

Economic and Policy Analysis for Natural Resource Management under Rainfed Agriculture

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Introduction

Developing countries are faced with many crises like hunger, employment and growth. To tackle the food and poverty crises these countries will require a new emphasis on small-scale water management in rainfed agriculture involving the redirection of water policy and large new investments. It is widely known that rainfed systems dominate world food production. However, water investments in rainfed agriculture have been neglected over the past few decades. It has been very well established that rainfed agriculture promises large social, economic, and environmental paybacks, particularly in poverty reduction, growth and economic development. It may be reiterated that rainfed agriculture covers most of the world's cropland (80%) and produces most of the world's cereal grains (more than 60%), generates livelihoods in rural areas and produces food for cities.

Specifically countries in the sub-Saharan Africa and Southern Asia will be facing an estimated hidden annual food gap of almost 400 million tons by the year 2020. According to a global IFPRI (International Food Policy Research Institute) study report, this is the food required above the total sum of projected domestic production and imports, to meet the energy needs of the population. Hunger and poverty are thus predicted to remain a major problem especially in these two regions, both subject to "Undernutrition climatology". In these regions, a large proportion of the arable land is located in water scarce areas that are subject to recurrent dry spells.

Water stress caused by such short and recurrent periods of drought during crop growth is a major cause of yield reduction. In the past, misleading "blue water" analyses (focusing only on perennial river flow and accessible ground water) and drought assessments (focusing only on annual cumulative rainfall) have been used as arguments to rule out semi-arid tropical savannah agro ecosystems as potential breadbaskets. There are several problems with such conventional analyses. The majority of the land users in these areas depend on rainfall for their livelihoods (i.e. green water), not on irrigation based on blue water. In drought prone drylands there are problems both due to rainfall deficiencies (primarily due to poor temporal distribution of rainfall and high evaporation losses), soil problems as well as plant problems, the latter originating from dry spell damages and nutrient deficiency. Investments in rainfed agriculture have large payoffs in yield improvements and poverty alleviation through income generation and environmental sustainability.

It is in this backdrop that economics of natural resource management with special emphasis on modeling, institutional analysis and other related aspects are studied. Natural resource economics deals with the supply, demand, and allocation of the Earth's natural

resources. This sub field of economics is therefore interested in the primary sector of the economy, which engages in resource extraction (that is, the extraction of raw materials). One main objective of natural resource economics is to better understand the role of natural resources in the economy in order to develop more sustainable methods of managing those resources to ensure their availability to future generations. An important dimension of ecological economics, a synonym for natural resource economics is the development of logical linkages between biophysical and economic models. Using biophysical data generated from industry standard models to determine the parameters of an experiment adds a level of external validity. This in turn promotes adoption by key stakeholders of the research findings.

India – a Storehouse of NRM techniques

In this region, 75 % of the agriculture is rainfed and most parts of the country receive rainfall no more than 50 days in short but heavy showers. Water harvesting is an ancient technique dating 4,000 - 5,000 years back, and currently under revival. Rainwater harvesting is now rapidly expanding in response to an escalating water scarcity. Ranges of water harvesting techniques have been developed for both drinking water supply and irrigation, to be found in the arid plains, the semi-arid plains, the floodplains and in the hill/mountain regions. The Centre for Science and Environment in New Delhi has recently published a state of the art report on the "dying wisdom" of indigenous rainwater harvesting techniques in India. A number of *success stories of greening of villages* have been developed in response to the severe droughts of the last three decades. In Rajasthan, Gujarat and Madhya Pradesh, communities that have undertaken water harvesting have a completely different livelihood situation compared to those without water harvesting. The projects have often been initiated by individual persons (especially famous are Anna Hazare and V Salunke) or by NGO's. A problem is that local institutions needed often are inconsistent with the predominant governmental structures and institutional set-up prevailing in the country.

The Complexities

The cultivation of distant and relatively low-potential rainfed upland fields was not associated with a distinct socio-economic stratification. It was expected that upland farmers would be relatively poor and forced to use land because of limited access to the valuable irrigated lowland fields. However, social and economic studies revealed that the economic potential of the upland fields was far from negligible, although significantly lower than for lowland irrigation. This potential allowed for well-off farmers to specialize in rain-fed agriculture and as such exploit its potential alongside a number of less well-off farmers. A particular individual, an entrepreneur and middleman, was discovered to be important for the exploitation of upland areas. He was an influential figure in the local community who had succeeded in establishing a monopoly of the sale of farm inputs and produce. Thus, land use was determined in part by a complex web of specialization, economic strength and partly by historically determined power relations. Land use could not be explained by location, soil quality and socio-economic stratification alone.

