CONTEMPORARY RESEARCH IN INDIA
ISSN 2231 - 2137

AQUACULTURE DEVELOPMENT IN KUMAON HILLS: A SPATIAL DECISION SUPPORT SYSTEM APPROACH

Dr. Ashok K. Nayak, *Sr. Scientist, Directorate of Coldwater Fisheries Research, Bhimtal (Present Address: ICAR-Indian Institute of Water Management, Bhubaneswar, Odisha)*
Dr. Prem Kumar, *Pr. Scientist, ICAR-Directorate of Coldwater Fisheries Research, Bhimtal, Uttarakhand*
Mr. A.K. Saxena, *Sr. Technical Assistant, ICAR-Directorate of Coldwater Fisheries Research, Bhimtal, Uttarakhand*
Dr. Mukesh Kumar, *Sr. Scientist, ICAR-Indian Agricultural Statistical Research Institute, Pusa, New Delhi*

Received: 20/01/2017 | **Edited: 28/01/2017** | **Accepted: 04/02/2017**

Abstract: *The proposed decision support system will be useful for farmers, researchers, planners and policy makers as it facilitate in selecting the appropriate location as well as different types of fish species for aquaculture development in that region. The aquaculture is one of the fastest growing food production system in the world in comparison to stagnation yield from many capture fisheries. In increasing demand for fish and fishery products, the requirement for aquaculture to increase its contribution to the world's production of aquatic food are in high. In absence of proper database system leading to inadequate development of aquaculture in hilly region, an interactive user-friendly system is required to be created in order to make planning for the aquaculture development with least investments. In the present study, theproposedsystem will provides a Geographical Information System (GIS) based decision support system known as spatial decision support system (SDSS) for aquaculture development in Kumaon region.Use of this decision support system can facilitate in selection of a suitable aquaculture system in considering various aspects of user's need. The study was carried out at ICAR-Directorate of Coldwater Fisheries Research, Bhimtal for the different villages of Nainital district, Uttarakhand.*

Key words: *Spatial decision support system, aquaculture, Kumaon hills, graphical user interface.*

Introduction

In recent years, aquaculture has emerged the world's fastest growing food producing sector with an average annual growth rate of approximately 10% since 1984. The concept of aquaculture in India is not a recent one. Aquaculture in India has evolved itself from the stage of a domestic activity to that of an industry over the years with entrepreneurs undertaking the practices in a big way. The freshwater aquaculture is an important sector for increasing the fish production level in the country as stagnation yield are found in many capture fisheries. For enhancing fish production, it requires to increase area coverage with emphasis on availability of water and other infrastructure facilities (Ayyappan and Krishnan, 2004).

The country has significant aquatic resources in terms of upland rivers, streams, high and low altitudinal natural lakes, reservoirs, in the Himalayan region, which hold large population of indigenous and exotic, cultivable and non-cultivable fish species (Vass and Gopakumar, 2002).Uttarakhand, one of the Hilly states of India has enormous freshwater fisheries resources that comprised of 2,700 km of rivers, 24,200 hectares of reservoirs, 297 hectares of lakes and about 2000 hectares of ponds(Vass, 2002). The state comprises two major regions namely Kumaon and Garhwal and both the regions are blessed with an abundance of aquatic resources. The Kumaon region is bounded on the north by Tibet, on the east by Nepal, on the south by the state of Uttar Pradesh and on the west by the Garhwal region. It includes the districts of Almora, Bageshwar, Champawat, Nainital, Pithoragarh & Udhamsingh Nagar and lying between latitudes 28^0 44' and 30^0 49' N and longitudes 78^0 45' and 81^0 15' E covering an approximate area of 21,035 sq.km. The altitudinal range varies from 204 m to 7,436 m above the mean sea level. Among the available resources, a number of natural lakes in the Kumaon region

constitute a valuable water resource even for development of aquaculture fisheries in the region. The principal lakes are Bhimtal, Garudtal, Hanumantal, Khurpatal, Nainital, Naukuchiatal, Sattal and Shyamlatal. In addition to these lake resources, the low and mid Himalayan Kumaon region has small aquatic ponds and great potential for creating more water areas for aquaculture development (Jalal, 1988; FAO, 2003).

