Institute for Global Environmental Strategies

Sustainable Livelihood Based Watershed Management – "Watershed Plus" approach

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Background of this study

Drawbacks of the existing watershed polices in India :

- Participatory approach for integrated watershed development has been fully endorsed as the most suitable method to achieve sustainable development within the project boundary without much specific targets.
- Assured income generation and reducing labor migration from a watershed project are poorly addressed
- Up-stream and down-stream environmental pollution control including ecosystem management are neglected existing in the watershed models in India.

What's the problem of the existing system?

- Existing watershed project development guideline doesn't have specific target to reduce the forced local migration. Local migration in the arid and semi arid zones of rain fed agricultural areas is a big social problem in India. Unfortunately watershed projects are mainly in these areas in India.
- Existing watershed projects/ programs in India do not specify or ascertain minimum level of income generation which is the key for the success of such activities.
- Conservation of local ecosystem (at the very basic level) is not considered in the watershed planning and development.

Research Objectives:

- ***To estimate the optimal income level that each watershed project should generate*** primarily to reduce or stop forced migration and secondly to provide the long term sustainability to the watershed project by improving the income level of the beneficiaries.

Literature Review

- Most of studies on Indian watershed are either case study based qualitative analysis which mainly focuses on the institutional arrangement of the program or static partial equilibrium econometric analysis of certain behavior of any parameters of the upstream or downstream activities. However, we found watershed project as a dynamic controlled system with various inbuilt constraints like water availability, human resource availability, agro climatic restriction of agricultural production, maintaining up stream and downstream ecological conditions etc.
- A dynamic optimization model needs to be developed to estimate the optimal path of the income generation potential of the watershed project. A static model may not be sufficient to capture the varied nature of income generation potential over the period of time.

Research Methodology: Some basic thoughts of the model

- As watershed is a common pool resource, there is a possibility of over utilization and harvesting of resources. There is also some provisioning problem to utilize the resources which leads to the question of who will monitor/enforce the ecological constraint in watershed management?
- Water being the intermediate input for the agricultural production farmers are always interested to minimize the input costs and supply uncertainty which watershed can provide to the farmers easily.
- Therefore, output linked self-interest related water use in agriculture production can easily monitor the ecological constraint in the watershed modeling to some extent.

Research Methodology: Some basic thoughts of the model

- Watershed reduces cost of agricultural production and ensure seasonal requirement of water which increases the profitability of the agricultural sector. But how long this process will sustain?

  There must be some criteria regarding the distribution of water. If the land distribution is identical, then same water distribution has to be followed. If land distribution differs, then weight for water distribution has to be decided on the basis of the incremental cost of water distribution. Therefore, cost of water supply and distribution is crucial for long term success of the watershed.

- Maintaining proper cropping cycle in the watershed area implies maintaining the local ecology. Hence, to incorporate ecological constraints in the model cropping cycle can be a good proxy for that.

Thematic Research on Sustainable Livelihood Based Watershed Development

Research Methodology: Some basic thoughts of the model

- Migration is the forced factor for failure of watershed management. To reduce migration, local employment generation is needed. In that a case, a minimum (i.e. threshold) level of income is required.
- So the purpose of watershed modeling is to generate income through agriculture. An intrinsic policy designing is need for sustaining the program through “Water plus Income”.
- Some supportive/ comprehensive policy is needed to create incentive for the people so that they can’t migrate. So “rootedness” is the most crucial factor and hence the introduction of some kind of social capital component is required in the model.

Model Specification

In order to frame a sustainable watershed modeling, a dynamic profit maximization function (by cost reduction of a water users' group cooperative who has cost free water distribution system) has been developed subject to the constraints of achieving minimum level of social and economic capital while maintaining ecological sustainability.

•We consider a Cobb-Douglas (to make matters simple) aggregative production function of the agricultural sector surrounding the watershed. The farmers form a cooperative to maximize their benefit (in the form of profit) from the watershed. The production function is given as

$$Y = AH^{\alpha}W^{\beta} \qquad (1)$$

- In equation (1) Y is the output of the agricultural sector, A is technological parameter, H is human capital (which covers labour) and W is water used for production of the agricultural output.

- The cost of employing human capital in producing the product is cH.

Model Specification …..(2)

- It is assumed that human capital grows logistically (a proxy for human capital is labour and it can easily be assumed that population grows logistically) and is given by

$$\frac{dH}{dt} = r H\left[1 - \frac{H}{K}\right] \quad \ldots\ldots (2)$$

- where r is the intrinsic growth rate of human capital stock, H. r depends upon the health and other infrastructural facilities of the study area that we refer to as social capital and it ultimately depends upon the *threshold* level of output, Y^*. Thus $r=r(Y^*)$ and the *threshold* level of output can be considered as a proxy of the level of *social capital* in the study area.

- K is the carrying capacity of human capital. We have used the term human capital in a broad sense so that it includes physical capital along with labour.

Model Specification …….(3)

We thus have the constraints as follows:

- $Y \geq Y^*$ (3)

  F*orced* labour *migration* among the beneficiaries of the watershed can be captured by this ineqality constraint .

- $W^* \geq W$ (4)

  To capture the static ecological constraint in terms of usage of water for agricultural purposes from the watershed we introduced the constraint of water use where W* implies water released from origin (i.e. the watershed) . The inequality sign in expression (8) captures the concept of *watershed plus* in the sense that water released from the watershed is used not only for agricultural purposes but also for drinking purposes, better sanitation facilities, forestry, aquaculture and others.