Financial Tools for NRM Performance Comparison

The expected rate of return from agroforestry ventures in Chattisgarh was estimated by adopting tools such as discounting, net present value, benefit cost ratio and internal rate of return by Marothia (2003). The results of the same are as follows:

Table-1: Comparative returns on investment in agroforestry and agriculture activities

S.N.	Activities	Expected life (years)	NPV (Rs'00000)			BCR at			IRR
Discount Rates (%)			5	10	12	5	10	12	
1	Silvi-Pastoral	15	8	3	2	3	2	2	23
a.	Subabul	15	14	7	5	8	5	4	29
b.	Acacia spp.	20	21	11	9	21	13	11	67
2	Agri-horticulture	56	107	48	38	28	17	14	115
a.	Lime orchard	30	15	8	6	45	34	30	115
3	Land treatment	50	3	1	1	2	1	1	21
4	Water harvesting tank	50	24	11	9	2	2	2	47
5	Remodeling of old tanks	50	11	4	3	2	1	1	20
6	Tube wells	20	17	10	8	2	2	2	34
7	Pasture Land	7	0	0	0	1	1	1	18
8	Overall	50	172	79	61	4	3	3	45

(Source: Marothia, 2003)

The comparative returns on investment were much higher (above 100%) in the case of agri-horticulture and pure orchard compared to silvipasture and and silviculture as seen above. This goes to prove that the rate of return is highly lucrative in agroforestry compared to other conventional projects of land development.

Regression Model for Prediction

A regression model was developed to predict the tree planting levels by the farmers in a semi arid district of central India (Kareemulla *et al*, 2002). The model descriptives and coefficients are given in Table-2.

Table-2: Model descriptives and coefficients in adoption of agroforestry

Variables	Mean	SD	Coefficient value	SE
No. of trees planted (Y)	10.00	13.90	-0.229	0.660
Cultivated land in ha (X ₁)	6.35	4.16	0.550**	0.117
Uncultivated land (X ₂)	1.35	1.86	0.090	0.454
Family size in no. (X ₃)	10.00	5.60	-0.152	0.905
No. of literates in family (X ₄)	4.00	2.80	0.295	0.578
No. of livestock (X ₅)	6.00	4.08	0.208	0.093
No. of existing trees (X ₆)	23.00	25.65	-0.229	0.660
Constant			(2.331)	4.747
R ²	0.48			

** Significance at 0.05 level

Similarly a study was conducted to improve understanding of conservation tillage adoption decisions by identifying key biophysical and socio-economic factors influencing no-till adoption by grain growers across four Australian cropping regions (D'Emden et al, 2008). The study is based on interviews with 384-grain growers using a questionnaire aimed at eliciting perceptions relating to a range of possible long- and short-term agronomic interactions associated with the relative economic advantage of shifting to a no-tillage cropping system. Together with other farm and farmer-specific variables, a dichotomous logistic regression analysis was used to identify opportunities for research and extension to facilitate more rapid adoption decisions. The broader systems approach to considering conservation tillage adoption identified important determinants of adoption not associated with soil conservation and erosion prevention benefits. Most growers recognized the erosion-reducing benefits of no-till but it was not an important factor in explaining whether a grower was an adopter or non-adopter. Perceptions associated with shorter-term crop production benefits under no-till, such as the relative effectiveness of pre-emergent herbicides and the ability to sow crops earlier on less rainfall were influential. Employment of a consultant and increased attendance of cropping extension activities were strongly associated with no-till adoption, confirming the information and learning-intensive nature of adopting no-till cropping systems.

Total Economic Value (TEV)

In order to capture the direct and indirect benefits as also to take in to account the intangible benefits, the only method is to work out the total economic value (Cavatassi.2004), which is estimated as follows:

$$TEV = \{Use\ Values\} + \{Option\ Values\} + \{Non-use\ Values\}$$

Which can be rewritten as

$$TEV = \{Direct\ Use\ V. + Indirect\ Use\ V.\} + \{Option\ V.\} + \{Existence\ V. + Bequest\ V.\}$$

Total economic value provides a convenient framework for pooling the different classes of value. The indirect market values may be estimated using surrogate values, replacement or avoided value, opportunity cost, travel cost, hedonistic methods etc. Use value refers to the actual use of a resource. For example, the cost of fertilizer when used

in some production is a use value. Option value is the value attached to the future use of a resource. Non-use values are independent of present use of a resource. They will be called existence values in the case of an endangered species and are called bequest values in case certain produces are preserved for future generations.