There is no proper database system available for planning for the development of aquaculture in the hilly region. So, a computerized system is required for planners and other stakeholders in development of aquaculture with less investments. The proposed database system will provides a spatial decision support system for development of aquaculture in Kumaon region. This system will support the planners and fish farmers in making decisions to exploit these resources judiciously. The study would entail use of emerging technologies *viz*. modelling and GIS to optimize the use of resources, production system there in and post-harvest programmes. Keeping in view of these issues it necessitate to create the spatial database on fish and fisheries resources, which would help the planners in order to increase productivity by applying appropriate management practices.

Materials and methods

The studies on GIS applications in India pertains to agriculture including fisheries are few and scattered. Patel *et. al.* (2002) used the remote sensing and GIS application in agro-ecology zoning for the Kumaon region and carried out forest resource assessment, agricultural pattern and soil sedimentation. A study was conducted by Nayak *et. al.* (2014) for identification of suitable aquaculture sites in Nainital district which was used in the present study for defining the aquaculture site suitability of the villages in preparation of the decision support system.

Thedecision support system (DSS) is an interactive computer-based system or subsystem intended to help decision makers by using communications technologies, data, documents, knowledge and/or models to identify and solve problems and decision-makings.A spatial decision support system can be either problem specific or situation and problem specific. Both are tailored to a specific problem, but the latter is generally limited to one specific spatial location. An SDSS is the ability to deal with spatial data and ability to be used effectively for diagnosis, planning and management of the resources (Carrick and Ostendorf, 2007). The SDSS commonly include a natural resources database, a production model and a GIS platform. Some of the attributes of the spatial database (e.g. temperature, water quality parameters, rainfall etc.) form the inputs to the production model while the spatial attributes and the output of the model form the input for the GIS.While selecting the fish species for culture, the database developed for coldwater fishes of India can accessed to take a decision about the culture of coldwater fish species and their behavior, production etc. (Nayak *et. al.*, 2009). The research evolved an authentic DSS ready in the form of a tailor made software package for use.

The DSS development approach is based on the assumption that the information requirement of a system can be predetermined. In designing the system, the approach is typically used for large, structured applications which requires significant investments of time and resources to reach the desired levels of output (Meador and Rosenfeld, 1986). Involving very structured situations, information requirements are determined by logical analysis. Though the system development life cycle has many phases, it can be generalized into themajor phases like are system analysis, planning, designing, construction, testing, implementation, operation and maintenance activities (Turban, 1990).

The decision support system database was developed in Microsoft Visual Basic 6.0 software as front end tool and Microsoft Access 2000 as back end tool. Various forms, menus, text fields and command buttons were created in visual basic software and it was linked with the backend tool of Microsoft Access (Siler and Spotts, 2002). The village information like name of the village, msal, latitude, longitude, population density,

nearest market, nearest hatchery etc. were stored in the back end which was accessed on the system for taking appropriate decision. In the present study, two types of aquaculture production system was considered *viz.* carp culture model and trout culture model. Based on the elevation of the village and water availability, the decision support system predicts the model accordingly. For example, if the masl of the village is above 1800m and continues water supply is available for pond culture, then the system prefers for trout culture model otherwise the carp culture model would be used for aquaculture development in the region. The output from aquaculture development is predicted based on the model for a desired time period. Further the meteorological data required by the model like mean temperature, average rainfall and other parameters required for aquaculture development were derived from the database for the selecting the suitable site for aquaculture. The flowchart of decision support system for aquaculture in Kumaon hills is described in Fig.1.

