline{P})$ (6)

$L^O{}_{CPR} = \phi(\overline{N}, \overline{Y}_N, \overline{L}_W, \overline{v}, \overline{W}, \overline{P})$ (7)

$= \phi(\overline{N}$, proportion of female and children, own land percapita, non agricultural income, benefits received from land reforms, technology policies and rural development programmes, area characteristics)

The last is obtained by using $\overline{Y}_N = f(\,)$, $\overline{L}_W = g(\,)$, while suppressing $\overline{v}$, $\overline{W}$, $\overline{P}$ as they are invariant for all residents of the village (and to that extent also covered by the area characteristics)

Method of Analysis: To analyse the determinants of demand, we first use ***OLS regressions*** with $L^O{}_{CPR}$ as the dependent variable and $\overline{N}, \overline{Y}_N$ as independent variables, we have:

$$L^O{}_{CPR} = \alpha + \beta_1 Y_N + \beta_2 N + \beta_3 \overline{L}_W \quad (8)$$

Next using the reduced form version of (7) using $\overline{Y}_N = f(\,)$, $\overline{L}_W = g(\,)$, while suppressing $\overline{v}$, $\overline{W}$, $\overline{P}$, we estimate the resultant ***reduced form OLS equation***:

$$L^O{}_{CPR} = \alpha + \beta_1 Y_{NA} + \beta_2 N + \beta_3 Female\% + \beta_4 Child\% + \beta_5 Areadummy + \beta_6 Policybenefits \quad (9)$$

It is important to note, however, that ***policies are frequently chosen based on household characteristics, income and area specifics***. For example, it is the low income and low landowning households that are beneficiaries of land reforms and rural development policies. Similarly, irrigation can be provided in some areas but not in others. When we make cross sectional comparisons between households or areas, this dependence of policy on household or area characteristics may cause substantial multicollinearity in the data. For example, in an ordinary OLS regression with CPR demand as the dependent variable, the coefficients of policy variables – particularly those that are more 'targeted' - would then be positive instead of negative, contrary to our expectation. This is because ***the recipients of antipoverty policy benefit smay have relatively higher CPR demand as almost all of them are poor***. This problem could have been eliminated if we could obtain data on CPR demand for each household before and after the policy. Unfortunately, this was not

possible in the present study. One way to get around this problem is to use ***the method of 2-Stage least squares*** where the household, income, land ownership and area characteristics are included as predetermined variables. We therefore estimate the following simultaneous equation system:

$L_{CPR} = \phi$ (**family size and composition**,, *policy benefits)* (10)

Policy benefits = ψ *(***family size**, *other policies,* **land & other endowments***)* (11)

by the method of 2-stage Least squares[3].

3.2.3 Common Property Resources, Inequality and The Gini Coefficient:

It has been already indicated that agricultural development policy is likely to have contradictory effects on CPRs. On the one hand, it is likely to degrade the current supply of CPRs and on the other it is likely to increase the households non-CPR income leading to a reduction of demand for CPR based resources.

In the long run, this latter effect may reduce the pressure on CPR and at least slowdown the rate of degradation if not actually improve its condition. In the short run, however, we are likely to observe two kinds of effects on rural inequality if the CPR income is taken into account:

- ***Relatively higher rural inequality in the high policy implementation villages***. This is because of the fact that only some of the poor households receive benefits from these policies while those that do not have to fall back on a reduced supply of CPRs. This effect should be stark when only the non-CPR income is considered, but is still present if one counts in the CPR income
- second, in general, the poor depend more on CPR income, so that ***if the CPR income is taken into account, the degree of inequality appears to be lower***.

To examine these factors, we calculate the GINI coefficients of income with and without the CPR income included for all villages in the area studied. This is given by the formula:

[3] The detailed form of the equations is given in Appendix A.

$$G = \frac{1}{2n^2\mu}\sum_{j=1}^{m}\sum_{k=1}^{m} n_j n_k \mid y_j - y_k \mid$$

where *j* and *k* represent the m distinct income levels, n_j and n_k the number of households with these income levels, μ is the mean of the income It sums up all *pairs of income differences* weighted by the number of such pairs $n_j\ n_k$ and normalized by population squared (because there are n^2 such pairs) and mean income.

An alternative practical way to measure the Gini coefficient

$$G = \mid 1 - \sum_{t=0}^{T-1} (Y_{t+1} + Y_t)(N_{t+1} - N_t)$$

where Y_t = Cumulative proportion of income upto t the income class

N_t = Cumulative proportion of income upto t the income class

An important point to note is that although our main focus is on increase in inequality among the poor due to agricultural development, we calculate ***Gini coefficients for the entire village and not only for the poor***. This is because as a result of agricultural policy implementation a substantial proportion of the population that was initially poor may be presumed to have crossed the poverty line over a period of time. While this is impossible to track now due to the absence of time series data, restriction of attention to the households who are presently poor would give an incomplete picture of the consequence of agricultural policies. To complement this, we present the proportional income levels for the lowest deciles of the population.

3.3 AGRICULTURAL POLICY INDICATORS

We shall adopt two types of indicators of agrarian development for the purposes of the study:

a. ***General indicators***: these are the items that indicate the overall level of agrarian development or progress in a region. Among these would be indicators of productivity like ***yield*** per unit area, ***cropping intensity***, ***wages*** per labour day.

b. ***Indicators of specific agrarian strategies***: In order to analyse the impact of specific agrararian development strategies, we also use specific indicators for these policies :

1. ***Land Reforms*:** percentage of landless who have received land and percentage of tenants who have recorded their tenancy, cropshare received by tenants,
2. ***Technological Reforms***: percentage of land irrigated, multiple cropping, fertiliser and HYV use per unit area, agricultural investment and institutional credit for production,
3. ***Rural Development Programmes***: proportion of the poor who have obtained jobs in rural employment (e.g. JRY) schemes or assets through self-employment (e.g IRDP) schemes. For IRDP, these include subsidies for the purchase of cattle, poultry, for making of saleable items from forest products such as 'sal' and 'kendu' leaves and promotion of fisheries which may increase the pressure on existing CPR resources.

In this work, we selected 18 villages – 6 for each type of CPR, i.e., land resource, forest resource and water resource – for a more intensive study. Out of these 6, 2 are chosen to focus on each type of agrarian development strategy, (i.e., land reforms, technology and rural development programmes). *Of these two*, one each has been chosen for 'high' and 'low' implementation. The high implementation villages for

1. land reforms have high proportion of registered tenants and a large percentage of land reform beneficiaries among small and marginal farmers;
2. those for technological reforms have high irrigation ratios, cropping intensity, fertiliser, HYV use and high agricultural investment;
3. those for rural development programmes have high percentages of IRDP and JRY beneficiaries among the poor.

In case of the regression analysis applied to the study of CPR demand, we have specified the indicator of each of the specific agricultural development policy used as a separate variable.

3.4 THE SURVEY

The data for this work is obtained from the two districts of Birbhum and Burdwan in West Bengal. At the **first stage,** the Principal and the co-Principal investigator made a preliminary survey of 60 villages based on the information from the District Census

Handbooks and topological maps from The Survey of India and National Atlas. These were covered with a *Preliminary Village Level Report* which with (a) general village information (b) natural resources (c) agricultural development (d) agrarian reform (e) health and education , (f) other village infrastructure and (g) CPR use and management practices etc. The information is obtained from discussion with block and district officials, elected representatives of *panchayats*, NGOs, and study of district and block reports and maps.

Based on this survey, 18 villages were selected in the **second stage** – 6 for each type of CPR, i.e., land resource, forest resource and water resource – for a more intensive study. Out of these 6, 2 are chosen to focus on each type of agrarian development strategy, (i.e., land reforms, technology and rural development programmes). *Of these two*, one each has been chosen for 'high' and 'low' implementation. For example, the villages chosen to represent 'high' land reform implementation have high proportion of recorded leases, high cropshares and number of land redistribution beneficiaries. Similarly, those chosen 'low' technology policies have poor public irrigation facilities, unsatisfactory levels of insitutional credit disbursals etc. These are covered with a *Detailed Village Level Report* dealing mainly with (a) village natural resource and CPR flows (b) the access to these flows and (c) use and management of these flows.

3.4.1 The Preliminary Survey (60 villages)

Considering the proximity of location, the investigation was limited to districts of Barddhaman and Birbhum. Barddhaman district lies between the latitudes of 22^0 N and 25^0N between the longitudes of 86^0 E and 88^0 E. The total land surface of the area of this district is 7034 sq. kms. The district is bounded on the north by the Santhal Parganas district of Jharkhand state and the districts of Birbhum and Murshidabad, on the east by the district of Nadia, on the south by the districts of Hoogly and Purulia (all in West Bengal) and on the west by the Dhanbad district of Bihar. The land of the eastern part of the district has been formed by silts from Bhagirathi river. The area is plain and sloping in the east-south direction. The land for this part is

MAP 1. West Bengal District Map

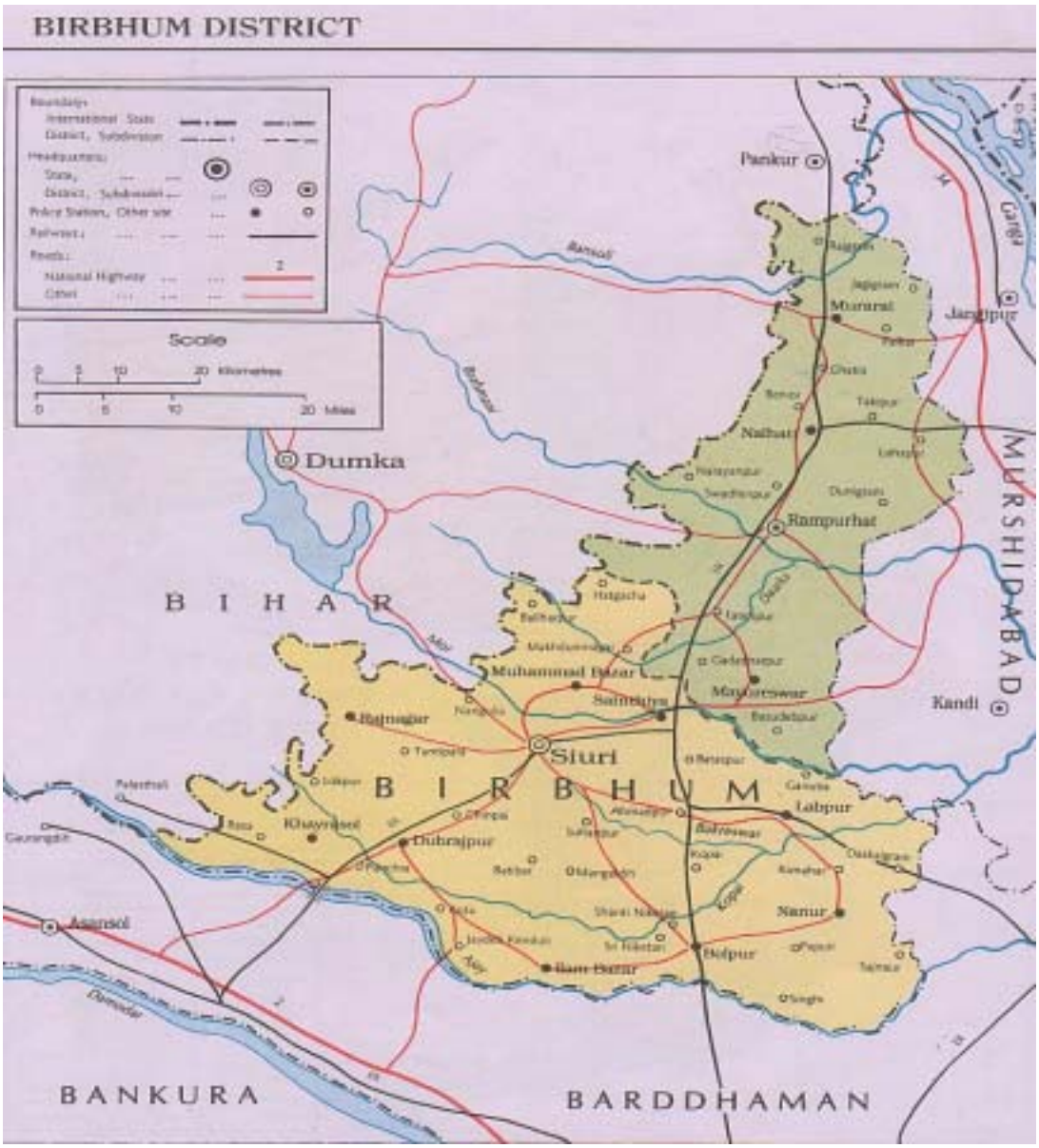
very fertile and suitable for paddy cultivation. On the other hand the land of the western part of the district is red and mixed with stone chips. The main rivers of the district are Damodar, Barakar, Ajoy and Bhagirathi. Of these Ajoy flows towards the western direction. There are 29 police stations and 32 C.D.Blocks in Barddhaman *Reference: Census of India 1991,Series – 26, West Bengal, Parts XII – A & B, District Census Handbooks for Birbhum and Barddhaman: Village and Town Directory, Directorate of Census Operations, West Bengal.*

Headquarter - Bardhaman

Subdivisions - Sadar(Bardhaman), Asansol, Katoya, Kalna

MAP 2: District Map of Barddhaman

Birbhum is situated in the western boundary of the state of West Bengal between the latitudes 23^0 N and the 25^0 N and the longitudes 87^0 E and the 89^0 E. The total land surface area is 4545 sq. km. with population of 2,556,105 according to the 1991 census. The district is bounded on the north by the hills of Rajmahal and on the west by Chhotanagpur valley of Bihar. It is situated in the west of Murshidabad district and in the north of Barddhaman district of West Bengal. The district is divided into three subdivisions. The district has 17 police stations and 19 C.D. Blocks.(Series – 26, Part XII – B, Appendix I, Page – 333).



Map 3: District Map of Birbhum

Data for this project were collected from four C.D.Blocks of Birbhum – Rajnagar, Labhpur, Ilambazar and Bolpur and three C.D.Blocks of Barddhaman – Ausgram I, Ausgram II and Raina I. Particulars about these C.D.Blocks according to the 1991 Census are given below.

Table 3.1A Basic Features of Selected Blocks in Bardhhaman District					
C D Block	No vill	Pop	Area (ha)	% of cultivable area	%of irr area
Ausgram I	58	93902	16450	83.68	83.57
Ausgram II	101	119019	35400	63.39	49.79
Raina I	111	143282	26644	89.96	65.45

3.1B Basic Features of Selected Blocks in Birbhum District					
C D Block	No vill	Pop	Area (ha)	% of cultivable area	%of irr area
Bolpur	155	152048	33152	75.11	72.10
Labpur	159	153546	26482	87.14	68.04
Ilambazar	135	120895	25950	72.45	43.61
Rajnagar	88	61539	22120	49.77	7.31

Sixty villages were initially surveyed for village selection. Considering the requirement of proximity of the researchers, these villages were taken from the two districts, Barddhaman and Birbhum. Areas with predominance of the CPR items were first marked from the topographical maps published by the Survey of India. The villages that fulfilled the requirement of at least one of the three types of CPRs – forest, water bodies and pastures – were then selected from these areas. An account of these sixty selected villages is given below.