Model Specification ….(4)

Finally the simple dynamic optimization model is as follows:

$$\textbf{Max} \int [\, p^*AH^{\alpha}W^{\beta} - c.H \,]^* e^{-\delta t dt}$$

subject to ;

$$(dH/dt) = r(Y^*)H[1-(H/K)]$$
$$Y \geq Y^*$$
$$W^* \geq W$$

'p' is the price of the agricultural product (we assume competitive market conditions so that the cooperative is a price taker implying price, p, is given), c is the (given) cost per unit of human capital and δ implies the discount rate.

The Lagrangian expression is given as

$$\mathbf{L = Hc + \mu 2[Y - Y*] + \mu 3[W - W]} \quad (6)$$

$$\mathbf{Hc} = \mathbf{[p\, AH\alpha W\beta - c\, H] + \mu 1[r(Y*)\, H\{1-(H/K)\}]} \quad \mathbf{(7)}$$ (Hc = current value Hamiltonian)

In expression (6), W is the control variable, H is the state variable, $\mu 1$ is the co-state variable and in expression (6) $\mu 2$ and $\mu 3$ are multipliers.

Expected result:

- An optimal income generation path would be derived in terms of profit maximization of the WUG cooperative which would provide certain amount of guarantee to contribute towards sustainable development at least for a longer term through integrated watershed programs.
- Result would tell us how much optimal income has to be generated by the project which can protect local labor migration and can reduce corresponding social problems.
- Result would also tell what is the marginal cost of improving the social well being of the WUG beneficiaries under the given constraints of environmental and ecological balances. Ecological constraint would be simplistically maintained at the level of maximum water use possible from the catchments area to maintain the year long availability of water and other necessary resources like fish.

Outcome of this study :

- A clear numeric target based indicator can be generated to evaluate the performance of the existing watersheds and to evaluate the future watershed project plans.
- Direct policy support to the NRAA (National Rain Fed Area Authority) activities under the following mandates:

  - To guide the implementing agencies on priority setting and monitor the specific interventions required.

  - To suggest modalities to strengthen National and State Level Institutions concerned with Rainfed / Dry land areas, and establish institutional linkages with prioritized watersheds.

  -To evaluate the effectiveness of completed watersheds and concurrent evaluation of on-going programmes.

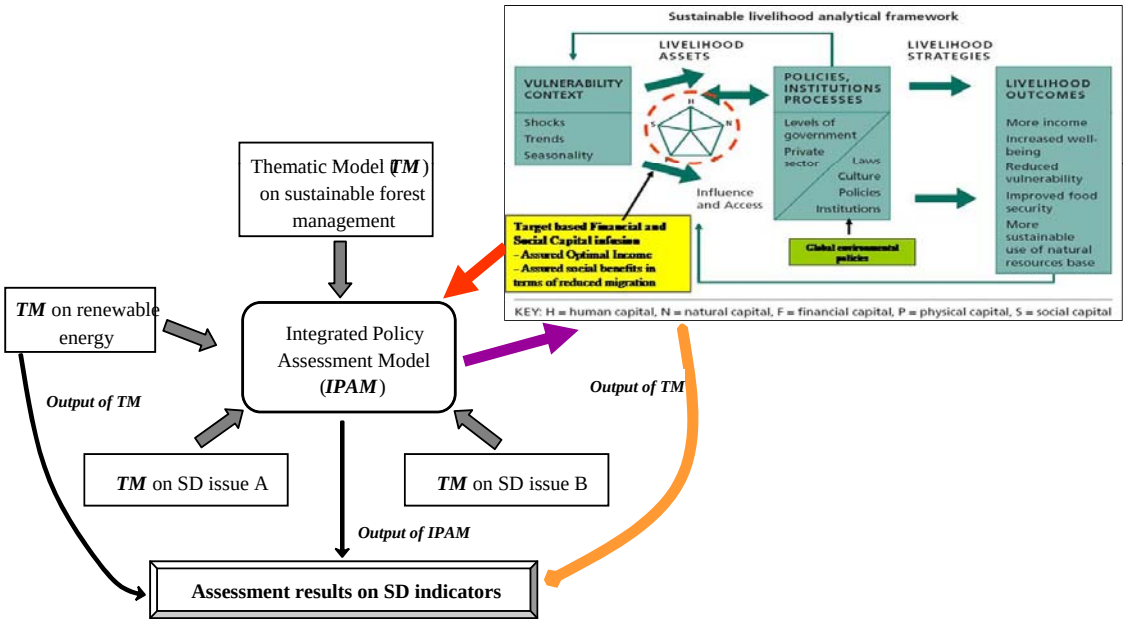
Research Plan & Time line - FY 09

Major Activities	Time line	Results and Major output
- Literature review - Model development -Identifying research partner and contracting	April 09: July 09	-Detailed research plan and methodology document - Establish research partnership
-Identifying data source - conduct data collection in India (if possible in Lao PDR & Cambodia)	Aug.09: Oct 09	- Complete dataset for running the model
- Data analysis and model estimation - Report preparation - Developing the linkage between TM and IPAM	Nov.09: March10	- Research report

Research Plan & Time line - FY 10

Major Activities	Time line	Results and Major output
- Model elaboration to fit into IPAM - Identifying the scope for further extension to other countries	March 10: July 10	- Establish the linkage between IAPM and the TM study
-Identifying data source - conduct data collection in the additional countries	Aug.10: Oct 10	- Complete dataset for running the model
- Data analysis and model estimation - SD Out Look Report preparation	Nov.10: March11	- Draft SD Outlook component

Potential linkage between IPAM and ISLA



Thank You for your attention !