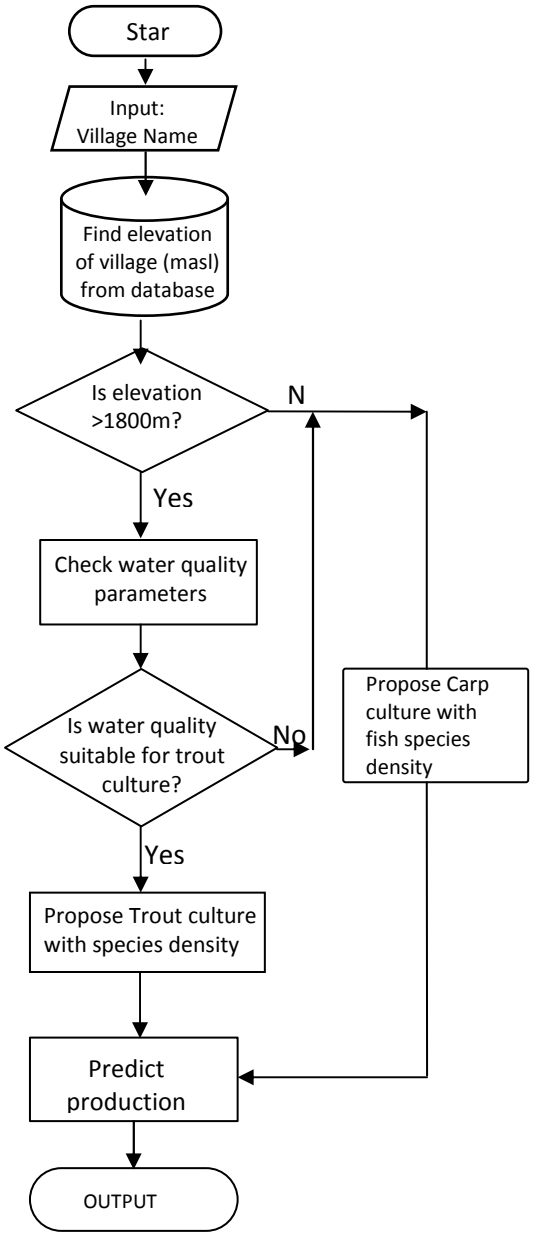

Fig.1: Flowchart diagram of decision support system for aquaculture in Kumaon hills

Results and discussion

The developed GIS based decision support system for aquaculture in Kumaon hills is a user-friendly software application which can be easily installable in a windows platform. The DSS software after opening starts with a welcome window where the option to enter username and password to authenticate for entering into the system as shown in Fig. 2.

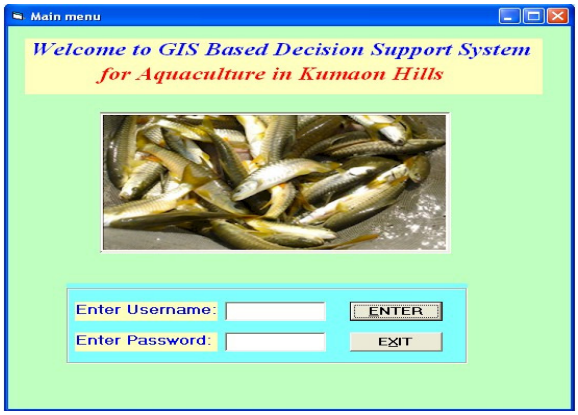

Fig.2. Welcome menu of the spatial decision support system

After authenticating in the database, another window for aquaculture site selection opens with option to select the village name of Nainital district. A combo box was created for clicking the village name, as there are more than thousand villages in the Nainital district are included in the database. After selecting the village name, the general information like latitude, longitude, elevation, population density, nearest hatchery and market will be displayed as shown in below Fig.3.

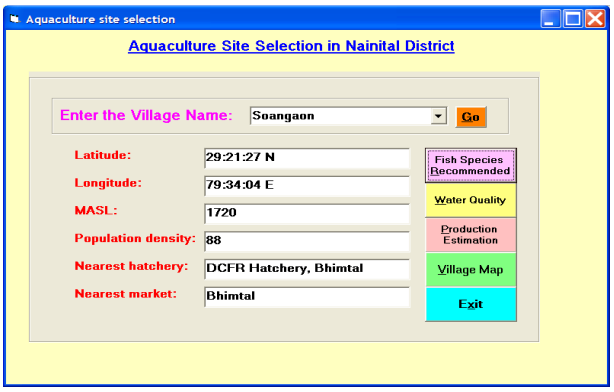

Fig.3. Aquaculture site selection menu of the DSS

In the menu, an option was created through command button to know the fish species recommended for that village based on the elevation and other parameters. Whileselecting, it suggested the probable fish species to be culture profitably alongwith the seed availability location as shown in Fig. 4, so that the farmer can plan their aquaculture development in the selected village.

