Global Science Research Journals

Global Journal of Fisheries and Aquaculture

Extended Abstract Open Access

Application of simulation modelling in planning and cost–benefit assessment of traditional fishery and aquaponics technology for livelihood generation and sustainable development - A case of Tawa command area, India

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Keywords: Aquaponics, System Dynamics, Livelihood Generation, Climate

.**Abstract**

Operanalization of sustainable development would entail search for innovative options that cause minimal environmental media and resource degradation, while maximizing socio-economic benefits in terms of environmental planning, policies and system's management. Computer Simulation modeling is identified as a powerful tool for charting out better options for sustainable development. The paper aims at exploring the utility of qualitative/semi quantitative simulation modeling methods in innovative-strategic planning, management and development. The specific methods for modelling of aquapoics/aquaculture dynamics are investigated as cross impact simulation and system dynamics. For the sake of illustration a simulation model has developed for cost benefit and economics of aquaponic/aquaculture system of Tawa Command Area in India. The System Dynamics model is designed to develop and integrates the cause & effect relationships of the variables in pond dynamics & various issues related to climate, farmers interest, people demand & liking, marketing and cost-effectiveness of Aqua/Aquaponic systems. The model has the potentiality to incorporate various policy options of Aquaponics feasibility & its comparison with traditional fishery for long term sustainability and livelihood generation of the region.

Introduction

Operanalization of sustainable development would entail search for innovative options that cause minimal environmental media and resource degration, while maximizing socio-economics benefits in terms of environmental planning, policies and system's management. Computer Simulation modeling is identified as a powerful tool for charting out better options for sustainable development. The paper aims at exploring the utility of qualitative/semiquantative simulation modelling methods in innovative-strategic planning, management and development. The specific methods for modelling of aquapoics/aquaculture dynamics are investigated as cross impact simulation and system dynamics. For the sake of illustration a simulation model has developed for cost benefit and economics of aquaponic/aquaculture system of Tawa Command Area in India. The SD model is designed to develop and integrates the cause & effect relationships of the variables in pond dynamics, related issues to climate, farmers interest, peoples liking, demand, marketing and cost-effectiveness of Aqua/Aquaponic systems. The model has the potentiality to

incorporate various policy options to improve Aquaculture/Aquaponic Systems for livelihood generation and sustainable development of the region.

Review of literature:

System Dynamics simulation modelling: System Dynamics is an area of modelling where dynamic and complex relationship among various aspects of a system are designed in a computer, thereby long term behavior of the system is analyzed. It is a powerful tool for analyzing the behavior of complex dynamics system to show how system structure and the policies used in decision making, govern the behavior of the system (forrester J.W. 1968, Barlas and Diker, 1996, Frances, 1995 & 2000, Kennedy, 2000, Singh, 2000, Coyle, 1977).

Modelling is useful for understanding and predicting environmental challenges at various times and areas. It can incorporate descriptions of the key processes that modulate systems performance or behavior with varying degree of sophistication. The development of so called policy support system is currently a becoming activity.

The concept of system dynamics and its application to industrial, social /environmental problems are not new, Forrester (1961).

Aquaculture/Aquaponics: It we compare aquaculture with activities like agriculture, horticulture, dairying and poultry; aquaculture comes out for ahead in terms of eco-friendliness aquaculture is therefore called a self-cleaning industry.

1. Deepti Diwan and Alka Parashar (2007) have carried out a study to evaluate the feasibility and potentials of water logged water land for aquaculture practices. The soil parameters of six villages of Tawa Command have intimated to see suitability of soil for aquaculture and enrichment of soils for aquaculture practices in eco-friendly manner.
2. Parashar Alka (2015) area has studies on success stories of famers on adoptaton of aquaculturein Tawa command and Region India. The work also addressed potentials and ecosystem approach to develop aquaculture in sustainable manner of Tawa Command.

Aquaponics is the integration of recirculating aquaculture and hydroponic plant production. Aquaponics is the cultivation of fish and vegetables/plants together in a constructed re-circulating ecosystem utilizing baetaical cyeles to converts fish waste to plant nutritants. The appeal of aquaponics lies on its capacity to produce aquatic animals (e.g. fish, crayfish, etc) and plants (e.g. vegetales, herbs, medicinal plants, fruits etc.) in an environmentally – friendly way, ensuring high levels of water reuse and nutrient recycling. Fig.-01. This is an environmentally friendly closed loop facilities natural food growing method, without add chemical fertilizer.