In **Barddhaman district** **26 villages** were taken from the three C.D. Blocks – Raina I, Ausgram I and Ausgram II. In ***Raina I Block***, **6 villages** were selected for their resources of *waterbodies*, which among themselves are situated in a 5.2 kms./square area. These 6 villages are Sripur, Basudebpur, Gopalpur, Samaspur, Sipta and Debibarpur. These 6 villages are under the jurisdiction of the Narugram G.P. These are located at distances ranging from 5 to 10 kilometres in the south from Damodar river. Barddhaman city is situated straight in the north, on the north bank of Damodar river.

Twenty villages were selected from the ***Ausgram I and II*** blocks, located in the south of the river Ajoy. River Kunur, flowing from west to east divides Ausgram into 2 C.D.Blocks. Ausgram I is in the south and Ausgram II is in the north of this river. The

selected villages in these 2 blocks are situated within a distance of 15 kms. from the east to the west and that of 12 kms. from the south to the north. Guskara town is 7 kms. from the village Karotia in the south-east and Bolpur town is 14 kms. from the village Nowapara in the north-east. Distribution of the selected villages in these 2 blocks according to the predominance of a CPR is given below.

Table 3.2A Villages Selected from Ausgram Block

	Forest	Waterbodies	Pasture
Ausgram I (9)	Hargoriadanga, Bananabagram, Dokhalganj, Alefnagar, Shokadanga, Dayemnagar, Ramchandrapur, Karotia		Warispur
Ausgram II (11)	Hedogora, Jalikandor, Gerai, Kalikapur, Moukhira, Akulia, Bistupur	Chora, Nowapara, Maliara	Dangapara.

Although 3 villages were selected for *waterbodies* and 2 villages were selected for *pastures* all of these are located within close proximity of the *forest*.

The remaining number (34) of villages were selected from the four C.D.Blocks of **Birbhum district** – Bolpur, Labpur, Ilambazar and Rajnagar.

2 villages – Salon and Bergram (Majhipara) - were selected for their resources of *waterbodies* from the ***Bolpur block***. These **2 villages** are siuated across the two sides of the Bolpur-Suri road, at a distance of 8 kms. in the north-west from Sriniketan.

The **4 villages** in the Labpur block are Haranandapur, Mamudpur, Joychandpur, Chaturbhujpur and Fingtore – all selected for *Waterbodies*..[4]

Table 3.2B Villages Selected from Ilambazar Block

Forest	Waterbodies	Pasture
Rangabandh	Ushar (Dharampur), Laksmipur, Ushahardihi	Sahebdanga, Khayerbani, Nelegar

[4] The map often gives the aggregate data for the mouzas instead of villages. Thus these four villages in Labpur could not be located in the map.

Seven **villages** were selected from the ***Ilambazar block*** according to the distribution of their CPR resources are Nelegar, Ushardihi and Laksmipur are situated within the forest area. Khayerbani has as much proximity to forest as Rangabandh. All these 7 villages are located within an area of 6 kms. from the east to the west and within 2.5 kms. from the south to the north. The maximum distance of a village among these 7 from the Bolpur-Panagar highway is 4 km. (Sahebdanga), from Bolpur town is 12 kms. (Laksmipur) and from Ilambazar town is ¾ km (Khayerbani).

Table 3. 2C Villages Selected from Rajnagar Block

	Forest	Waterbodies	Pasture
Gangmuri G.P.	Bhurabali		Paharigora, Musabani, Bagdipara, Aligar, Harhare, Khurigar, Asna
Rajnagar G.P.	Sundarkhela		
Bhabanipur G.P.	Agoabandhi, Mahisagram	Belera	Kundira, Natungram, Gurakata, Bhabanipur, Dhabona, Karonjabani, Machantali

The **19 villages** in the ***Rajnagar block*** according to the CPRs are situated in the north of Kushkarani river on the border of Santhal Parganas district in the Jharkhand state, in the north-west end of the district of Birbhum. Village Sundarkhela has a common boundary with the district of Santhal Parganas. These villages are at a distance of more than 6 kms. from the Mayurakshi river. Kushkarani river is a tributary of Mayurakshi. Belera is located at a distance of 1.5 kms. west of the Kushkarani river. These 19 villages among themselves are situated within a distance of 13 kms. from the east to the west and 4 kms. from the south to the north.

In this project villages were selected from the above C.D.Blocks. Among the selected villages few matched with the names of the revenue villages recorded in the Census. Data on this common villages from the District Census Handbooks are given below.

The items for which data were taken from the Census Handbooks and compared with the data collected in this survey are as follows. The headings of the columns are abbreviated forms of the characteristics - Name of the village, Area in hectares, No.of households, Total population, Cultivators(M, F), Agricultural labourers(M, F), People engaged in Livestock-Foresty-Fishing-Hunting and Plantations-Orchards and Allied activities(M, F). The workers are taken on the basis of their main occupation, in which they are devoting more than 50 per cent of their working time. The next items are on land use – Forest, Culturable waste(including gauchar and groves). The Census figures, shown in the upper row are compared with the data collected from the village survey of this project. The data of village survey for every village are shown in the lower row against the name of every village.

Table 3.3A Census Data for villages Selected from Barddhaman District

Vill	Area	HH	Pop.	Mcult	Fcult	Magl	Fagl	Moth	Foth	For	waste
Alefnagar	1013.	326	1814	257	16	243	172	2	0	256.8	111.7
	279	155	1500							34	12
Bannabagrm	947.6	634	3091	366	48	368	268	5	1	161.5	3.64
	1455	600	3600							130	0
Warispur	245.4	323	1725	179	20	253	163	6	0	15.87	5.67
	353	510	2900							17	5
Karatia	923.7	565	2958	283	99	445	394	5	0	245	6.06
	266	271	1500							222	0
Akulia	210.8	119	663	43	6	136	127	0	0	26.30	0.21
	822.4	150	750							600	6
Chora	787.2	628	3271	320	16	361	219	1	2	156	33
	509.4	800	5000							34.4	0
Hedogaraya	848.8	259	1213	122	9	214	174	0	0	432.8	0
	470.2	267	1477							70	4.8
Debibarpur	160.8	155	853	144	1	20	0	2	0	0	0
	299.5	190	980							1	0
Sipta	158.3	175	1138	140	0	117	12	0	0	0	0
	289.3	230	1275							0	0
Samaspur	47.26	227	1228	100	0	181	1	0	0	0	0
	178.7	275	1351							17	5

Table 3.3B Census Data for villages Selected from Birbhum District

Vill	Area	HH	Pop.	Mcult	Fcult	Magl	Fagl	Moth	Foth	For	wast e
Bg Mj	426.2	240	1245	162	74	163	119	1	0	0	2.02
	72.99	52	312							0	4
Hnpur	82.29	99	571	101	0	42	0	0	0	0	0
	196.8	127	660							1	8
Fing--tore	100.9	134	820	161	0	34	0	0	0	0	0
	208.2	178	900							1	5.2
Khaye rabani	170.7	282	1421	180	21	7	19	5	0	1.62	0
	282.4	200	1100							.33	33.33
Nelegr	90.53	uninhabited								17.4	0.81
	173.3	60	302							20.66	60
Aligar	654.4	228	1249	254	145	19	31	4	0	6.04	269.9
	125.2	85	500							4	8.33
Sunda rkhela	232.0	74	364	33	21	63	62	2	1	93.64	6.37
	387.9	89	340							182.5	61
Kundir	674.9	246	1204	182	1	127	16	0	0	65.08	192.9
	721.2	160	800							17.6	11
Belera	90.86	175	877	52	0	94	6	0	0	0	23
	280	200	1200							0	12
Bhaba nipur	49.50	164	756	26	0	74	22	4	0	0.54	16.19
	163.5	139	850							0	92
Mahis agram	255	31	157	16	0	27	0	30	0	40.57	81.90
	150.2	33	220							120	26.8

Majhipara is a small locality of Bergram. In all the cases, excepting Aligarh, Mahisagram, Alefnagar, Karatia, Chora and Hedogaraya areas of the villages according to the survey of this project are larger than those of the Census. Although the areas has been recorded as smaller in the project for Mahisagram and Chora, the population data of the project are larger than that in the Census. The order of difference for the latter can not be explained by the population growth of the decade after the Census of 1991.

3.4.2 The Selected Villages (18)

Following the tabulation and comparison of the data obtained from the preliminary village level reports, 18 villages were selected for a more intensive study. Following the methodology adopted for the study, 6 villages were chosen to focus on each type of CPR -- forest resources, water resources and open access land or fallows. Further, out of this 6, 2 were chosen for the study of the implementation of each type of agrarian development strategy – land reform, technology and rural development programme – one high and the other low.

From the preliminary household level survey, we ranked the villages of each area (FOREST, PASTURE or WATERBODY) according to the level and quality of the implementation of different policies. Then we selected the villages with the best and worst record of implementation of a particular policy - subject to the requirement that their other characteristics were close enough to each other. This was done in order to control for the other factors – particularly, the other set of policies.

A brief picture of the implementation of some policies in the selected villages is presented in the following table. This is not a complete picture of the village characteristics. For example the difference between the proportion of land reform beneficiaries in Jalikandar and Gerai - the ‘high’ and ‘low’ implementation villages selected to demonstrate the effect of land reforms in pasture areas – seems large enough. But while they have the same cropping intensity, the proportion of the poor in these two villages receiving IRDP – which is an indicator of the third type of policy – appears to be somewhat different. This is because there are other factors – execution of other policies, the quality of implementation etc. – which are behind the selection.

Table 3.4: Indicators of Policy Implementation in Selected Villages from Survey Data						
AREA TYPE	POLICY TYPE	IMPLMNT	VILLAGE NAME	LR ben/Hhold	Gca/Nca Vill	Irdp/poor
		HIGH	jalikandar	0.68	1.27	0.54
	LAND REFORM					
		LOW	gerai	0.06	1.38	0.2
		HIGH	ramchandrapur	0.76	1.53	0.56
FOREST	TECHNOLOGY					
		LOW	sundarkhela	0.48	1	0.65
		HIGH	hargoriadanga	0.5	1.23	0.65
	ANTIPOVERTY					
		LOW	shokadanga	1	1.25	0.2
		HIGH	dhabona	0.67	1	1.07
	LAND REFORM					
		LOW	ashna	0.21	1	3
		HIGH	warishpur	0.32	3	0.43
PASTURE	TECHNOLOGY					
		LOW	bhabanipur	0.41	1.06	0.5
		HIGH	mushabani	0.64	1.28	0.66
	ANTIPOVERTY					
		LOW	nelegarh	0.48	1.45	0.27
		HIGH	bergram-majhipara	0.79	1.94	0.3
	LAND REFORM					
		LOW	fingtore	0.08	1.1	0.4
		HIGH	salone	0.79	2.04	0.5
WATERBD	TECHNOLOGY					
		LOW	chaturbhujpur	0.63	1	0.64
		HIGH	gopalpur	0.22	1.13	1.4
	ANTIPOVERTY					
		LOW	mamudpur	0.13	1	0.5

3.4.3 The selection of households

Along with the detailed village survey, a preliminary listing of all households in each of the 18 villages based on a *Preliminary Household Questionnaire* is carried out. This questionnaire focuses on (a) agricultural and nonagricultural income and assets (b) identification as poor or non-poor (c) benefits obtained from land reform, rural development and other agrarian development strategies and (d) use of CPRsThis

will lead to a classification of all households into three groups: (I)non poor, (ii) poor, beneficiaries of agrarian development policies, (iii) poor non benefiaries.

At the **final stage**, 30 households are selected from each village. Their economic position is determined by the proportion of the groups (e.g. non poor, poor beneficiaries, poor non beneficiaries) in the population. These families are covered by a *Detailed Household Questionnaire* covering (I) family particulars like age, sex etc, (ii) occupation and income from usual i.e. private property based sources, (ii) productive, household and financial assets, (iv) time spent in collecting CPR items, (v) income and consumption of CPRs, (vi)human development indicators such as health , mortality and education (vii) perception of villagers regarding availability and use of CPRs.

Chapter IV : DATA ANALYSIS AND RESULTS

4.1 THE SUPPLY OF CPRs

It has already been indicated that one important property of CPRs is that the supply of the resource is in some sense common to all households in a particular village or locality. In other words the effective supply of CPRs would generally be the same for all households in a village although it will vary across villages.

Since we have detailed data for only 18 villages, it makes sense to begin by studying the impact of policies on the average levels of supply. As indicated in the methodology, we attempt to quantify the level of CPR flows in the village by the value of resources collected per adult hour devoted to collection (CPRPRHR). The underlying assumption is that both the quantity and the quality of CPR products are reflected in the value collected per unit of time. We consider this to be an adequate representation when comparing data over not too large regions where market prices are sufficiently close together. As elsewhere, when the product is not marketed we attempt to value such collections (eg forest based fuel) at the price of the least costly alternative (eg kerosene).Thus our first task is to find out how the quality /extent of policy implementation affects the value collected per hour.

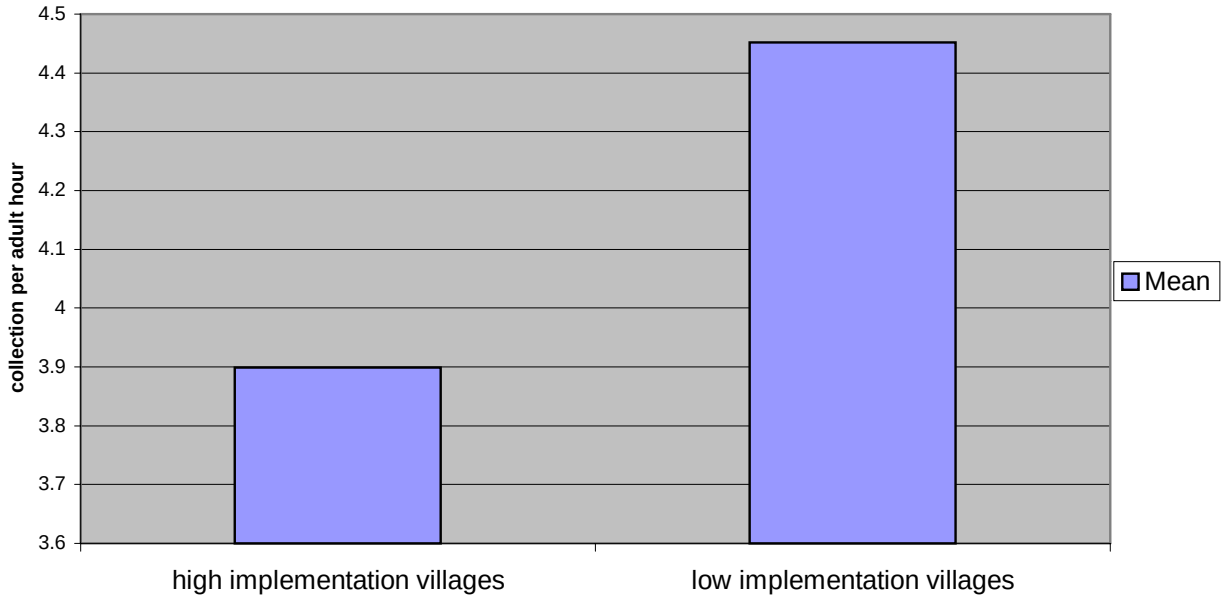
We first look at the impact of all agricultural policies on CPR supply.