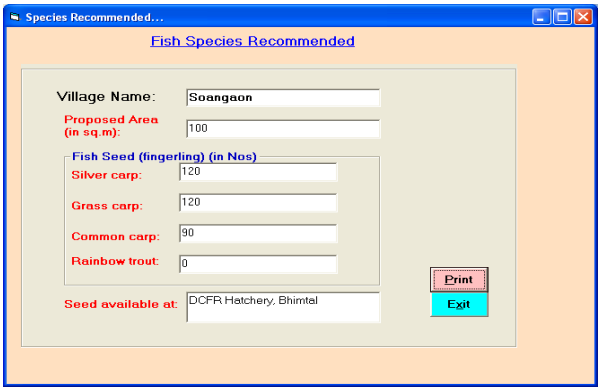

Fig.4. Fish species recommended for a particular village

There was another option created on the database to find out water quality parameterfor aquaculture development. Under this module, the user can find out the ideal values of water quality parameter and option to check the water quality of the particular pond available in that village (Fig. 5). If the water quality values are is not suitable for aquaculture then this system will also suggest its remedial measure for that water quality parameter to make economically viable or cheaper for aquaculture practices as shown in Fig.6.

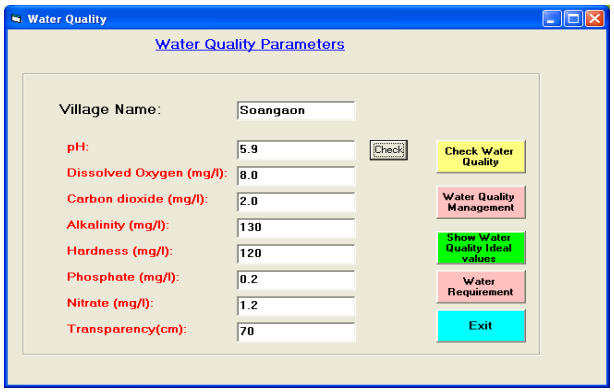

Fig. 5. Water quality parameter for aquaculture

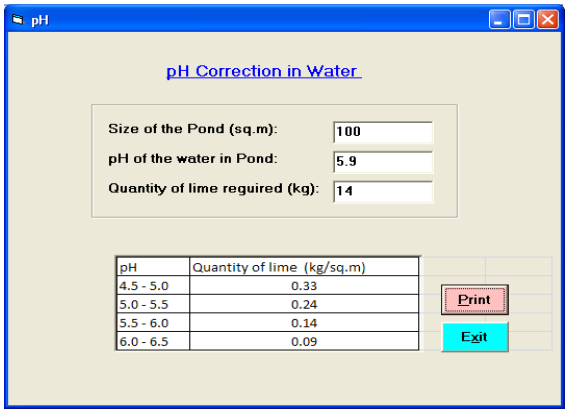

Fig. 6. Water quality parameter remedial measure

A fish production estimation module was also created which will estimate the fish production after certain duration of time. This production may vary based on the village location, water quality and other parameters for a particular village as shown in Fig.7.

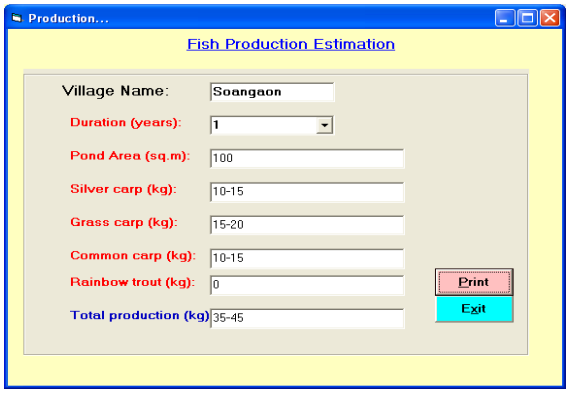

Fig.7. Fish production estimation model

This DSS will facilitate to take decisions considering technical as well as economic aspects for aquaculture development under various scenario. This tool will be useful for farmers, researchers, planners and policy makers as it will be user friendly and facilitate

interaction in selecting the villages for large scale aquaculture development.

Conclusion

The decision support system was developed taking into account the elevation of the village and different water quality parameters. Now this DSS will provide decisions which system are technically suitable and also provides different options of the doing aquaculture practices. The graphic user interfaces (GUI) have been designed in Visual Basic 6.0 and suitable database in Microsoft Access for data storage in the system. The different stakeholders can easily access the system to find the feasibility to construct a new pond in the village. The fish species and their density for aquaculture development can also be found though the DSS. The expected output after a certain time period can also be estimated. The system is menu driven and user-friendly designed so that the use of this system will provide intellectual support to farmers and other stakeholders in proper planning for aquaculture development in the hilly region.

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