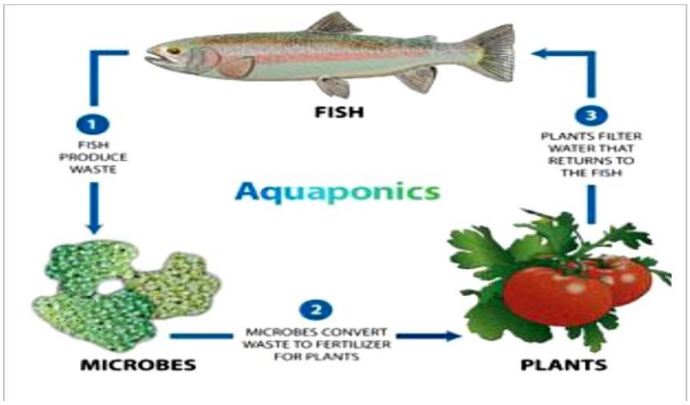

Fig.01

Aquaponics is suitable for environments with limited land & water because it produces about three to six times the vegetables. and uses only about 1% of the fresh water used by traditional aquaculture.

Objectives:

This paper aims at exploring the utility of system dynamics simulation modelling in developing traditional fishery dynamics & eco-friendly aquaponics technology for innovative strategic planning, cost benefit & management. For the sake of illustration a

case of Tawa command area were taken by inclusion of aquaponics technology.

A cost benefic economic model has developed so for aquaponics production of food & wealth of farmers in the regions.

Further objectives of this study are to minimize water (recirculation) and fertilizer requirement, focusing on creating aquaponics awareness adaptations in the region to cost-effectiveness. To identify the best scenario and its possible impacts on the socio/environmenta for future adaptation.

Material & Methods:

Study Area - Tawa command: Madhya Pradesh is situated heart of India. Tawa Project is one of the major river project in the Madhya Pradesh, designed for optimizing agricultural production of command area in Narmada basin developed. It is proposed to promote the utilization of irrigation and increase its intensity by adaption multiple cropping of each crops, Fruits, vegetables and spices.

Although the entire command area is dominated by clay and clam loam soil suitable for a variety of agricultural crops. At present there is good availability of water but indiscriminate exploitation of underground water by farmers and some parts of the command region like Sukh Tawa & Kesala blocks facing scarcity of water. Water table is going down gradually. Therefore looking into future scenario of water. scarcity it is imperative to take innovative steps for balanced food production in eco-friendly manner for sustainable development.

Survey & Delphy study: A preliminary survey of Tawa Command area has been done for gathering information on topography of the area, climatic conditions physic chemical nature of soil/water (consumers liking & social impacts through observations measurements & questionnaires in the support of establishing boundaries and designing the model. A Delphy study was carried out among experts of the region like fishery scientists, agronomists, aquafarmers, & social activist to get more representative results.

System Approach & Model Development: System Dynamics modelling method is applied to develop aquaponics & traditional fisheries (practicing in the area) models. Where the dynamic models structure & functioning of the systems represented by differential equations with respect to time.

The selection of state variables & their interconnection were obtained through the methodologies mentioned above viz surveillance, interview, Delphi technique & experimentation as well as gathered through literature data on interactions of pond ecosystem for traditional and aquaponics system.

A causal loop diagram for model development is drawn, as a graphical tool. Different Parameters & variables associated with Aquaculture/Aquapoics system are taken into account. How they are inter related and interacted with each other are illuslrated (fig. 02) by drawing causal loop diagram.

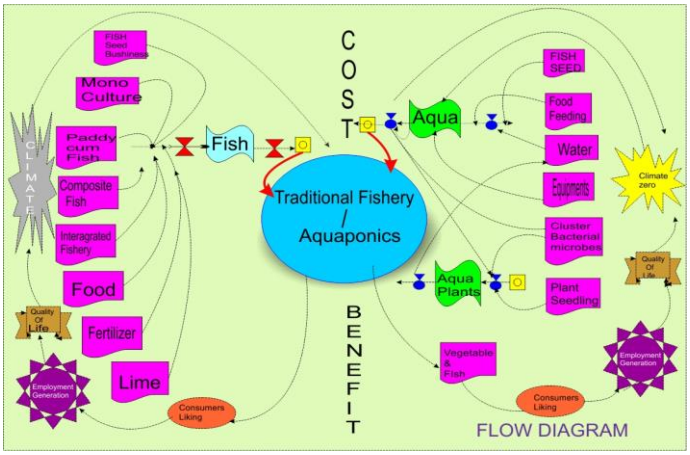

Fig.-02: Linkages & Flow Diagram of traditional Fishery & Aquaponic System

The paper also addresses the potentiality of system dynamics modelling in generating various policy options for the long term assessment maintenance of ecological health as well as intervention of various policies in the model for innovative aquaponics to provide

strategic planning for sustainable development.