Table 4.1A:
Impact of Policy on the CPR Supply – Value of Collection per hour (CPRPRHR)

	GDBD	N	Mean	Std. Deviation	
CPRPRHR1	high	210	3.8992	2.7154	
	low	210	4.4614	2.7011	
	Levene's Test for Equality of Variance		t-test for Equality of Means		
	F	SigF.	t	df	Sig.(2-tailed)
Equal Variance Assumed	6.659**	0.010	-2.09**	418	0.037
Equal Variance not assumed			-2.09**	418	0.037

** significant at 1% level
N may be less that total respondents as everyone does not collect

Chart 1: Effect of Policy Implementation on Average CPR supply



Our analysis shows that :

Result 1: *The average collection per hour in the high implementation villages is lower than in the low implementation villages and also that this difference is statistically significant*.

In other words implementation of all agricultural polices taken together does seem to have a negative impact on CPR supply across areas as measured in the (sometimes imputed) monetary value of collections per hour.

However, it is important here to look at the specific types of policy and to do that we conduct the same test separately for the 3 types of areas representing the three types of policies chosen here. The result of this investigation as as follows:

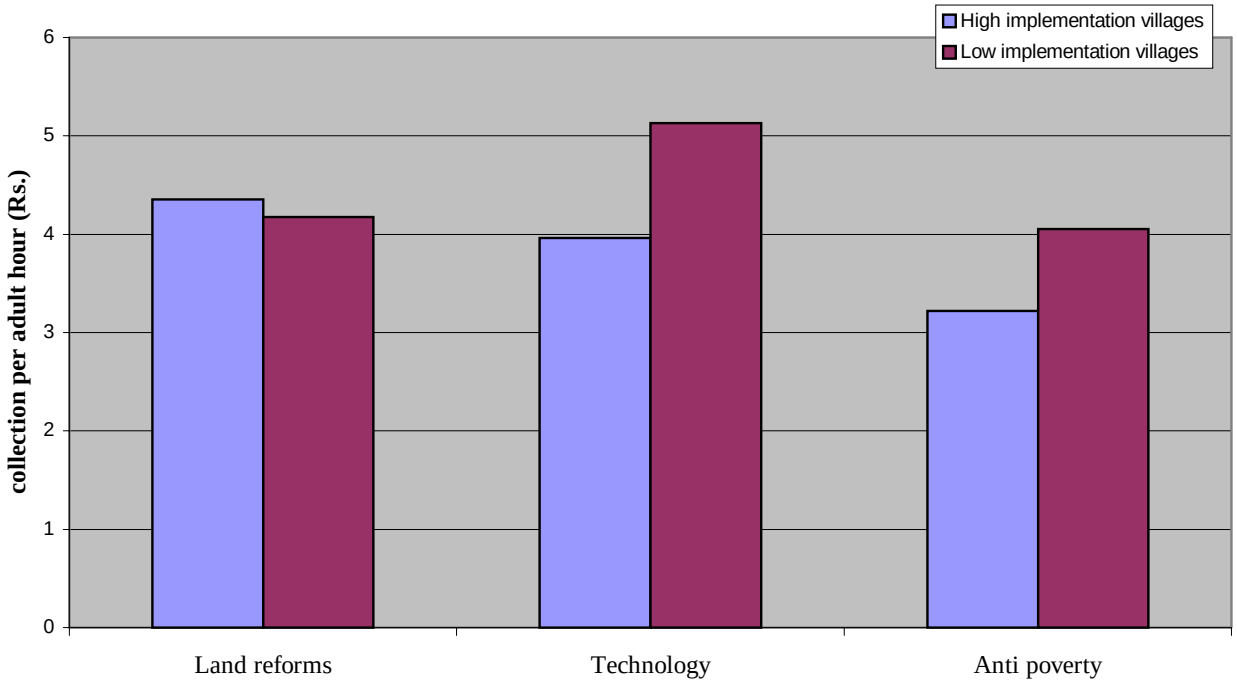
Table 4.2: Impact of Specific Policies on CPR Supply CPRPRHR

		Land reforms	Technology	Anti poverty
High				
	Mean	4.3513	3.9593	3.2196
	Standard dev	4.0235	.9150	1.5648
Low				
	Mean	4.1771	5.1327	4.0549
	Standard dev	1.3192	3.9400	1.9826
Levene's Test for equality of variance				
	F	3.009**	76.090**	1.344
	Sign F	.085	.000	.248
t-test for equality of means				
	t	.332	**-2.411****	**-2.671**/-2.746**** #
	df	143	137	134/134
	Sig 2 tailed	.740	.017	.008/.007

Note: As indicated, the components of Land Reform are the *proportion of tenants registered* and the *distribution of ceiling surplus land*. The relevant components of technology policy are *irrigation*, *cropping intensity*, *input intensive cultivation* using high yielding varieties and *investment* in agriculture. Antipoverty programmes include *IRDP* and *JRY*.

** significant at 1% level, # the alternative t-statistic with equality of variances not assumed is given since the F statistic for the Levene's Test is not significant

Chart 2: Effect of Specific Policies on Average CPR supply by policy



Thus, we have:

Result 2*:* *For areas chosen to study the impact of technology policies as well as anti poverty programmes, the average value of collection per adult hour is significantly higher in the 'low' implementation regions compared to the 'high' ones. However, the average collection in the 'high' land reform implementation areas is slightly higher than in the 'high implementation' areas though the difference is not statistically significant.*

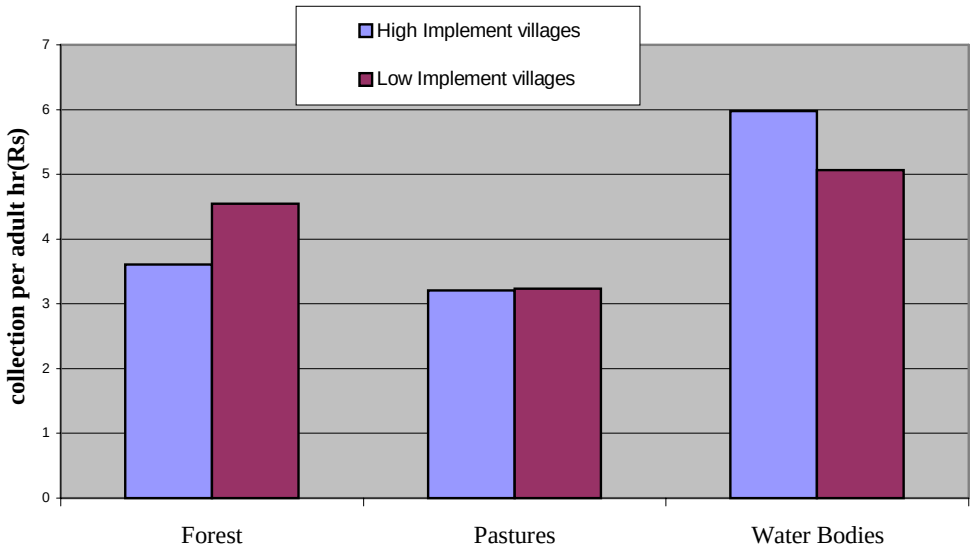
In other words, while intensive technology use and public self employment and rural works programmes contribute to the depletion of available CPRs , this is not true of the implementation of land reforms. To probe this a bit deeper, we investigate the average value of collection per hour in the land reforms areas in each of the 3 types of CPR areas: forests, pastures and water bodies.

Table 4. 3: Impact of Land Reform on CPR Supply (CPRPRHR) by areas

		Forest	Pastures	Water bodies
High				
	Mean	3.6031	3.2095	5.9775
	Standard dev	.8476	.8541	6.2467
Low				
	Mean	4.5490	3.2332	5.0674
	Standard dev	.5182	.2625	2.1528
Levine's Test for equality of variance				
	F	16.076**	4.026**	2.231**
	Sign F	.000	.050	.143
t-test for equality of means				
	t	**-4.735****	-.130	.546
	df	47	49	43
	Sig 2 tailed	.000	.897	.588

** significant at 1% level

Chart 3: Impact of Land Reform on CPR Supply by area type



Thus, we observe that:

Result 2A: *In both the forest and pasture areas, high land reform implementation lowers the average value of collection per hour, the difference being statistically significant for forests. However, for water bodies, high land reform implementation has a large enough positive (statistically insignificant) impact on average collection per hour to overcompensate for the negative impact in the other two areas..*

It is therefore necessary to look at the details of CPR supply in the 2 villages selected to compare the impact of 'high' and 'low' land reform implementation in common property water resources.

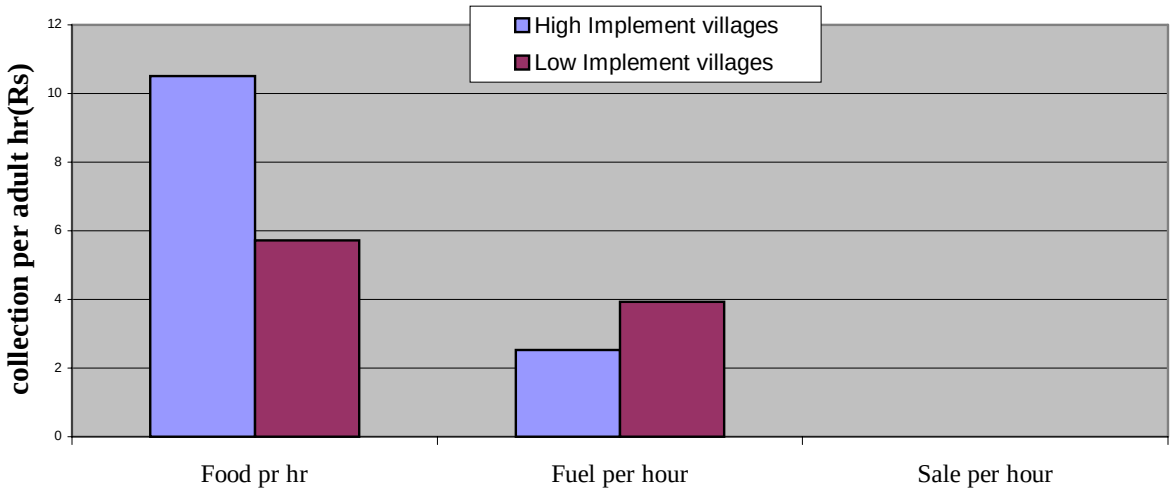
Table 4. 4: Impact of Land Reform on common property water resorces CPRPRHR

		Food pr hr	Fuel per hour	Sale per hour
High				
	Mean	10.5010	2.5302	.000
	Standard dev	14.4767	2.0178	.000
Low				
	Mean	5.7151	3.9354	.000
	Standard dev	2.8656	.9559	.000
Test for equal of variance				
	F	2.359**	.317	
	Sign F	.132	.577	
t-test for equality of means				
	t	1.218/1.685[5]	-2.468**/-3.134**	
	df	40	42	
	Sig 2 tailed	.230/.102	.018/.003	

** significant at 1% level

[5] When F is relatively low we have sometimes presented the t-values with and without assuming equality of variances

Chart 4: Impact of Land Reform on CPRs in Waterbody areas by Resource Type



Comparing the two areas of 'high' and 'low' implementation, we find that:

1. The major item of collection in both areas turns out to be food, which is almost twice per hour devoted to collection in the high villages compared to the low implentation ones. The difference is statistically significant at the 6% level (one-tailed) when equality of variance is not assumed which appears reasonable given the large F-values.
2. Value of fuel collected per hour is larger in the 'low implentation' villages and the difference is statistically significant.
3. Collection for sale is insignificant in both villages.

4.2 THE DEMAND FOR CPRS:

It has been already indicated in the introduction that while CPRs are basically a collectively owned asset, the demand for CPR based products would naturally vary from household to household. It would depend in particular on household income and population characteristics. Since we have data on 540 households we begin our analysis by running multiple (OLS) regressions of such determinants on CPR demand. Since we have chosen three different types of areas for our analysis based on types of CPRs, area dummies have to be also included.

In each area villages have been selected so as to focus on particular types of policies, the degree of implementation of each policy ('high', 'low') and households in each village selected according to whether they are rich, poor beneficiaries and non-beneficiaries. Thus it may be necessary to weight the household data in some appropriate fashion. We think, however, that (1) our study is not about predicting the demand for CPRs in the overall region in which case the villages would have to be weighted by their proportion in the entire area. We are rather concerned on the general effect of policies on household demand (2) household demand depends directly on whether the household itself has received the policy rather than on the level of implementation in the village. This is directly captured by the household data on the policy benefits received. (3) within the village the number of non-poor, poor beneficiaries and non-beneficiaries selected reflects the proportion of these groups in the village and are therefore already weighted.

The principal methods which we have chosen to capture the household demand for CPRs is the hours devoted per unit of time (hours per year) to collection. We have found that in our area that the collection by children is not of much significance and the data about the hours spent by them is also difficult to obtain. We therefore concentrate on the hours devoted per adult member of the family (PRADHRCP).

We begin by estimating the OLS regression (8) which sets PRADHRCP as a function of FAMAD, PERCAPINC and LABDAYS In addition, we also examine the effect of household characteristics like number of members (HOUSENO), percentage of children in the family (PCTCHIL), percentage of women among adults (PCTFEMAD) and area specific dummies (FOREST, PASTURE).

Table 4.5: General determinants of hours spent on collection per adult (PRADHRCP)

Model	1.OLS	2. OLS	3. OLS
CONST	247.940 **	79.802* *	23.091
	(8.470)	(2.798)	(.753)
PRCPINC	-.774**	- 487	-.576
	(-2.171)	(-1.485)	(-1.788)
LABDAYS	.702**	1.510**	1.159**
	(7.196)	(4.081)	(4.202)
FAM ADL	-25.122**		
	(-3.482)		
HOUSENO		-11.162**	-9.320**
		(-2.238)	(-1.924)
PCTCHIL		2.798**	2.484**
		(5.586)	(5.107)
PCTFEMAD		3.355 **	2.859**
		(8.306)	(7.208)
FOREST			151.900**
			(6.581)
PASTURE			58.901 *
			(2.575)
R^2	0. 188	0.305	0.358
AdjR2	0. 183	0.299	0.350
F	41.322	46.967	42.355
SigF	.000	.000	.000

* significant at 5% level; ** significant at 1% level

Result 3. *Time devoted to collection per adult member decreases with per capita income, labour days and family size and increases with the the proportion of female and children in the household. It is also higher in forest and pasture areas compared to waterbodies*.

First, poorer households devote more time to collection per adult, a phenomenon suggested by most studies (Jodha, 1980). Families hiring out labour appear to collect more for the same reason. The negative coefficient on FAMADL or HOUSENO means that the per capita demand for collection decreases with household size – because there are economies of scale in fuel use. Households with higher proportion of children and higher proportion of children devote more hours to collection per adult. This is clearly because women and children devote more time to both collection and use of CPR based items. Finally, it turns out that the

coefficients on both the area dummies are positive and significant, which implies that the households with access to forest based and pasture based CPRs devote more time to collection, than those with access to water based CPRs.