A study conducted in Indonesia using the TEV The unavailability of total economic values of indigenous people in Indonesia, both in the short and long term, has created the rejection of their existences in the forest area. The purpose of this study is to estimate the total economic value of sustainable forest management conducted by indigenous tribes in Indonesia using total economic value concepts. The tribe's total economic value is expressed by estimating the use value, indirect use value and non-use value. The study used benefit transfer and survey methods using questionnaires to estimate the tribe's total economic value. The estimated total economic value of the Benuaq Dayak of U.S. \$ 6,025.88 per hectare per year was calculated by summing the direct use value (U.S. \$0.028 per hectare per year), indirect use value (U.S. \$3,156 per hectare per year), and non-use value (U.S.\$2,870 per hectare per year).

Utility Model

The economic analysis of this study has a theoretical basis in a neoclassical household production model. A representative household is assessed to maximize utility in each period subject to budget and natural resource constraints. In a subsistence economy, agricultural production often takes place on land adjacent to or in place of natural vegetation such as forests. The representative household solves an optimal control problem of agricultural production and forest use that has the relationship between forest biomass and soil quality and the same variables Larson and Bromley (1990) identify in their theoretical model. The model consists of these functions: a crop production function, a soil fertility function, a utility function, and a forest biomass function. Agricultural production is a function of both soil fertility and farming intensity and is assumed to be strictly concave. Soil is a renewable resource and its evolution depends on farming decisions and rate of change in soil quality.

Policy options for controlling sediment runoff – Experiences from Australia

In this study four policy instruments were explored: a first and second price tender system, a cap and trade market, and command and control regulation as instruments often used in natural resource management to control pollution levels. In the tender experiments players acting as farmers made offers to a central authority to construct riparian buffer zones to reduce sediment loads entering a river system. A sealed offer procedure was used in the first and second price tender experiments. The central authority accepted the lowest price offer upwards until the reduction target or the budgetary constraint was met. In the first price tender experiments the successful sellers were all paid the price of the highest successful offer. In the second price tender successful sellers were paid the price of the first unsuccessful offer, consistent with the notions of a second price sealed bid.

The cap and trade system, as the name suggests, involves a regulating authority imposing an upper limit on the level of total suspended solid loads exiting the system. It allows farmers to trade in sediment credits to achieve the cap. The notion of cap and trade

implies that each player can potentially be a buyer or seller. In this experiment players can buy credits or produce credits for sale by constructing riparian buffer zones, which capture more sediment than required. When the market price of credits is below the players' marginal cost of constructing buffer zones, they are expected to enter the market and buy units rather than construct buffer zones. When the market price is above the marginal cost of constructing buffer zones, players are expected to exceed their target production level, produce credits and sell the additional units.

The most recent and significant applications of the cap and trade approach is in the implementation of the Clean Air Act by the U.S. Environmental Protection Agency to achieve its Clear Sky objective and the European Union greenhouse gas emissions-trade scheme, which expected to start in 2005. The Clear Air Act 1990 introduced a cap and trade policy instrument on the electric utility industry in the US in order to reduce emissions.

A standard closed call auction structure was used in the cap and trade experiments. There is a large body of divided literature comparing and debating the relative merits of call and double auction structures. A closed call auction structure was chosen because it is the most commonly used in natural resource markets in Australia. The Northern Victoria Water Exchange, for example, use closed call auctions to operate temporary water markets. It is assumed that when the participants are inexperienced, a closed call pool price auction structure minimizes the likelihood that ill-considered offers will determine the pool price. These would adversely impact on the players' income when they are learning how the market operates. Poor outcomes may result in low market participation in latter years.

An alternative to either a closed call tender or cap and trade is a command and control regulation, such as standards prescribing riparian land management or levels of pollution emission. Market based instruments are gaining political standing. However, command and control instruments are still used more commonly by state and federal agencies to control pollution emissions as a result of gaps between normative theory and positive reality. To minimize the risk of adverse selection and moral hazard associated with non-point pollution emission regulation, regulation has tended to be on production rather than emission levels per se.

Under the regulatory instrument explored in this study, each landholder was required to construct defined lengths of riparian buffers. This, in aggregate, would achieve emission reductions equivalent to the tender or cap and trade instruments. The requirement imposed on each landholder is determined by proportioning. The cost of meeting the regulation imposed on each landholder would therefore also be proportional to their cost of supply. For example, if the requirement was a reduction by 20% then each landholder would be required to construct riparian buffers on 20% of each type of riparian land type on their property.