Discussion:

Implementing the system dynamics approach for model development by drawing flow chart & assigning values to each variables, the model has such using software (STELLA environment) to know the behavior & status of present as well as future dynamics of the system. The status of various aquaculture practices which are feasible and being adopted in the Tawa Command area are delianeated through Pai (π) (Fig-03) and BAR Digram (Fig.-04). Fish seed business & culture of India Major carps (IMC eg. Rohu, Catla & Mrigala) are the most flourishing practices are being adopted in the area.

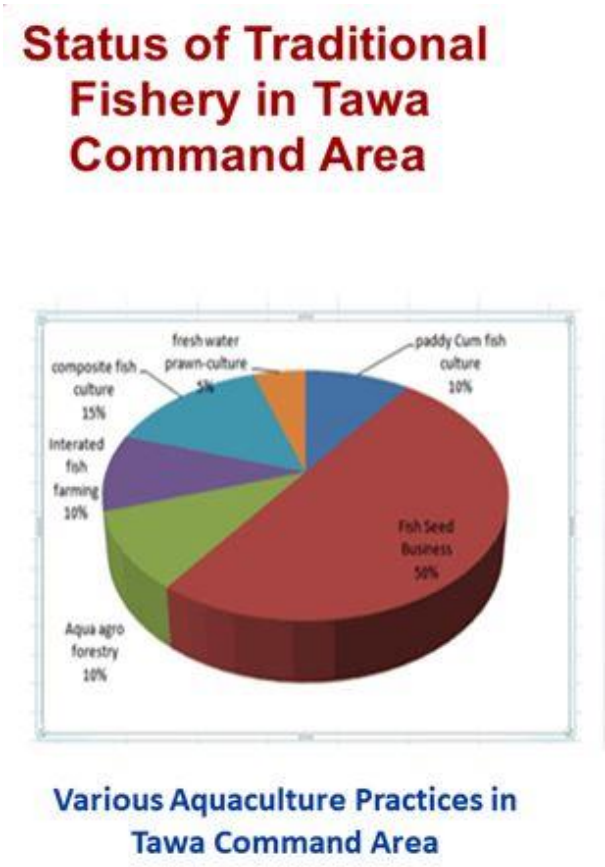

Fig.: 03

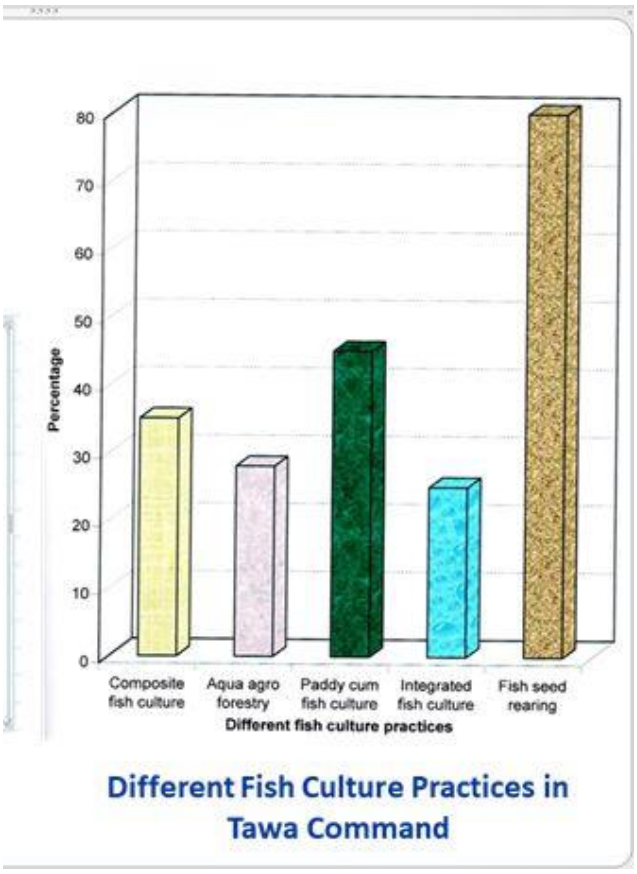

Fig.: 04

Conclusion:

It is the time to change with climate, and we to have the potential in terms of technologies and strategies that enhance our ability to improve sustainable growth in aquaculture and fisheries. The SD Model has the potentials to develop and analyze the cost - effectiveness of the system. The model has the ability to generate best scenarios of Aquaponics production with different climate attributes.

Inclusion of aquaponic technique will have, positive results but at different rate of returns. This may herald the future as impetus to change the food system along with predominating agriculture in the area. Further adoption of scientific innovations in aquaponics can create business opportunities & will help them succeed as entrepreneurs, new responsible farming technology to achieve sustainability in long terms for future generation.

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