To study the impact of policy on the hours devoted to collection per adult member we first carry out OLS regression of the following policy variables on PRADHRCP: (1) VESTPERC – per capita land received through redistribution – and REGDTEN – dummy variable indicating if tenancy is registered for land reforms policy, (2) IRDP – per capita loans received under IRDP scheme and JRY – number of days of employment per adult obtained under public works programme as indicators of antipoverty programmes, and (3) CRINT – cropping intensity and COSTINT – expenditure on cultivation per unit gross cropped area as indicators of technology policy.

The policy variables are of two types – (a) those specifically targeted towards the poor – like anti poverty programmes as well as some of the land reforms policies particularly land redistribution and (b) those that are generalized – like technology policies including spread of multiple cropping and input intensive HYV agriculture.

There is a difficulty in examining the impact of the first group of policies from cross-section data. If we had time series data on collection before and after the policy it would have been easy to determine the impact. In the absence of such data all we have to compare the collection of those who have received the benefits. However, ***as the people who have received the benefits are poor to begin with, policy recipients are likely to be associated with high levels of collection.*** One possible solution is to control for initial income levels, which we attempt to do in the OLS framework by introducing variables for percapita land ownership (OWNPRCAP) and income from non-agricultural sources (NAGPCP). Further, we also include the impact of household characteristics – like HOUSENO, PCTCHIL and PCTFEMAD – and areawise dummies like FOREST and PASTURE in our OLS regressions.

Table 4.6: Impact of Policy on hours spent on collection per adult (PRADHRCP)

Model	4. OLS	5.OLS	6. OLS	7.2SLS
CONST	226.856	117.064	23.464	373.88
	(7.179)	(2.450)	(.483)	(2.300)
REGDTEN	-49.390	-60.355*	-40.093	-7.556
	(-1.508)	(-2.028)	(-1.338)	(-.142)
VESTPERC	.547	398.613	325.493	303.540
	(1.449)	(1.497)	(1.915)	(.076)
COSTINT	-30.145**	-21.175*	-6.354	-136.428**
	(-3.383)	(-2.158)	(-.661)	(-3.144)
CRINT	-18.894	9.183	19.794	21.300
	(-.987)	(.609)	(1.365)	(.910)
IRDPBEN	23.221*	6.387	6.856	-15.369
	(1.753)	(.488)	(.554)	(-.820)
JRYPRCP	2.280**	1.557*	1.585*	-.490
	(3.377)	(2.240)	(2.385)	(-.077)
OWNPRCAP	-64.003**	-43.356	-41.807	
	(-2.655)	(-1.684)	(-1.687)	
NAGPCINC	-1.389	-.660	-1.216	
	(-1.260)	(-.553)	(-1.067)	
LEASEPERC		125.285**	143.036**	
		(3.682)	(6.197)	
HOUSENO		-11.682 **	-9.923**	
		(-2.626)	(-2.355)	
PCTCHIL		3.142**	2.541**	
		(5.928)	(5.140)	
PCTFEMAD		2.039**	1.818 **	
		(4.272)	(4.007)	
FOREST			92.863**	
			(3.668)	
PASTURE			66.401**	
			(2.5088)	
R^2	0.202	0.386	0.458	0.288
AdjR2	0.185	0.363	0.434	0.265
F	11.671	16.966	19.384	12.651
SigF	.000	.000	.000	0.000

When the only explanatory variables are the policy variables and the income level variables (equation 4, OLS), the ***impact of the non targeted policies*** – ie those representing technology policy like COSTINT and CRINT and the one for tenancy registration, REGDTEN – are ***all negative***, although only the first is significant. The ***impact of targeted policies*** like IRDPBEN and JRYPRCP and proportion of land received through redistributive land reform, VESTPERC are, however***, positive and***

significant. The sign on income level variables OWNPERCA and NAGPCINC are negative, the first one statistically significant.

We then explicitly estimate the reduced form equation (9) section 3.2.2 by the OLS method, first without the area dummies. The ***non-targeted policy variables*** REGDTEN and COSTINT are now both ***negative and significant***, while the targeted policies – JRYPRCP, VESTPERC and IRDPBEN – are all positive, though only the first is significant. Including the area dummies and household characteristics (equation 6, OLS) does not help, as although these variables are mostly significant and have expected signs, the significance of the policy variables is reduced.

A possible problem is that ***the households who have received the targeted policies have been selected on the basis of their household characteristics, income, as well as area specific parameters***. We therefore estimate Equation (10) in the simultaneous equation system described in Section 3.2.2 (see also Appendix A) by the method of Two Stage Least Squares where the above factors are include as Predetermined Variables and the policy variables as endogenous variables. Below we consider the results of the OLS and 2SLS models side by side.

From the results described below we can conclude that:

Result 4: *Time devoted to collection per adult member in the household is significantly*(*in the statistical sense*) *lower for households that have directly benefited from land reforms and technology policies. However, for policies targeted towards the poor - like IRDP, JRY and land redistribution - the validity of this relationship is difficult to discern from cross-section data.*

Comparing the OLS and 2SLS models, observe that all the policy parameters are now negative and significant under the 2SLS.. This arguably confirms our position that the positive signs on these policy variables are due to the fact that they are endogenously determined based on household, income and area characteristics.

In the preceding analysis, we studied the impact of all policies on household CPR demand as indicated by time devoted to collection per adult member. Next, we compare the difference between the average hours devoted to collection in areas selected for high and low implementation of anti poverty programmes. The purpose is to find out whether good implementation of such programmes have an overall impact on demand for CPRs in the area beyond the effect on targeted beneficiary

households. First, we consider the difference aggregating across both population groups and areas.

Table 4.7A: Comparative Time spent in collection in villages selected for high vs low implementation of Anti-Poverty Programmes

	GDBD	N	Mean	Std. Deviation	Std. Error Mean
PRADHRCP	high	90	157.4986	310.98	32.7799
	low	90	280.1296	329.92	34.7763

Chart 5: Impact of Policy Implementation on CPR demand in Anti Poverty Program Areas

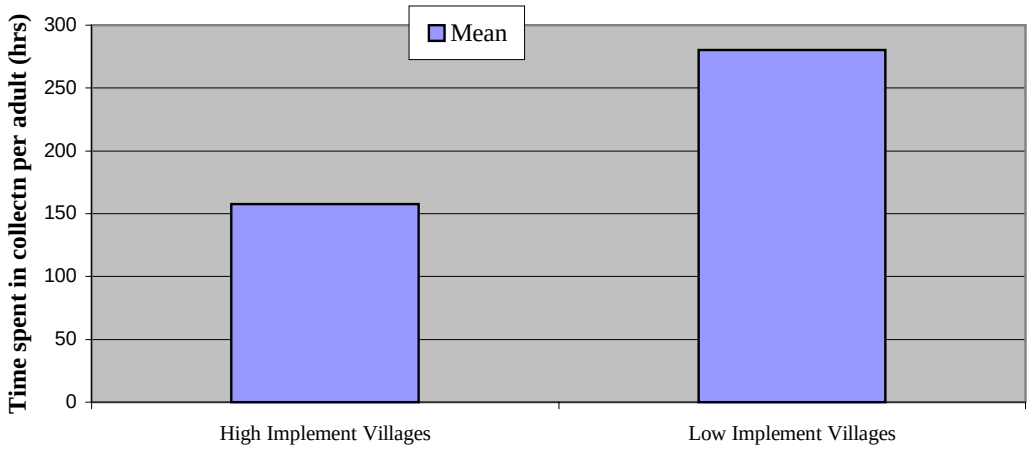


Table 4.7B Independent Sample t test for Comparison of Means

	Levene's Test for Equal Var		t-test for Equal Means		
	F	Sig.	t	df	Sig. (2-tailed)
Equal variances assumed	5.816**	0.017	-2.566**	178	0.011
Equal variances not assum			-2.566**	177.38	0.011

Thus we find that

Result 4A: *The average time spent per adult is significantly lower in villages selected for good implementation of anti poverty programmes compared to the areas where the implementation of such policies were poor.*

It is still possible that the lower mean time spent on collection in the high implementation areas may be due to the different economic condition of the people

in the two areas. To examine this possibility we classify the population in each area into 3 distinct groups : poor non beneficiaries, poor beneficiaries and the non poor.

Further, we also consider a breakup of the time spent on collection per adult into time devoted to collection of specific categories of items. In particular, we look at the time devoted to collection of 'food', 'fuel' and 'saleable' items as these are likely to vary in different ways in response to policy implementation:

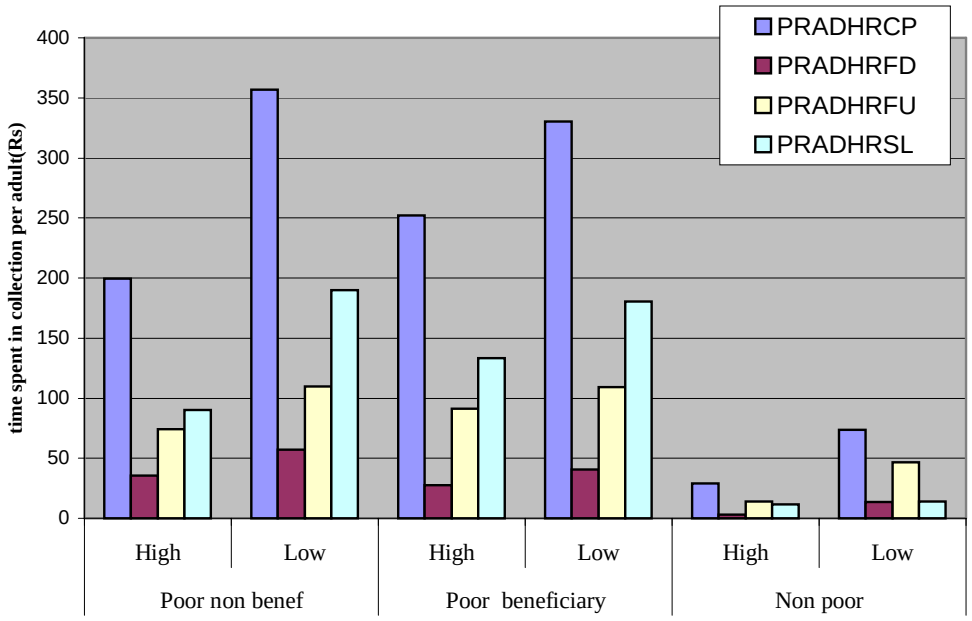
- time devoted to collection of CPR based foods are likely to be lower in the high implementation areas as their income from other sources increase.
- time devoted to fuel collection may increase as their cooking requirements increase
- time devoted to collection of saleable items may increase or decrease depending on the connection of anti poverty programmes to CPR based items sources like cattle food (pastures), fisheries (waterbodies) and leaf /twig based products (forests)
- The result of such comparison of average time spent on collection are presented below:

Table 4.8: Detailed breakup of average Time spent in collection in villages selected for high vs low implementation of Anti-Poverty Programme Villages

POPGRP	GDBD		PRADHRCP	PRADHRFD	PRADHRFU	PRADHRSL
Poor non ben	high	Mean	199.6266	35.5321	73.9984	90.0962
	vill	N	26	26	26	26
		Std. Deviation	344.4589	83.6122	122.9268	244.065
	low	Mean	356.9186	57.0083	110.0128	189.8974
	vill	N	52	52	52	52
		Std. Deviation	355.8957	53.4409	109.4765	272.9942
	All	Mean	304.4879	49.8496	98.008	156.6303
	vill	N	78	78	78	78
		Std. Deviation	357.7507	65.3087	114.6138	266.3524
Poor benef	high	Mean	251.9292	27.5349	91.1536	133.2406
	vill	N	32	32	32	32
		Std. Deviation	387.8716	36.9203	97.3773	356.7087
	low	Mean	330.4356	40.4244	109.3222	180.6889
	vill	N	15	15	15	15
		Std. Deviation	284.1703	39.3527	80.2332	225.7933
	all	Mean	276.9844	31.6486	96.9521	148.3837
	vill	N	47	47	47	47
		Std. Deviation	356.8357	37.7734	91.7756	319.0074
Non poor	high	Mean	28.8391	3.0068	14.1917	11.6406

POPGRP	GDBD		PRADHRCP	PRADHRFD	PRADHRFU	PRADHRSL
	vill	N	32	32	32	32
		Std. Deviation	61.0831	6.992	28.5274	44.4575
	low	Mean	73.7116	13.3188	46.5217	13.871
	vill	N	23	23	23	23
		Std. Deviation	187.3679	25.3902	132.8858	39.5414
	all	Mean	47.6039	7.3191	27.7115	12.5733
	vill	N	55	55	55	55
		Std. Deviation	130.1678	17.8061	88.997	42.1054
All groups	high	Mean	157.4986	21.1241	58.8334	77.5411
	vill	N	90	90	90	90
		Std. Deviation	310.9777	51.4687	94.817	253.8974
	low	Mean	280.1296	43.0793	93.6722	143.3781
	vill	N	90	90	90	90
		Std. Deviation	329.9168	48.8154	114.0937	238.6324
	all	Mean	218.8141	32.1017	76.2528	110.4596
	vill	N	180	180	180	180
		Std. Deviation	325.5496	51.2163	106.0541	247.9016

Chart 6:Average itemwise CPR demand by population group in anti poverty program areas



From the above, we may make the following observations:

1. While 35% in the ‘high implementation’ villages are non poor, the ratio is 25% in the ‘low implentation’ villages.
2. 55% in the ‘high implementation’ villages and 22% in the ‘low implentation’ villages have received policy benefits.
3. Every population group in the ‘high implementation’ villages – devote less time to collection per adult than the same group in the ‘low implentation’ villages
4. In the ‘high’ as well as the ‘low implentation’ villages the non poor devote less time per adult to collection on average than the poor households
5. In the ‘high implementation’ villages the poor non beneficiaries (PNB) appear to devote less time to collection than the beneficiaries (PB) though the opposite happens in the ‘low implentation’ villages.
6. Notice however that the PNB spends more time in food collection than the PB households in both types of villages. The difference occurs principally because in the high implementation villages the PB households devote more time per adult on collection of fuel (which may be due to greater income and food consumption) and collection for sale (which may be connected to their income generating schemes under the rural development programmes)

4.3 INTERACTION BETWEEN CPRs AND PPRs

The preceding analysis deals with the CPR based items such as food and fuel for the household's consumption in addition to items such as 'leaves', aquatic foods including fish and similar items. As already indicated in Section, there are some uses of CPRs not adequately covered by the above analysis. The most important among them are the ***use of CPR based items in agricultural and related productive activity*** - such as grazing and irrigation. These constitute the field of interaction between CPRs and PPRs, where the level or growth in one sphere limits the level or growth in the corresponding one. Thus, more intensive cultivation or maintenance of dairy cattle requires more farm animals and greater demand for pastures; it also requires greater withdrawal of common property surface and groundwater resources.

On the other hand, it also leads to the reduction in seasonal fallows and degradation of CPR water resources. This section deals with such activities.