Community Based NRM

Community-based Natural Resource Management (NRM) is increasingly becoming an important approach for addressing natural resource degradation in low-income countries (IFPRI.2005). This study analyzes the determinants of enactment, awareness of and compliance with by-laws related to Natural Resource Management (NRM) in order to draw policy implications that could be used to increase the effectiveness of by-laws in managing natural resources sustainably. A strong association between awareness and compliance with NRM bylaws was found. This suggests the need to promote environmental education as part of the strategy to increase compliance with NRM bylaws. Econometric analysis of the survey data indicates factors that are associated with enactment of local NRM bylaws, and awareness of and compliance with NRM requirements:

- Local NRM bylaws are more likely to be enacted in communities where there are programs and organizations focusing on agriculture and environment, but less likely where the land tenure system is customary than where other land tenure systems are predominant.
- People are more aware of requirements related to bush burning in communities that are closer to an all-weather road and have better access to credit. People are more aware of requirements related to tree planting and protection closer to roads, and where there are more programs and organizations with focus on agriculture and the environment
- People are more likely to comply with a bylaw enacted by the local council than otherwise. People are more likely to comply with requirements related to tree planting and protection in communities where agricultural potential is high, where income poverty is lower, where adults are more educated and where there are more credit organizations.
- These findings imply that improving awareness of NRM requirements is critical to increase compliance with such requirements. Awareness is greater in areas closer to all-weather roads, probably due to better access to information in such areas. Development of roads and communication
- Devolution of responsibility contributes to greater compliance with NRM requirements, given that compliance is greater with bylaws enacted by local councils than with laws enacted at a higher level. Involvement of locally accountable and representative authorities in enacting and enforcing NRM requirements appears critical for the legitimacy and success of such regulation.
- Involvement of external programs and organizations focusing on agriculture and environment issues can help to promote such local enactment.
- Several dimensions of poverty, including greater income poverty, poor education, and poor access to credit are associated with lower compliance with tree planting and protection requirements. This supports the hypothesis of a poverty-natural resource degradation trap, and suggests that measures to reduce poverty can have “win-win” benefits helping to improve NRM as well.

Decentralized NRM

Drawing a two-year study of decentralization processes at State, district and village levels in Andhra Pradesh, Madhya Pradesh and Karnataka, it was concluded that the influence of political economy factors on decentralized natural resource management in India is tremendous. The paper assesses the constraints and potentials for decentralization that are posed by the current political economy. It argues that centralizing political forces constrain both the political and ecological scope of the decentralization agenda. The suggested way forward is a more strategic approach in concept and practice, as well as a reconsideration of the ultimate objectives of decentralized natural resource management.

The gap between the lab and the farm is possibly the widest in rainfed agriculture. Conservation of land and water resources, their effective use and adoption of technologies collecting dust in the shelves could be the foundation supporting a transformation in rainfed agriculture (Rao, 2008). Rainfed farmers are poor but not unenterprising. There are many struggling to rise but fail due to unfriendly policies.

- Watershed development is not merely a matter of harvesting rainwater. Its success crucially entails working out collective protocols of equitable and sustainable use of surface and ground water, bringing together of scientists and farmers to evolve a dryland agriculture package and a host of other livelihood options, detailed land-use planning at the micro-watershed level and the mobilization of rural communities in the direction of the disadvantaged
- A web based National Database (should) be used as a tool for planning and monitoring from national level down to district/micro-watershed level” .
- Regarding “ convergence and synergy”, the Report observes “ activities pertaining to wage employment undertaken in the Integrated Watershed Management Programme (IWMP) (should) be converged with NREGS and SGRY for sustainable livelihood opportunities. * “Approaches to rainfed area development should focus on strengthening governance institutions, particularly Panchayats. A decentralized strategy towards rainfed area development should essentially be aimed at aiding PRIs to identify, implement, operate and maintain their own priority investments in the direction of improving the delivery of services that benefit the poor.” (page 14).
- We should strongly consider the pricing model adopted by China to address the situation of water scarcity in India. Water should be treated as an economic good and therefore its price should reflect the full cost of water supply as in the case of the Chinese model. The enforcement mechanism should be strengthened so as to facilitate efficient use of this scarce resource. However, any taxation policy should bear in mind the fact that most farmers in India are impoverished. We suggest that the taxation policy should be of a progressive nature Water taxation policy must take into consideration the economic condition of the farmer”.

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