Integrated Farming Systems in the Frame Work of Bio-Economic Modelling for Sustainable Development of Small and Marginal Farmers under Changing Climatic Scenario

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Introduction

In order to meet the multiple objectives of poverty reduction, food security, competitiveness and sustainability several researchers have recommended to adopt integrated farming systems (IFS). IFS is an approach in which different land-based enterprises are integrated within the bio-physical and socio-economic situations taking farmers preference and goal in to consideration. This is a multi-disciplinary approach and very effective for solving the problems of small and marginal farmers (Gangwar, 1993). Under the gradual shrinking of land holding in India and other developing countries, it is necessary to go for IFS to make farming more profitable and sustainable. In agricultural research and development activities in India and other developing countries, the major emphasis is given to component and commodity based research projects This research have proved largely inadequate in addressing the multifarious problems of small farmers (Jha, 2003). Due to this, there has been a demand for holistic approach for technology generation and dissemination. However, mechanisms are lacking to provide the whole farm picture. Providing such a picture in the context of a farm or village or a region is a tedious process and difficult to calculate by human mind since number of factors are involved. Such problems can be overcome by the bio-economic modelling approaches. The research in IFS for the last few decades reveals that the enterprise planning and implementation needs scientific and systematic approach. In this situation, optimization techniques are useful for resource allocation and designing of IFS in a scientific basis (Mahapatra and Behera, 2004). Farming system studies involving a number of enterprises and taking the physical, socio-economic and bio-physical environments into consideration are complicated, expensive and time-consuming (Mahapatra and Behera, 2004). This is one of the reasons for slow progress in the field of farming systems research in India and elsewhere (Jha, 2003). This problem could be overcome by construction and application of suitable whole farm models (Dent, 1990). Optimization models optimize the use of farm resources, and can analyse farm response to policy change in an effective way (Loucks *et al.*, 1981). Among available, linear programming (LP) is one of the most applied solution methodology in agricultural planning to determine the optimal policy (Loucks *et al*., 1981) in single and multiple objective framework. In this paper different bio-economic modelling techniques, which can help for optimal combination of the enterprises within the farming systems by taking farmers single and multi-objectives into consideration as well as an advanced modelling tool "MODAM" which has potentiality to integrate the environment and ecological goal with economic goal in the context of a farm/society or region are discussed briefly.

Materials and Methods

Integrated farming systems in single objective frame work Decision making is the most important aspect of any business and industry. Farming is a business and agriculture is also an industry. Hence, decision making plays an important role with regard to the problems concerning production of commodities. The main questions before the producer or the production manager/farmer are: (i) What to produce, (ii) How to produce, and (iii) How much to produce. LP is a modelling tool that can assist in the solution of many problems in agriculture. LP model are designed to "optimize" a specific objective criterion subject to a set of constraints, the quality of the resulting solution depends on the completeness of the model in representing the real system. Integrated farming systems in multi-objectives frame work In real world IFS situations farmers face the difficulty of considering several objectives simultaneously, which are conflicting in nature. In addition farmers like to produce enough food for the farm family by utilizing his resources effectively. For this, compromise programming method can be effectively employed (Behera et al., 2008). Two multi-criteria programming techniques, goal programming and compromise programming (both variants of linear programming), were used in a study of small-scale dairy farms in central Mexico by Val-Arreola et al. (2006). Compromise Programming (CP) is used to provide more insight into the problem which caters multiobjective needs of the farmers. Linear and nonlinear programming methodologies can be employed in CP environment to draw different scenarios' for comparison. This enables in developing holistic model. Compromise Programming methodology has been demonstrated for designing integrated farming system (Behera *et al*., 2008).

Results and Discussion

Multi-objective decision support tool for agro-ecosystem management (MODAM) There is a need for a modelling tool to analyse agricultural sustainability as a combination of economic and ecological objectives. This model should be able to: (i) simulate effects of political and economic conditions on decisions about agricultural land use at farm level; (ii) screen current and new production technologies in a standardised form and show their effects on defined indicators of sustainability; and (iii) allow economic and ecological evaluation of production techniques at regional scale, including trade-offs among ecological and economic goals with respect to one farm or to a group of several farm types (regional approach). Keeping above aspects in to considerations, a powerful bio-economic modelling tool was developed at ZALF, Germany (Zander and Kachele, 1999). In the bio-economic model MODAM, several farms are aggregated to regional model to evaluate the effects of different protection strategies and the methodology of developing region-farms. Model allows to draw different scenarios of agronomic and ecological and political decision making. MODAM is an interactive modelling system, generating trade-off functions between ecological and economic objectives and helpful from the points of view: (i) interactive experimentation (ii) it allows analysis of the maximum goal achievement possible under given conditions (iii) trade-off functions will show areas where a small decreases in achievement of the goal leads to much large realisation for another goal (iv) sensitivity analysis of the model will show where further research is necessary ; and (v) scenarios of different conditions will help political decision makers to identify the most efficient instruments to realise the desired goal achievement in practise. Description of the model The Model show hierarchical linkage between the economic and ecological parts of the model. Where maps in the geographical information system (GIS) are available, the result of the model in the form of crop rotations and their technical, economic, and ecological coefficients can be transferred to the GIS for the graphical presentations (Wossink *et al*., 1992). The model is based on the multiple goal linear programming approach. It consists of five levels of the hierarchically linked modules. The first level of the modules generates the technical coefficients, second level calculates economic coefficients of site-specific production techniques. The third evaluates the ecological effects of these production techniques, and the fourth generates the linear programming model. The fifth level starts the subprogram which solves the equation system, analyses the results and prepares the transfer of data to the Geographical Information System.

Conclusion

In extension and developmental programmes in most of the developing countries, the respective agencies generally go to farmers and give a variety of advice in an ad hoc manner. In the context of present challenges to make small farms profitable, it is necessary to place an overall scenario for farm income and employment generation and other associated benefits before the farmers in order to motivate them towards farming. Placing such pictures before farmers will aid their confidence to adopt new technologies in an integrated manner for enhancing farm income and sustainability, Research programme must acknowledge current concerns on poverty elimination, food security, environment, equity gender and sustainability. Bio-economic modelling methodology can prove as a potential approach for providing the whole farm picture by considering economic and ecological consequences. MODAM is an instrument that can serve to mediate in conflicts among competing groups of land uses, by generating information about economic and ecological effects of the particular decisions. The modular structure permits linkage of additional economic and ecological modules and facilitates inclusion of the new scientific knowledge. This will be useful for interdisciplinary research.

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