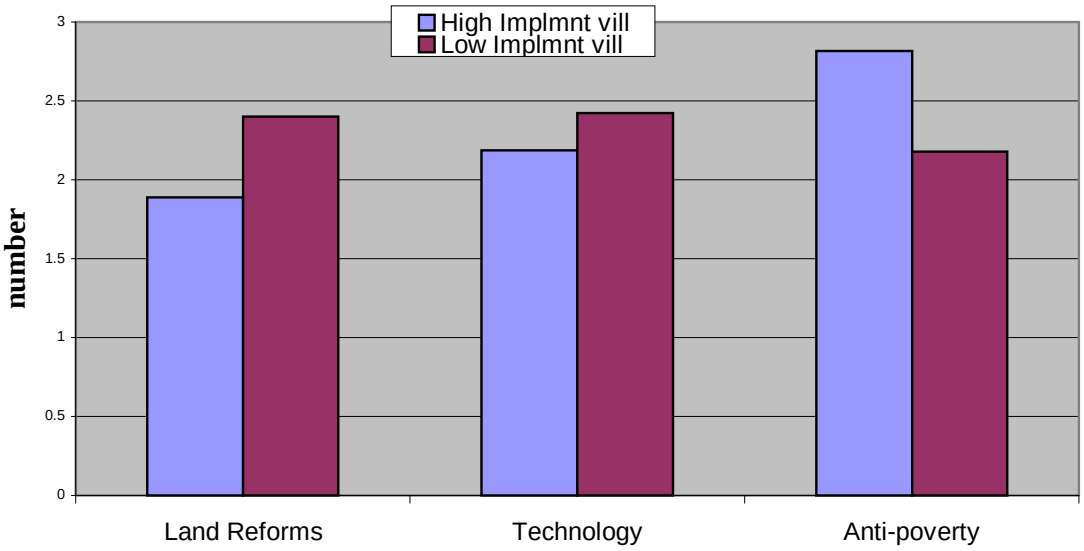
4.3.1 Grazing

It has already been indicated that a different approach is necessary to measure the supply and demand for CPR based grazing activity as the adult hours spent on it are not adequate indicators. A possible approach is to take cattle ownership and income from grazing per cattle (see Methodology) as proxies for the demand for and supply of the relevant CPR based resources. While cattle ownership is an obvious measure of 'demand for grazing', the reduction in feed cost per cattle from grazing is an indicator of the (per cattle) grazing resources in the relevant area.

Table 4.9: Impact of Specific Policies on Average Cattle Ownership

		Land Reforms	Technology	Anti-poverty
Mean	high	1.889	2.1889	2.817
	low	2.4	2.422	2.1778
ST. Dev	high	1.7828	2.7103	3.4774
	low	2.54	2.4171	1.8368
levines test eq var	F	4.129	0.001	6.964
	sig F	0.044	0.969	0.009
t-test equal means	t	-1.559	-0.61	1.536
	df	178	178	178
sig 2-tailed		0.121	0.543	0.126

Chart 7: Impact of Specific Policies on average cattle ownership



From the above, we find that average cattle ownership per household is higher in the 'low' implementation villages compared to 'high' implementation ones for all policy regimes except anti poverty programmes. The latter is due to the fact that many self employment schemes directly subsidise the purchase of cattle.

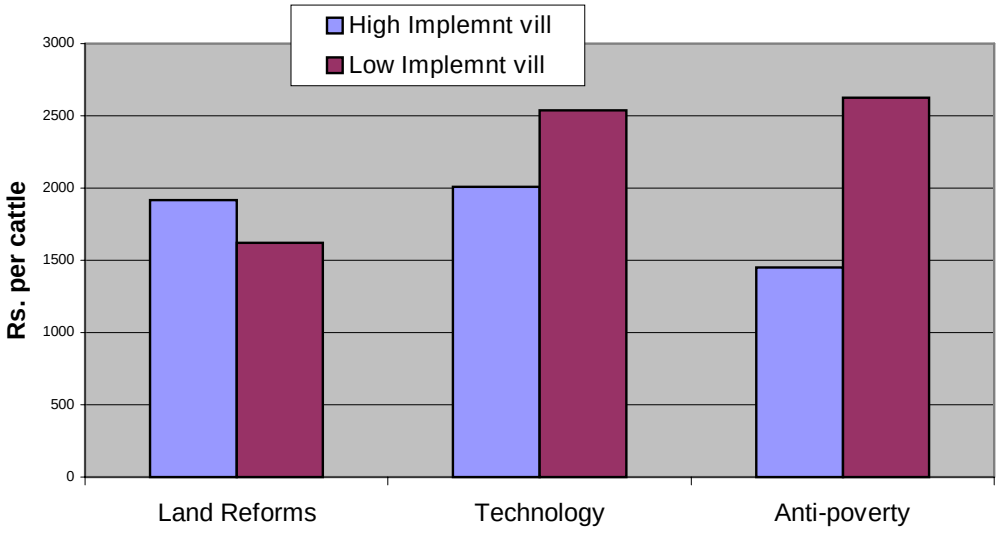
As cattle depend substantially on grazing for their feed, cattle ownership by the households can be interpreted as a measure of the 'demand for grazing' on common property grazing grounds. To obtain a similar measure of the 'supply' of common property grazing resources - both in terms of quantity and quality - we look at the value obtained from grazing per cattle. As indicated in Section 3, this is an indicator of the degree to which grazing is able to substitute for purchased feed and depends on the quantity and quality of the uncultivated land and fallows that are practically utilized as common property grazing grounds by the villagers.

Table 4.10 Impact of Specific Policies on Average Income from grazing per cattle

	Policy implemnt	Land Reforms	Technology	Anti-poverty
Mean	High	1915.454	2007.66	1450.781
	Low	1622.167	2536.57	2625.747
ST. Dev	High	882.5467	754.172	1032.656
	Low	1064.661	1088.516	1125.036
Levene's test eq var	F	3.048**	8.162**	1.113
	sig F	0.083	0.005	0.293
t-test equal means	t	1.691	-2.956**	-6.394**
	df	126	110	136
sig 2-tailed		0.093	0.004	0

** significant at 1% level

Chart 8: Impact of Specific Policies on average income from grazing per cattle



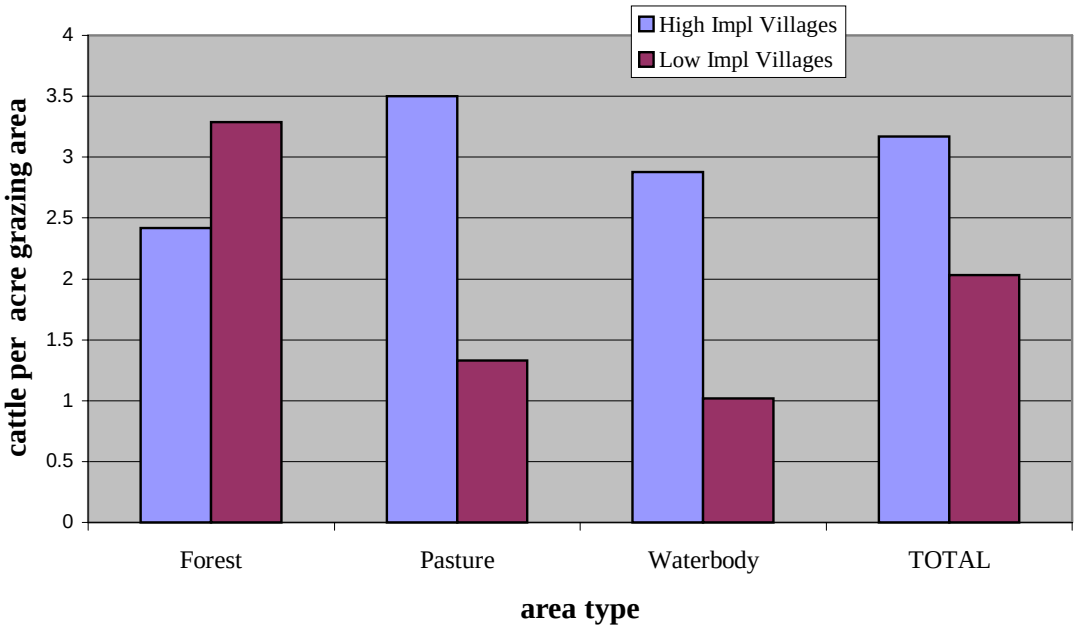
From the above we find that:

Result 5: *The income from grazing per cattle appears to be higher in the low implementation villages compared to the high implementation ones except in the case of land reforms, where the difference – although in the reverse direction – appears to be statistically insignificant.*

It is important to note that while the average income from grazing per cattle is higher for villages with low implementation of technology and anti poverty policies, the reasons in two cases would appear to be different. In the latter case, where good implementation of programs like IRDP lead to higher cattle per household, the greater pressure on grazing land is likely to reduce the income from grazing per cattle in the high implementation areas.

The same is unlikely to be to be true under the technology policy where 'high implementation' villages appear to have lower cattle ownership per household. Rather, the likely reason here for lower average income from grazing per capital is the greater pressure on grazing land as expressed by the number of cattle per unit grazing area. This is confirmed by the following chart which shows the number of cattle per unit grazing area in the technology policy villages.

Chart 9: Impact of technology policies on grazing intensity by Area Type



Such pressure may also explain the relatively lower cattle ownership per household in the high technology policy implementation villages compared to the high implementation ones. Further, the majority of the cattle population here are draught animals used for cultivation and therefore cannot be grazed for long periods during the peak agricultural season. This is also responsible for the relatively low value obtained from grazing.

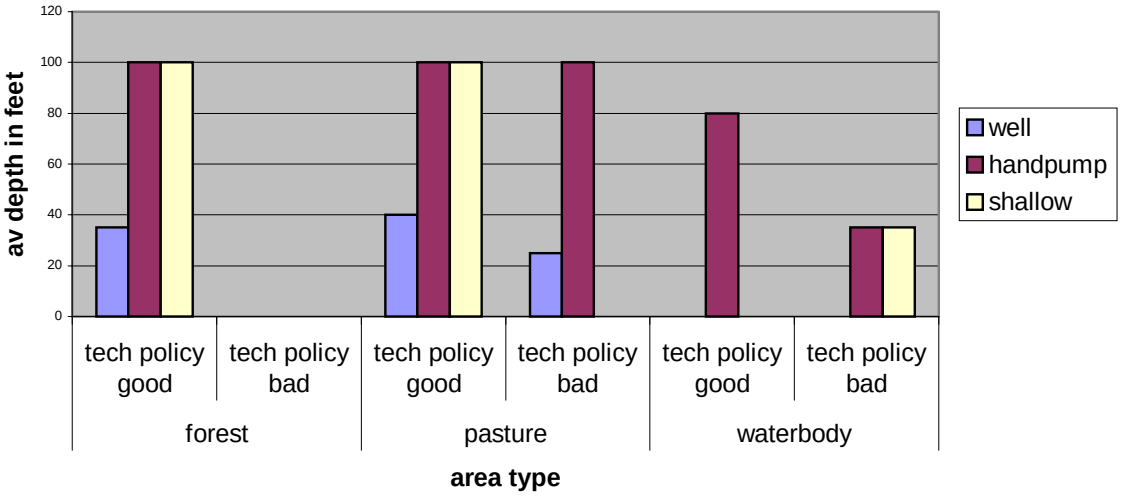
4.3.2Use of Common Property Water

There are also some aspects of common use of village water bodies that are also not completely covered by the preceding analysis. These include (a) domestic water use for drinking, cooking, washing, bathing etc and (b) use of common property groundwater in irrigation.

The problem in the context of these aspects is that they are very difficult to link with the implementation of agricultural policies. For example consider two villages in reasonably close areas - but with different levels of implementation of technology policy in the sense that one has exploited groundwater to a much greater extent by the use of shallows. The extent to which this reduces the availability of common property groundwater should ideally be revealed by the difference in the average depth of shallows. Unfortunately, we find that in most cases the overexploitation of groundwater would increase the average depth of tubewells not only in the 'high' technology village but also in its 'low' technology neighbour. This is because both villages often draw water from the same underground aquifer.

A possible way to get around this is to include the average depth of wells and hand pumps. However, there are further problems in the sense that the actual depth to which the pumps are sunk may not necessarily indicate the precisely required depth. With these limitations in mind, along with the obvious fact that not all villages have all types of schemes, we present the water table data for the technology policy areas in the following chart to show that intensive cultivation indeed lowers the water table.

Chart 10: Impact of Specific Policies on the water table

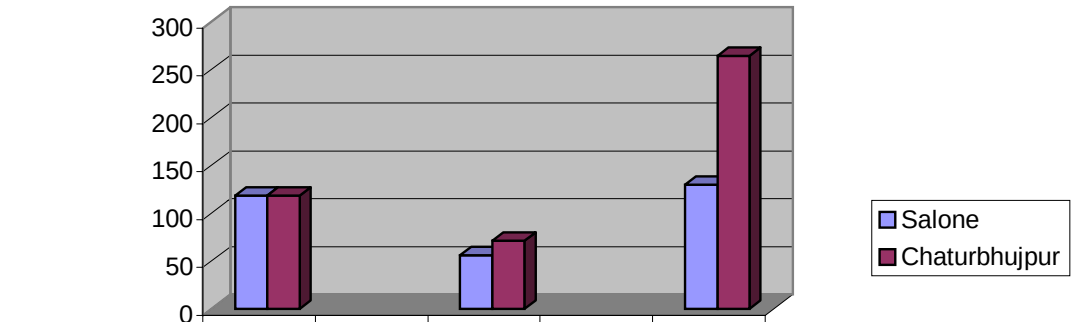


The other impact of intensive farming is the use of fertilizers and pesticides which contaminates the tanks that are commonly used sources of domestic water like bathing, cooking etc. Over the years, most people in our study area have ceased using surface water sources like tanks and ponds for drinking and cooking. These are now mostly utilized for bathing, washing and cleaning. Previously the waterbodies used for drinking and cooking were not used for other purposes. Hence, a comparison with the past will show that there is a reduction in water bodies for drinking and cooking and increase in those used for bathing, washing and cleaning. This is true across all areas regardless of the level of policy implementation. Consequently, this is more likely to have occurred due to rise in health awareness than contamination of water due to technology - although the latter may have played a part.

4.3.3 Carrying Capacity Analysis:

Another way to analyse the impact of agricultural development - as already indicated - is the method of carrying capacity analysis. We have carried out this analysis for two ponds in waterbody areas selected for the study of technology policy - Salone and Chaturbhujpur. The results are presented briefly below while the technical results are given in Appendix B.

Chart 11: Carrying Capacity Analysis of Impact of Technology Policy on Surface Water Resource Productivity



	Gross Prim		Net Prim Pdvt(mg		Second. Fish
Salone	118.3		56.16		129.6
Chaturbhujpur	118.75		71.09		264.6

To quote from the analysis of the expert " Although the gross primary productivity values are found to be equal in both the ponds, the net primary productivity is much greater in pond II (Chaturbhujpur). Therefore the energy availability being more, the biogenic capacity is also enhanced in this pond. Therefore the estimated fish productivity is much higher in pond II."

4.4 AGRICULTURAL POLICY, CPRs AND INEQUALITY

It has been found in several studies that the poor depend more on CPR based resources than the comparatively better off. Thus, including CPR based income in the calculation is likely to decrease the estimate of rural inequalities. Agricultural development policies, while improving the economic opportunities accessible to a section of the population, leads to a deterioration of most types of CPR products. Thus, those not benefited directly by these policies may be forced to fall back on a reduced supply of CPRs. As a result, while mean incomes in the area may increase as a result of implementation of agricultural development policies, income inequality of income including the CPR resources in the village is likely to increase over time.

Therefore it is worthwhile to compare

1. The mean per capita income levels - including and excluding the CPR component -of high and low implementation villages for each type of agrarian development policy,

2. the GINI coefficients for the good and low implementation villages for each area and policy both with and without the CPR component.

Table 4.11 Impact of Policies on Mean Income and Income Inequality (Gini coefficients)

		land reforms				technology				Antipoverty			
	poly												
area	impln	PCpINC w/o cpr		PCpINC with cpr		PCpINC w/o cpr		PCpINC with cpr		PCpINC w/o cpr		PCpINC with cpr	
		mean	gini	mean	gini	mean	gini	mean	gini	mean	gini	Mean	gini
forest	low	6693.161	0.406	7867.28	0.353	3243.7	0.327	4718.69	0.273	1892.6	0.324	4037.89	0.235
	high	9303.133	0.596	10663.6	0.512	5428.38	0.538	7546.56	0.415	3042.36	0.298	4989.103	0.244
pasture	low	3769.303	0.347	4762.59	0.295	5389.88	0.526	9135.2	0.447	4940.45	0.439	6208.809	0.372
	high	2603.114	0.434	4060.57	0.339	7882.42	0.385	6938.93	0.314	7342.81	0.4	7711.421	0.383
watbd	low	6195.371	0.255	6718.21	0.268	3697.54	0.312	5608.12	0.238	2979.2	0.461	4729.776	0.405
	high	4261.002	0.315	5584.39	0.454	6709.95	0.422	7586.51	0.394	6514.85	0.36	7304.099	0.284

Observe that

a. for superior land reforms implementation while mean incomes with and without CPRs increase in forest areas, it declines in pasture and waterbody areas; inequality, however, is higher in high land reform implementation villages for all areas,

b. mean per capita income with and without CPRs is always higher in high technology policy implementation villages in all types areas; so is inequality, except in pasture areas

c. in high anti poverty programme implementation villages, however, both mean income - with and without CPRs - is higher and inequality lower (or at least not higher)

From the above we may conclude that:

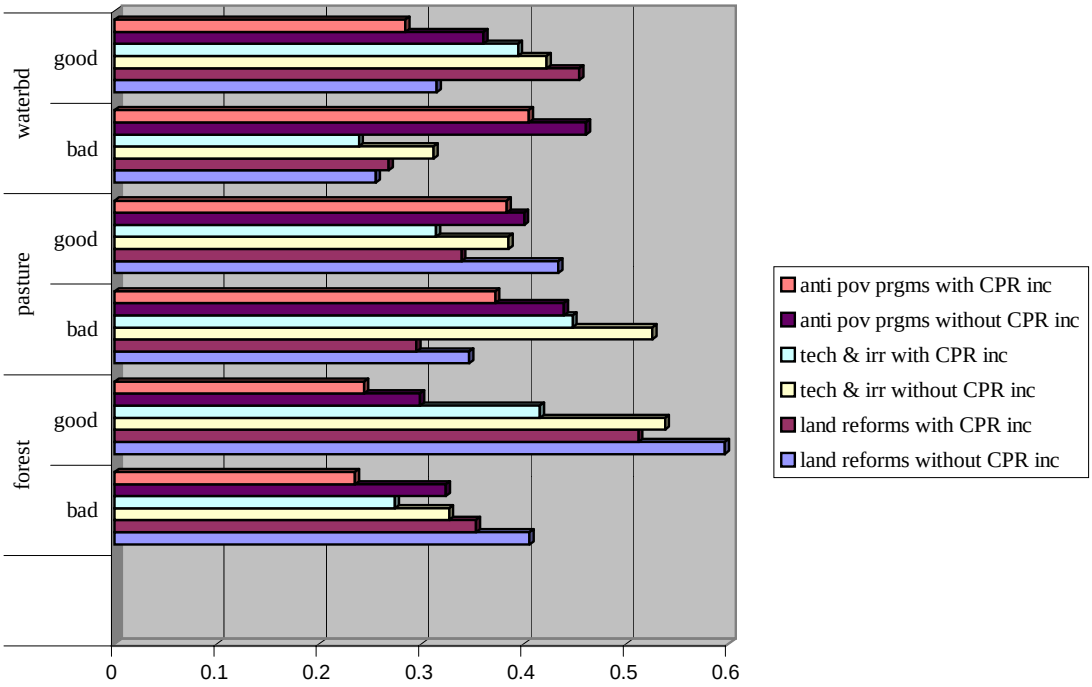
Result 6: *High implementation of Agricultural Development Policies*

(i) raises mean per capita income - with and without CPRs - except in the case of land reforms (in pasture and waterbody areas),

(ii) raises inequality except in the case of anti poverty programs

The Gini coeffients are presented in the following table

Chart 12: Impact of Different Policies on village Income Inequality (gini coefficients) with and without CPR income



gini coefficient

In case of (i) note that it is natural to expect that superior implementation of agriculultural development strategies would imply higher income opportunities and hence higher levels of per capita income. That this does not happen under higher implementation of land reforms in pasture and waterbody areas may With respect to ((ii) recall that anti poverty programs are targeted in the sense that beneficiaries are selected based on their (low)'income status' and household characteristics, which may explain why high implementation reduces inequality. *In fact, due to such 'endogeneity', benefits obtained by the household under such programs appear to be positively (though not significantly) correlated to CPR demand*. Specifically, this occurs due to

- Lower proportion of poor in the 'high implementation' villages and
- higher hours spent by poor beneficiaries relative to non-beneficiaries on CPR based fuel and saleable items in the high implementation villages which confirms their better economic status.

Chapter V : DISCUSSION

5.1 A SUMMARY OF THE MAIN RESULTS

The impact of implementation of different types of agricultural policies on CPRs in our study area may be summarised as follows:

1. High implementation of Land Reforms reduces the demand for CPRs (Result 4) without significantly affecting supply (Result 2, 2A). Thus, it is unlikely to cause a major degradation of CPRs in the long run. This is also supported by the fact that value obtained from grazing does not decline in the 'high' implementation areas (Result 5). However, land reform lowers mean per capita income - except in case of forests - and raises inequality within the village, whether one includes or excludes the CPR income of the households – except in the case of waterbody areas (Result 6).

2. Implementation of Technology Policies reduces both the demand for (Result 4) and the supply of CPRs (Result 2). In our study area, intensive cultivation also reduces perennial and seasonal fallows so that the value obtained from grazing is reduced (Result 5). The long run impact would therefore depend on which of the two effects are stronger. Mean per capita income and income inequality within the village is higher as a result of policy implementation(Result 6).

3. Implementation of anti poverty programmes usually raises the demand for CPRs (Result 4, 4A) while adversely affecting supply (Result 2). Thus, these policies are most likely to cause degradation of CPRs in the long run. For example, anti poverty programmes lead to higher cattle ownership per household (Table-4.10) causing greater pressure on land and lowering the value obtained from grazing. However, satisfactory implementation of these programmes raises mean per capita income and reduces rural inequality (Result 6).

Thus CPRs may be adversely affected by agricultural development policies in two ways:

1. by direct degradation which lowers the supply of CPRs, an example of which is the degradation of surface water by pesticides or reduction of seasonal fallows by multiple cropping. This happens both in the case of technology policy and anti poverty programmes.

2. By **congestion** of CPR resources, that is through raising the demand. This happens mainly in case of anti poverty programmes (Result 4, 4A). These include the increase in grazing demand due to subsidizing cattle, pressure on forests from forestry related schemes and promotion of fisheries in waterbody areas. It also sometimes occurs in the context of technology policies - for example by raising the demand for surface and groundwater resources. It is in the context of this second type of effect that participatory demand management - through formation of Joint Forest Management Committees, for example - and selection of appropriate self employment schemes can have the maximum impact.

5.2 LIMITATIONS OF THE ANALYSIS

The results obtained from the formal analysis of data is subject to several limitations:

1. First, as noted before, the boundaries of the village and the estimates of the CPRs are often ambiguous. Several villages may access the same forests, pastures and or waterbodies. We have therefore chosen the value of CPRs collected per hour as a proxy of the "virtual supply" of CPRs

2. An important difficulty is that we are unable to precisely study the effects of agricultural policy on the same households at two different points of time - i.e., before and after receiving the benefits. Instead, we have to compare the effect of benefits indirectly - i.e., between households that have and have not received specific policies or villages with high and low implementation - on their demand for or supply of CPRs. But in some cases where policies are specifically targeted at the poor, the correlation between receipt of benefits and CPR demand may be misleading. For example receipt of IRDP may be positively correlated with higher CPR demand precisely because it is the poor with high CPR demand who receive these benefits.

3. A possible consequence of this lack of time series data is the absence of the effect of land reforms on the demand and supply of CPRs. As is well known, most of the implementation of land redistribution and tenancy policies were completed within the first half of the 1980s. Consequently, the adverse impact of these reforms - which occurs due to the 'privatization' of virtually open access uncultivated wastes - is very difficult to establish from the data.

5.3 PERCEPTION OF VILLAGERS:

One way to partly overcome some of these problems is to take account of the perception of the villagers. This can be done in two ways - devising precisely formulated opinion polls on the relevant issues or through informal discussions. We decided both methods because (a) clear answers on these issues are difficult to obtain (b) some of the issues are better understood through informal descriptions.

Table 5.1 Perception of Villagers Regarding Time Spent in CPR Collection and CPR Status

				Time spent on CPR		Status of CPR	
Policy Type	Implemntn	Pop	Total	Perceptibly	not perceptibly	Perceptibly	not perceptibly
		Group	Respondents	Higher	higher	Lower	lower
Land Reform	High Impl vill	PNB	4	50%	50%	75%	25%
		PB	17	64%	36%	53%	47%
		NP	9	66%	34%	66%	34%
	Low Impl Vill	PNB	10	90%	10%	0%	100%
		PB	13	100%	0%	0%	100%
		NP	17	76%	24%	88%	12%
Technology	High Impl vill	PNB	20	25%	75%	35%	65%
		PB	4	0%	100%	0%	100%
		NP	6	0%	100%	16%	84%
	Low Impl Vill	PNB	19	0%	100%	15%	85%
		PB	2	0%	100%	0%	100%
		NP	9	0%	100%	0%	100%
Anti Poverty	High Impl vill	PNB	14	35%	65%	35%	65%
		PB	6	50%	50%	50%	50%
		NP	10	50%	50%	30%	70%
	Low Impl Vill	PNB	8	12%	88%	13%	87%
		PB	8	0%	100%	37%	63%
		NP	14	28%	72%	42%	100%

PNB=poor non beneficiary, PB = Poor Beneficiary, NP = Non poor

Observe that (a) for areas selected to study the impact of Anti Poverty programs, more respondents from the High Implementation Villages perceived that time spent on CPR collection had increased and CPR status had declined compared to the respondents from the low implementation villages. This is line with our basic finding regarding increase in CPR demand and reduction in CPR supply as a result of high implementation of anti poverty programs. (b) For areas selected to study the impact of land reforms - on the other hand - more respondents from the high implementation

villages appear to perceive that CPR demand has not perceptibly increased in the past relative to low implementation villages. However, relatively more people in the high implementation villages also seem to find that CPR status has perceptibly declined which contrasts with our finding. (c) In the technology policy villages, the results are indeterminate.

Many villagers were of the opinion that overall, CPRs were being degraded as a result of population pressure and agricultural development. This happens in a variety of ways. For example, in the village of Fingtorre we were told that the availability of fish in the large seasonal waterbodies ("beels") are declining. These beels are essentially private property lands which are submerged during the monsoon and used as common property fishing tanks. The excessive use of pesticides on these lands during the boro season has led to the decline in fish production. On the other hand, in Musabani village the irrigation dams are breached during monsoon and merge with the perennial tanks. The fish from the tanks swim out into the rivers so that there are scarcely any fish left in the tanks.

According to many villagers, the practice of grazing cattle has decreased due to the unavailability of "bagels" or cowherders. Part of the problem arises because the practice of maintaining round the year farm servants who were given these tasks is on the decline. In addition the improvement in the economic condition of the poor agricultural labourers has led them to withdraw their young children from the house of their landlords where they were earlier sent to work in exchange for maintenance. It is not that all these children now go to school. In fact, we encountered a problem of 'missing children' in many of our study areas - children who neither work nor go to school. Specifically, in the opinion of the respondents, this has led to a lower cattle ownership by the prosperous farmers along with a higher ownership by the poor supported by various anti poverty schemes. Further, while the farmers graze their cattle less due to the absence of "bagals", the agricultural workers often take their cattle with them and graze them near the farmlands. They bring them home when they return.

Many villagers were of the opinion that it was the poorest farmers who were hurt the most when the forests were degraded and turned into uncultivable wastes. This is because forests products are used by everybody and the poorest who have few alternative sources of income depend most on it. On the other hand, uncultivable

wastes which are principally used as pastures can be used only by the relatively better off who own cattle.

Most people, particularly in the Forest and Pasture areas said that they depended primarily on the forest for their fuel. While the poor collect fuel daily, the better off often take carts and hired labour to the forest to gather larger amounts. In addition, sale of kendu and sal leaves during the agricultural off-peak season is also an important source of income for the poor. Some people, mainly tribal also hunt forest fowl and small animals. In some areas like Jalikandar, we were told that earlier the tribal people used to ritually clear and set fire to the forest during the hunting season to ferret out the 'game'. Large tracts of forest have been ruined due to this practice. However, following the implementation of land reform and technology policies they are now busy in farming. The Forest Protection Committees have also drawn the attention of the Forest Department Staff to this practice. As a result, the tribal people have been made aware of the harmfulness of such rituals and desist from setting fire to the forests.

Chapter VI : POLICY RECOMMENDATATIONS

Three classes of policies need to be discussed in the context of our study:

1. Policies that directly protect CPRs
2. Appropriately implementing agricultural development policies taking into account their impact on CPRs

6.1. POLICIES THAT DIRECTLY PROTECT CPRS

Policies that directly protect CPRs includes policies for the protection and maintenance of forest resources, village water bodies and pasture areas. We briefly mention some of these policies (see for example, Murty 2001) in what follows, although our focus in this study is on the second type of policy.

Rules for protection of forests such as the Indian Forest Act, 1865, have existed in India since the colonial period and were strengthened after Independence through the Wildlife Protection Act, 1972, Forest Conservation Act, 1980 and the National policy for Conservation of Forest and Wildlife, 1992. In West Bengal, the Government encouraged villagers to form Forest Protection Committees (FPCs) and bestowed them the right to collect minor forest products and to a part of the sale of timber. In return, the FPCs were to aid the Forest Department in protecting the forests and in implementing social forestry schemes.

Policies for maintenance of water bodies are of two types : (a) The Water Act, 1974 and the Water Cess Act, 1977 which attempt to curb water pollution by industries and local authorities in urban areas, (b) The National Watershed Development Programme for Rainfed Agriculture for the development of dryland agriculture.

The problem regarding the protection of wastelands is very similar. There exists a Wasteland Development Policy and a National Wasteland Development Board set up in 1985. The purpose is to (i) increase tree and green cover on wastelands (ii) to prevent good lands and forests from becoming wastelands and (iii) management and development of existing wastelands.

6.2 AGRICULTURAL POLICIES AFFECTING CPRS

The main thrust of our policy recommendations, of course, are in respect of taking account of the impact of agricultural development policies on CPRs. If we look at specific agricultural policies, the recommendations are as follows:

1. **Land Reforms**: Land Reforms - including both redistribution and tenancy policies - appear to have the least adverse impact on the demand and supply of CPRs in our study areas. Note, however, that this may be largely because policies in these regard were formulated and implemented before 1980s - and their possible adverse effects would be difficult to establish from current data. Fortunately, this deficiency is unlikely to cause a major difference in policy recommendations in the context of these areas. This is because even if land reform did have a substantial impact on CPRs in the past there is nothing that can be done about it now as there is little scope for further land reform.
2. **Technology and Irrigation Policies:** As we have noted, technology and irrigation policies in our study areas have the effect reducing both the CPR demand and supply - the former favorable and the latter detrimental to the condition of CPRs. This is also supported by the lesser value from grazing despite lower total cattle ownership, which is caused by the smaller supply of grazing land.

The degradation in CPRs caused by increased irrigation, multiple cropping, greater use of fertilizers and pesticides, cultivation of high yielding varieties and agricultural price policy has many facets. The important among these are (a) Lowering of the water table due to intensive use of shallow tubewells, (b) Contamination of village tanks from pesticide and fertilizer use and lower productivity of these tanks in terms of fish and other water based foods, (c) Reduction of grazing land due to multiple cropping (d) Reduction of indigenous roots and plant foods from degraded lands and pastures

Sustainable agricultural policies in this context should aim at preserving agricultural income and employment - particularly that of the poor - without degrading CPRs. Thus we do not recommend a reduction in cropping intensity to save CPRs. Rather, we favour the following policies that reduce the damage to CPRs while at the same time maintaining agricultural output, employment and incomes:

a) in depth **study and charting of the natural resources** in each area including measurement of groundwater resources, soil and forest cover. This should include local stock taking of natural resources as well as more advanced scientific studies through such means as satellite mapping,

b) Choice of appropriate choice of crops in each area and for each season through providing **incentive or support prices**,

c) Increase in the use of organic manure and pesticides to replace chemical fertilizers and pesticides to the extent possible and more prudent use of water resources. These may be implemented through **appropriate taxes and/or subsidies** on fertilizers, pesticides, organic manure, water use, tubewells.

d) Optimizing the use of surface and groundwater to preserve the water table. This may be done by **introducing participatory management methods** to store rainwater, designating tanks exclusively for purposes of irrigation, regulations to control the set up and operation of shallows. The owners and users of waters may collectively make decisions regarding water use through Joint Water Management Committees aided by technical experts. A model for this is the *Pani Panchayat* System adopted in Maharashtra (Salunkhe, Lokkur and Pangare 2000).

Anti Poverty Programmes: While these programmes reduce rural inequalities, they often have negative environmental impacts in terms of raising the demand for CPR products, while damaging existing CPRs. This is also supported by the finding of reduced value from grazing in the high antipoverty programme implementation areas.

Hence, it is important that the administrators of these programmes in each particular area take into account the consequences of these policies on CPR demand and supply. For example, promoting purchase of cattle by the poor in an area with low pastures and abundant cattle or the production of products based on 'sal' or kendu leaves in areas with low natural forests should be discouraged.

Further, in the course of our surveys, we noticed a severe lack of coordination between the concerned departments of the government such as the Departments of Agriculture, Forests, Irrigation, Rural Development etc. To a large extent, each independently pursued their own policies without taking account of the others,

although there is scope for interaction between them. This makes it difficult even to obtain data and there is a lot of incompatibilities in the data obtained from various sources. In our opinion, this constitutes one of the principal weaknesses of the system and is crucial to the preservation of CPRs because these are subjected to stress from a variety of sources

The urgent need in this context is therefore:

a) the formation of **Joint Rural Resource Management Committees** that take an integrated approach towards the private and common property resources in an area.

b) **Selection of appropriate self employment and rural works schemes** taking into account the area specifics so as to minimize the damage on CPRs

c) **Coordinate the functioning of CPR management schemes (such as JFM committees) with Rural Development Programmes** for better all round functioning(see for example Singh 1994)

d) Judicious use of rural works programmes - like JRY - for developing and maintaining watersheds and in promoting social forestry.

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Appendix A

Structural Equations of the Simultaneous Equation System (10) - (12) in Section 3.2.2

$L_{CPR} = \phi$ **(HOUSENO**, **REGDTEN**, *CRINT, COSTINT*, *VESTPERC, IRDP, JRY*) (B.1)

VESTPERC = γ(**OWNPRCAP, NAGPCINC**, **REGDTEN, FOREST, PASTURE,** IRDP**)** (B.2)

IRDP = β(**OWNPRCAP, NAGPCINC**, **REGDTEN,** *VESTPERC*) (B.3)

JRY = α **(HOUSENO**, **PCTCHILD, PCTFEMAD, OWNPRCAP, NAGPCINC**, **REGDTEN,** IRDP, *VESTPERC*) (B.4)

CRINT =μ **(HOUSENO**,**OWNPRCAP, NAGPCINC**, **REGDTEN, FOREST, PASTURE,** *VESTPERC, COSTINT*) (B.5)

COSTINT = ρ**(OWNPRCAP, NAGPCINC**, **REGDTEN,** *VESTPERC, CRINT*) (B.6)

There are seven endogenous variables : L_{CPR}, *INCPRCAP, CRINT, COSTINT*, *VESTPERC, IRDP, JRY*, and eight predetermined variables **HOUSENO**, **PCTCHILD, PCTFEMAD, OWNPRCAP, NAGPCINC**, **REGDTEN, FOREST, PASTURE.** Equation (B.1) is identified since it excludes five predetermined variables - which is just 1 less than the number of endogenous variables included.

APPENDIX B

A REPORT ON CARRYING CAPACITY OF LENTIC WATER SYSTEMS UNDER COMMON PROPERTY RESOURCES

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Introduction

The current rate of growth in developing versus developed countries indicates that population will become even more unequally distributed in the future. India, having an exponential growth of population stands a chance of ruining its natural resources through over exploitation. In all cases, an ecosystem has a limit on the number of individuals it can sustain. This limit is usually referred to as the system's carrying capacity and it is based primarily on the amount of resources available for consumption. The carrying capacity is the theoretical equlibrium population size at which a particular population in a particular environment will stabilize when its supply of resources remains constant. It can also be considered to be the maximum sustainable population size; of the maximum size that can be supported indefinitely into the future without degrading the environment for future generations.

Carrying capacity is a very controversial term, evolving from the philosophy that there is a limit to growth. It is based on the facts that there are local shortages of water and food, atmospheric changes affecting people and many species are becoming endangered. The carrying capacity of the water resources for the human population is difficult to determine because human beings have the ability to alter the environment and to go beyond the usual checks and balances that ecosystems use to limit population growth. Most other species are only

able to consume resources upto the rate at which an ecosystem provides them. Humans, on the other hand, use technology to remove these natural constraints, bypassing the ecosystem's built in control mechanisms. However still, carrying capacity analysis will be meaningful if a focused and realistic view of it is carried out.

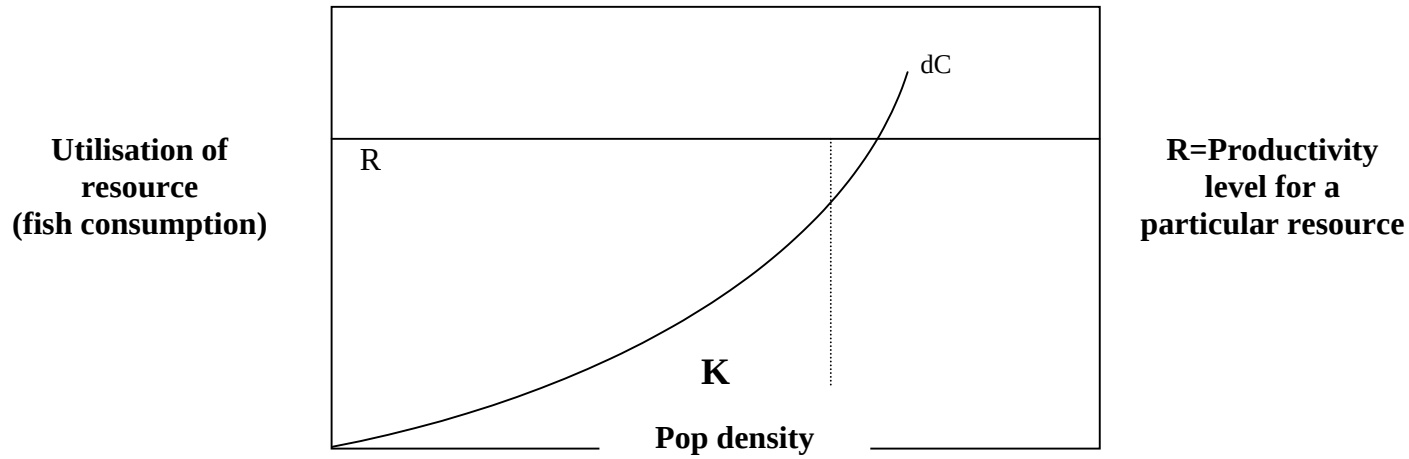
Qualitative Assessment of waterbodies and analysis of the carrying capacity :

This present programme was carried out in two representative villages in the district of Birbhum in West Bengal, India, falling under the sample areas of the World Bank aided project on Common Property Resources, Agricultural Development Strategies and The Poor In West Bengal under India: Environmental Management Capacity Building Technical Assistance Project. The specific objective of this programme was to assess the qualitative condition of the CPRs (waterbody in this case) accessible to the residents of the village. The lentic water systems of variable surface area are lying mostly uncultivated since these are viewed as common property resources. In absence of supervision and modern farming methods and unhygienic use of the systems, these are not contributing to fisheries. A few waterbodies used to produce fish under intensive method of farming were observed in a dilapidated state and dystrophic condition. Furthermore some waterbodies are being stressed by natural and anthropogenic eutrophication due to population's misuse and overexploitation. This is resulting into transformation of waerbodies into virtual terrestrial system through ecological succession. There seems to be a potent threat towards lss of habitat diversity and subsequent biodiversity in the aquatic bodies.This indicates a much lower level of utilization than the true potentials of the resources.Therfore a thorough qualitative assessment of the water resources alongwith their human carrying capacity towards an optimum and acceptable level of living standard has been evaluated to throw light on their true potentials.

This study has been carried out on model ponds categorized according to their usage pattern on which the value of carrying capacity depends. This value is also influenced by environmental stochasticity as well as demographic stochasticity.

Demographic features of the systems have been studied by zooplanktonic community as an estimator surrogate of the total biodiversity because their population could be a close measure of the total community attributes leading to the productivity of the fishes which are the most important resources for human population. Environmental stochasticity has been studied through limnological analysis. Both primary and secondary productivity have been measured to assess eutrophication status and the vital productivity potentials needed to measure the carrying capacity. Primary productivity is the rate at which radiant energy is utilized by the photosynthetic activity of producers to form organic substances of high potential energy from inorganic sources. Primary production is the amount of organic carbon produced and primary productivity is therefore the rate of production i.e. amount per unit time. Net primary productivity is the amount of organic matter stored after expenditure in terms of maintenance. Secondary productivity is finally the ultimate amount of organic matter produced at the consumer level (in this case measured in the form of fish productivity) of the system under study.

The carrying capacity is based on these two important parameters, Productivity and Consumption. This relationship has been explained by the following figure.



The figure shows a density dependent increase in the level of utilisation or consumption of a particular resource from waterbodies (the solid curve denoted as dC) and a constant productivity rate (the horizontal line denoted as R).Where the two lines cross is the carrying capacity (K) of the waterbodies beyond which no major increase in the population is possible (under the given amount of resource productivity (Ricklefs and Miller, 2000). The final question is what is the maximum number of population of human beings that can be sustained in a particular region. The carrying capacity calculations of any region is based on the food producing capacity of that system (Subramanium, 2000). It is calculated as Carrying Capacity (C) = Maximum food production / Food required for a person.

Therefore, in the present study C = Maximum fish productivity / per capita fish consumption.The carrying capacity here is measured in two different categories of ponds ---Pond I in Salone which is a technologically advanced area. Pond II in Chaturbhujpur which is a relatively backward area in terms of technology. Both the ponds are situated in the district of Birbhum.

Methods :

Environmental Analysis : Water sampling was done at the early hours of the day between 8 -- 9 a.m. and dissolved oxygen dissolved free carbon dioxide, pH, total hardness,Methyl orange alkalinity were analysed on the spot following standard methods (APHA, 1995).The total dissolved solids (TDS), Nitrate,Phosphate and Chloride were analysed in the laboratory. Primary productivity of the waterbodies were measured by Light and Dark Bottle technique. For an assessment of the aquatic ecosystem, Shannon-Weiner's index of species diversity was calculated following the formula

$$H = - \Sigma ni/N \times (\ln ni/N)$$

This index is a measure of stability of an ecosystem because more biologically diverse ecosystems possess greater power of resilience and resistance to withstand fluctuations.

The most important measure in the present context - the value of fish productivity was determined by the empirical method of evaluation following the Leger-Huet formulae. The annual fish productivity per unit area of a water body is equal to the product of the biogenic capacity (B) of the size of the pond and of the co-efficient of productivity (k). It measures the highest possible production obtained under a particular farming condition. The components of secondary productivity measurements are the biogenic capacity, the size element and the productivity co-efficient.

The 'Biogenic capacity' is the expression denoting the nutritive value of water examined for its feeding qualities for fish. It is expressed in the 'scale of biogenic capacity' of which the degrees correspond individually to a given nutritive value from I (the weakest biogenic capacity) to X (the greatest biogenic capacity). This enables fresh water to be placed in three categories : (1) Poor water with a biogenic capacity between I and III; (2) Average water with a biogenic capacity between IV and VI; (3) Rich water with a biogenic capacity between VII and X. Sterile waters are given O and the richest X. The estimation of biogenic capacity was based on phytoplanktonic and macrophytic abundance and physico-chemical characteristics of the water body. Although the biogenic capacity determined is an absolute value yet it is very precise depending mostly on judgement than measure.

Secondly, the productivity is proportionate to the extent and size of the surface of water. Thirdly, the co-efficient K is composed of four secondary co-efficients designated as k_1, k_2, k_3, k_4, which correspond respectively to temperature (K_1), to the chemical characteristics of the water (k_2), to the species of fish (k_3) and to the age of fish (k_4). The product of the four secondary co-efficient gives the measure

of productivity co-efficient. The fish productivity calculations from the above mentioned values were done following Leger-Huet model (Huet, 1985).

Results :

The results of the environmental analysis, factors to measure the carrying capacity and the carrying capacities of the resource ponds have been tabulated below. The carrying capacities of the two ponds were measured in terms of current living standard, optimum living standard and also their potentials after sustainable cultivation processes are initiated.

Table I: Environmental Analysis

Parameters	Resource pond - I	Resource pond - II
Dissolved oxygen (mgl^{-1})	2.82 $\pm$ .20	2.85 $\pm$ .25
Dissolved free CO_2 (mgl^{-1})	3-5	5 - 8
pH	6 - 7	7 - 2
Alkalinity (mgl^{-1})	64 - 68	96 – 98
Total Hardness (mgl^{-1})	100 -104	112 – 166
Total Dissolved Solids ($g\ l^{-1}$)	0.83 – 1.08	0.66 – 1.81
Nitrate (mgl^{-1})	25.0 – 40.0	35.0 - 100
Phosphate (mgl^{-1})	0.25 – 0.74	0.75 – 1.86
Chloride (mgl^{-1})	0.035	0.075

Table II: Human Carrying capacity levels in water resources

Water Resources	Carrying capacity estimated for present level of living standard	Carrying capacity for optimum level of living standard	Maximum carrying capacity estimated with semi-intensive cultivation of resources	Present adult population / water area
Resource pond I	3.2 adult population/acre	0.81 adult population /acre	2.38 adult population /acre	8.8 nos. / acre
Resource pond II	6.5 adult population/acre	1.67 adult population /acre	2.78 adult population /acre	

Table III: Measurement of factors leading to analysis of carrying capacity

Parameters	Pond I	Pond II
Area (acre)	0.6	0.7
Depth (ft)	4	5
Water Temperature (^{0}C)	22^{0}C	22^{0}C
Air Temperature (^{0}C)	24^{0}C	24^{0}C
Macrophyte abundance	-	10% (Floating & Submersed)
Phytoplankton abundance	+	+ +
Total Number of Zooplankton / L	350	680
Shannon-weiner species diversity index (()	1.3	1.7
Biogenic capacity (Grade)	VI	VII
Gross Primary Productivity (mgC/m^3/hr)	118.30	118.75
Net Primary Productivity (mgC/m^3/hr)	56.16	71.09
Secondary (Fish) productivity (kg/acre/yr)	129.6	264.6
Productivity co-efficient	9	13.5
Total consumption of fish resource (kg./ acre / year)	40.48	40.48

Discussion :

The increasing need for resource due to increasing population and wants of people may stress an area or region. Hence, it is desirable to conduct studies to obtain the Limits on the availability of resources and their uses. Since different regions may not be developing at the same level, there is normally a skewed level of development. Utilization of resources will not be uniform in all regions. As the development is a continuous process, carrying capacity studies should be carried out to divide the areas into categories based on resource use intensity. This will aid in development plans for a given region. While planning for the development of a region or to find out the sustainability of resources in that region or carry out carrying capacity studies, the basic aspect to be looked at is the consumption of resources. It depends on the understanding of the consumption of resources and the development of proper strategies for usage based on the existing consumption pattern. Hence, the first step in doing any of these studies is to calculate and estimate the consumption of resource. In this study, an exercise has been incorporated to look into the carrying capacity of two types of water bodies as explained before. The carrying capacity is dependent on environmental variables. Therefore, a relevant factorial analysis of water bodies was performed and presented in table 1II.

Based on the obtained values of dissolved oxygen and the dissolved free carbon di-oxide in the early morning , the water bodies are assumed to be suitable for biological activity within them. The pH of the Resource pond 1 is sligtly acidic and that requires correction to a more alkaline condition for increasing productivity. The Resource pond II, however, is absolutely perfect to provide higher production. The corresponding values of total alkalinity indicate that pond I is low in carbonate and bicarbonate ions. However, the total hardness values in both the pond types are indicative of potentially good biological productivity.

The nitrate & phosphate values are higher in pond II because of moderate farming activities. The chloride content and TDS are within normal limits in both

the situations. The measurement points out that the resource pond II maintains a water quality that favours good biological activity. The pond I is less suitable but can be corrected with approciate technological support.

Based on macrophytic and phytoplanktonic abundance, and quantifying the zooplankters, the biogenic capacity of Resource pond II seems to be greater. This is corroborated by Shannon-Weiner index that indicates greater richness and evenness of the different planktonic organisms in pond II.

Although, the gross primary productivity values are found to be almost equal in both the ponds, the net primary productivity is much greater in pond II. Therefore, the energy availability within being more, the biogenic capacity is also enhanced in this pond. Therefore, the estimated fish productivity is much higher in pond II. The results depicted in Table-III are clear and explicit in determining the resource productivity for both the ponds.

The current resource consumption as estimated from the nutritional status of the villagefolk providing a true reflection of their living standard. The carrying capacity values analysed from productivity and consumption are represented graphically (Fig. 1-6) and in Table II.

However, the carrying capacities of the resource pond could be much increased with adequate semi-intensive technological strategies. The projected values in such cases are expected to satisfy the nutritional needs of the present generation and at the same time semi-intensive technology involved will not degrade the environment . Therefore, based on this study, recommendations are put forward to take immediate steps for upgrading the aquaculture activities towards upliftment of poor people in this region.

The role of the state is necesary to deal with the externalities associated with common property resources (Das & Sahoo,2000). Apart from licensing etc. regulation includes the appropriate technology and intensity of resource use. Maximum yield through very intensive methods is economically inefficient and

unjustified from the viewpoint of environmental sustainability. However, modified extensive, or at the best, semi-intensive culture technologies can be adopted. For this, the lower income level of the rural folk is a barrier to acquire these improved technologies. The existing market system and the nutritional habits of the people are also a source of inequality. Appropriate measures should therefore be taken to narrow down these inequalities.

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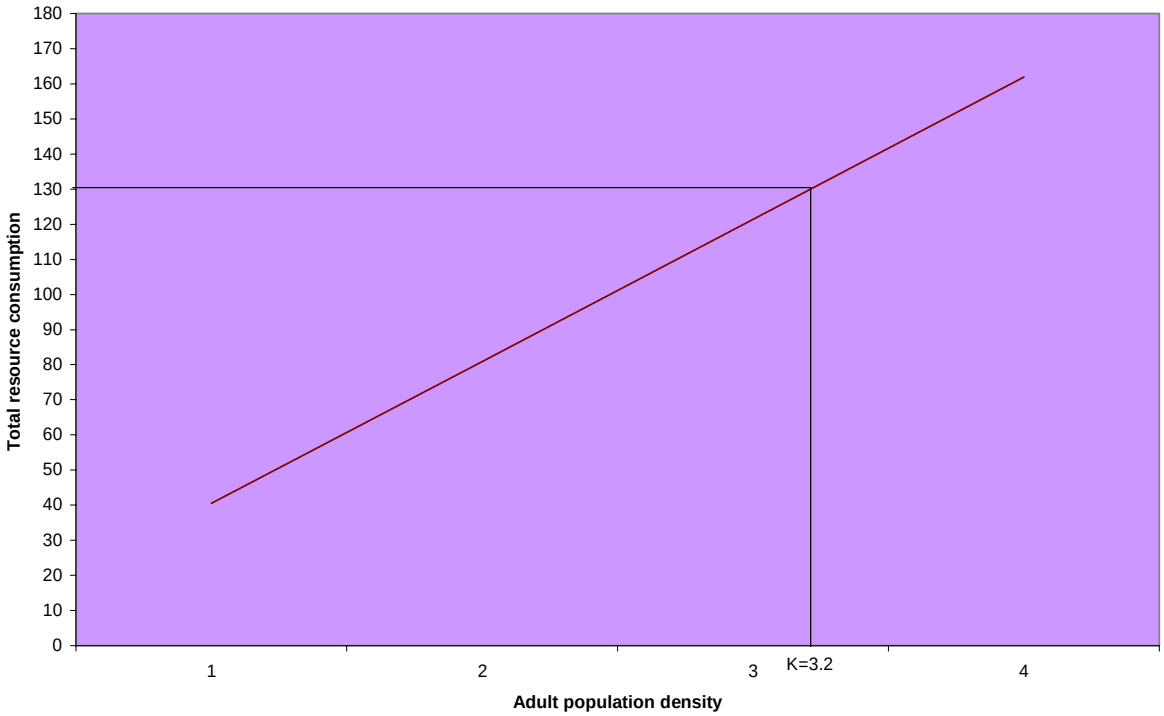
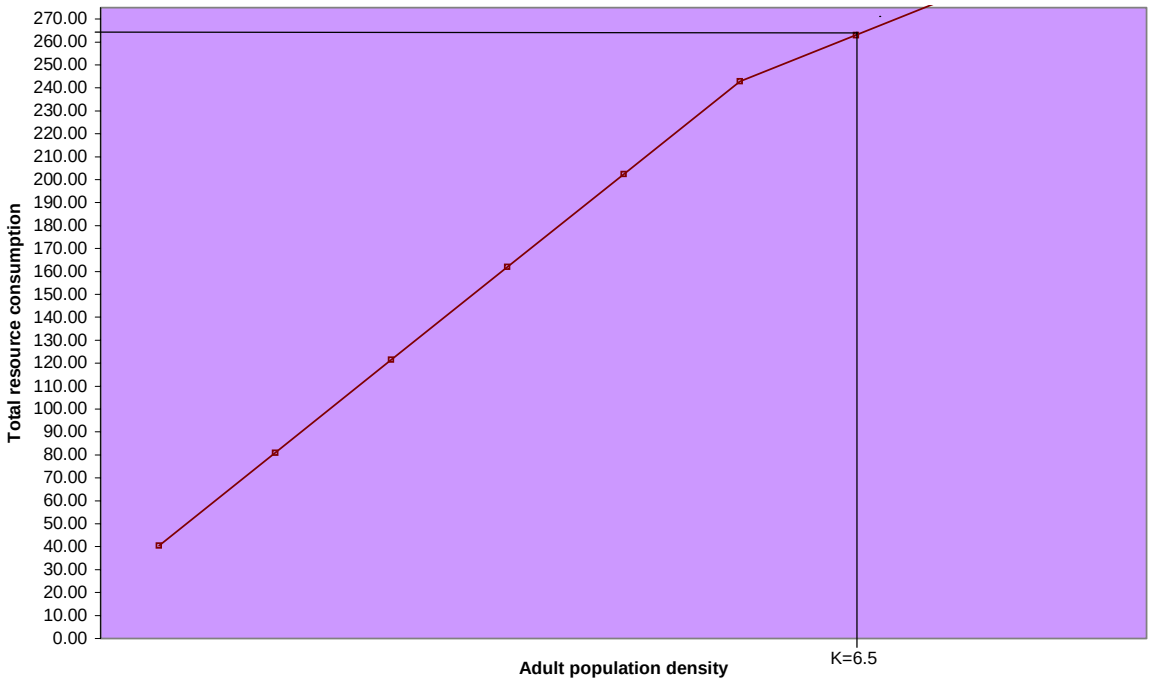
Carrying capacity of Resource Pond 1 at current level of living standard

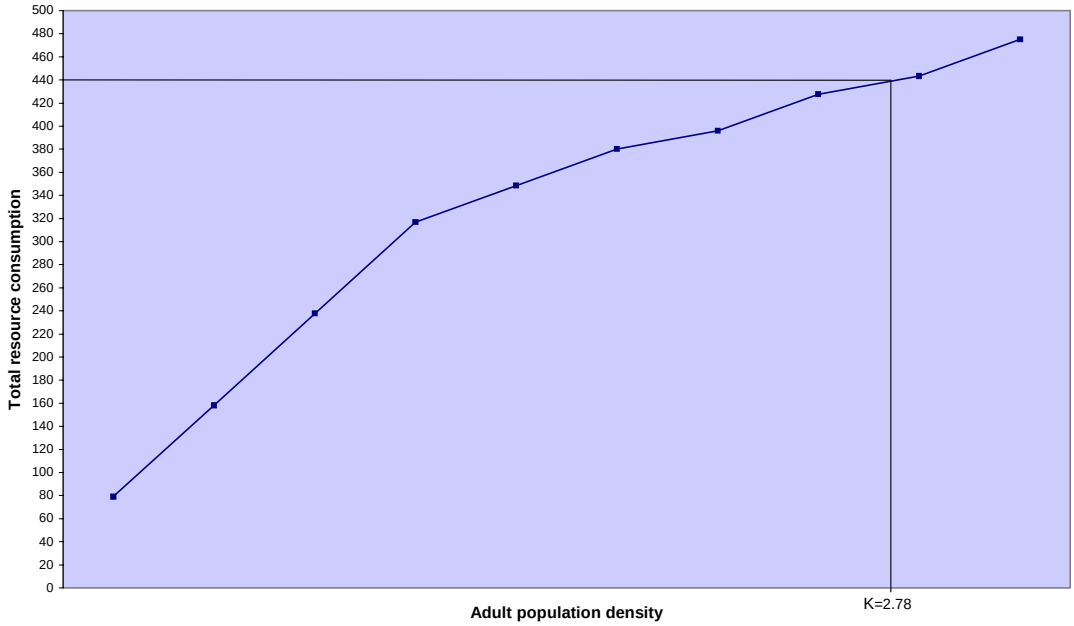


Carrying capacity of Resouce Pond 2 at current level of living standard

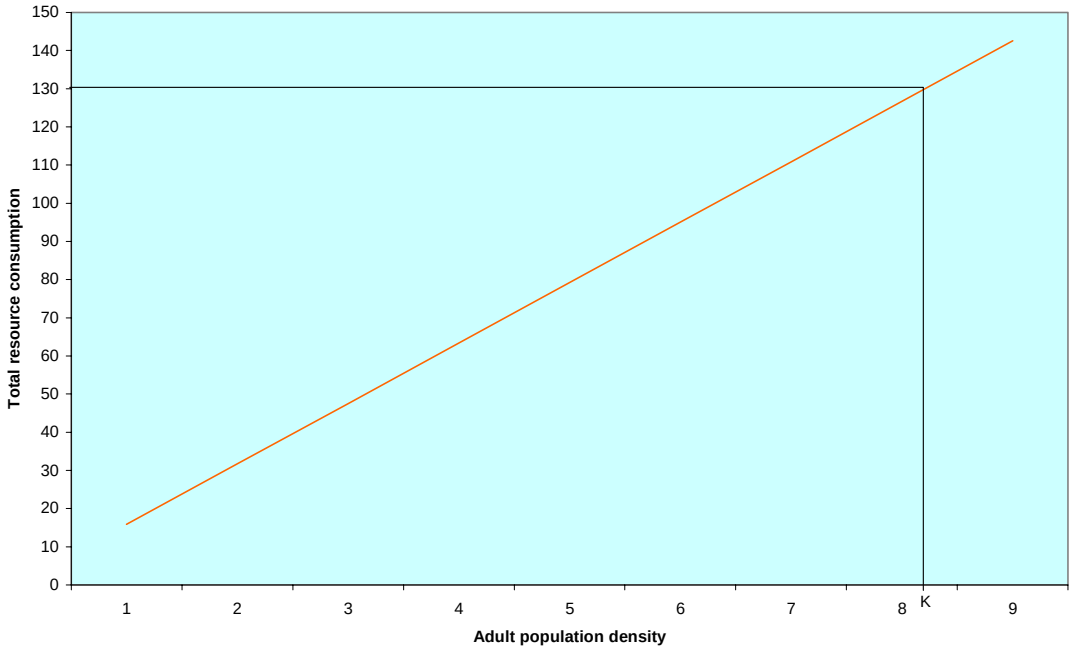


Maximum sustainable carrying capacity (projected) of Pond 1 at optimum level of living standard

Maximum sustainable carrying capacity (projected) of Pond 2 at optimum level of living standard



Carrying capacity of Resource Pond 1 at optimum level of living standard



Carrying capacity of Resource Pond 2 at optimum level of living standard